INSTITUTE OF AGRICULTURAL RESEARCH

PROCEEDINGS

SIXTH ANNUAL RESEARCH SEMINAR

12 NOVEMBER TO 14 NOVEMBER, 1975

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CONTENTS

PAGE

CROPS AND SOILS | PAGE

not know enough about agricultural research to talk about it for very long. You have gathered here today for the Sixth Annual Seminar of the Institute of Agricultural Research to discuss the outcome of research conducted so far and the direction for effort in this field in the immediate future.

You are engaged in the scientific search for knowledge which, in the Ethiopian context, will help raise the productivity of Ethiopian rural masses, who earn their livelihood on farms and pastures and for the knowledge which will protect their crops and livestock. The need for agricultural research in Ethiopia may be gauged from the fact that 23,000,000 or 90% of Ethiopians now practice subsistence agriculture. Their gain, according to a recent estimate, is an annual growth of domestic products of E$103/head. This places Ethiopia well down at the bottom of the list of least developed countries. The urgency of improving agricultural productivity and conserving harvest may be judged from the following predictions:

'At the present 2½%/year rate of population growth there will be 50,000,000 people in Ethiopia by the year 2000; 40,000,000 of them will be then practicing agriculture in the country side. These people will have to raise food for themselves and approximately 10,000,000 of their urban compatriates, as well as, whatever agricultural commodities are exported. There can be little doubt that then, as now, their productivity will determine the standard of living of all Ethiopians. It is true that the Land Reform Proclamation issued by the PMAC last March has removed the feudal land holding system that in the past has oppressed Ethiopia's broad masses. The full realization of the transformation of rural life and the attainment of a just and equitable society that motivated the proclamation depend very greatly on research into the raising of agricultural productivity. It is true, that research in other sectors will contribute towards the attainment of this objective. I am happy to note that the agricultural sector itself is broadening out by the establishment, in the recent future of an Agricultural Engineering Research Institute.

For the reasons briefly stated above, I am happy to note that agricultural research, under the umbrella of Institute of Agricultural Research has grown to win the major share of the research appropriation of the Ethiopian Government and also has very substantial support in research funds provided by the United Nations through FAO and other donner agencies as well as from friendly countries. The Ethiopian Science and Technology Commission, which was launched a little over a month ago when a Commissioner and a Deputy Commissioner were named, will add it's support to your efforts in agricultural research. It's major objectives as spelt out in the draft proclamation are:

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INTRODUCTION

The meeting was declared open by Dr. Samu Negus Haile Mariam, the General Manager of the Institute of Agricultural Research and the overall chairman for the meeting.

The chairman opened the meeting by thanking the participants for their attendance and expressing the hope that the following three days would produce both papers and discussions that were stimulating. He then went on to apologise to the meeting and the opening speaker for the change in the programme. It had been hoped that the Commissioner from the Planning Commission would open the meeting but he had been otherwise committed. It was therefore a great honour and privilege for the chairman to introduce His Excellency, Ato Haile Lul Tebekie, the first Commissioner of the newly established Science and Technology Commission.

The chairman went on to say: 'First of all I would like to apologize for the short notice given to you in asking for you to come and open our seminar, but we are very delighted that you have found it possible to come here and be among us. Last year at the end of the Fifth Annual Research Seminar a resolution was passed by practically the same body of people that are present here today. This resolution was to the effect that the establishment of National Science Research Council was a necessity and should be seen as an important section to be established by the Government. This resolution was passed to the Minister of Agriculture through our office in order to speed up the establishment of this organisation. That is why I call on you with confidence and express our gratitude and satisfaction that you can be here among us and are able to open the Sixth Annual Research Seminar.'

His Excellency, Ato Haile Lul Tebekie:

'Ladies and Gentlemen. I have been requested, as Dr. Samu Negus said, at uncomfortably short notice to address your seminar at it's opening and I am happy to have this opportunity to get to know the agricultural research community. The short notice will mean that you can take comfort in the fact that my opening address will be short because I do

1. To encourage, strengthen and guide, the Scientific search for knowledge, which will ease the struggle for existance of the broad masses of Ethiopians and raise the productivity in their every day livelihood tasks.
2. To encourage, strengthen and guide the search for Ethiopian natural resources and the research for those technologies which when applied to their tools will serve to win an optimum means of production in all sectors.

'It is the task of the Commission to try and implement the aims of the Proclamation by coordinating research in the many sectors within the nation. It is hoped that in its task of organizing research in other sectors, such as: health, industry & technology, education, the Commission will profit from the experiences of the agricultural sector in their difficult task of beginning to institutionalize, as you have done so well in agriculture, scientific research in these other sectors. It is also hoped that the geographic spread of the agricultural research net-work throughout Ethiopia will serve as a useful example for the organization of research in the other sectors.

'I wish you success in your seminar and in your future research work. Thankyou.'

The Chairman thanked the Commissioner for his interesting and encouraging opening speech and said that the agricultural research community was looking forward to seeing the Science and Technology Commission well established and in full operation. He was certain that the scientists in agricultural research will benefit greatly from this new Government organization.

STRATEGY FOR THE LIQUIDATION OF UNDERDEVELOPMENT IN REFERENCE TO ETHIOPIA'S AGRICULTURE

by
Mulugetta Taye
(Agricultural Economist - Planning Commission)

This paper, brief as it is, reflects my own personal opinion and is not an official statement from the Planning Commission where I am working at present. In this paper an attempt has been made to sketch a possible strategy for the development of Socialist Ethiopia's agriculture. It is neither exhaustive nor original; many of the opinions are basically of a broad theoretical nature without much statstical back-up. The paper is only to indicate, at the micro level, the extent to which development policy and strategy can address itself to the problems of under-development in Ethiopia's agriculture, Last but not least the aim of this paper is to serve as a starting point for a serious and extensive discussion on the problem noted above in order to provide a starting point to provoke the imagination of concerned citizens. As we all know, we are now at a new threshold in our history. The semi-feudal, semi-capitalist order had been smashed and socialism is officially declared as our national goal bringing with it all the rights of progress and a better life for the previously neglected masses. We are now pressed with the tremendous and often protracted task of developing our economy.

It would be most fitting at this point to quote Cuba's Faedal Castro. In his speech of July 26, 1967, he said: "The most difficult task was not the overthrowing of Baptista, "the then president of Cuba," but the one we are engaged in today; the task of constructing a new country on the basis of an underdeveloped economy."

Like any other country Ethiopia has to undergo a painful and difficult process of economic growth. It has been reitterated time and again that the developing countries must find and allow for their own road to progress at the price of great effort, difficulties and sufferings. In doing so, they should take into account all the achievements of value in human culture and historical progress but must also start from their own potentialities. This is in line with the Marxist & Leninist view of the historical progress of humanity and social transformation. We can best understand our economic, social and political problem by employing political economy as our analytical methodology. Development cannot be diverced from politics and vice versa.

Now let us look at the situation in Ethiopia's agriculture prior to the time of our revolution. For the purpose of an analytical elaboration on the possible strategy for the development of Ethiopia's agriculture, it is essential to provide some background material of the situation in Ethiopia's agriculture prior to the time of our revolution. As one easily recognizes, this is wide topic on which one could write volumes after volumes. For our purpose here, however, I will only give a brief and cursory review of the situation in as much as it serves as an introduction to the main topic.

As we all know, Ethiopian agriculture was characterised mainly by the feudal class relationship in which the broad masses of the peasantry were exploited by the feudal ruling class and its henchmen. The continuous syphoning off of the economic surplus by the parasitic feudal class was, in the main, responsible for the primitive state of technology and low labour productivity in agriculture. The existing property relationships prohibited the realization of the potential of much of the nation's agricultural resources. Of the peasant class the tenant farmers were the most exploited and oppressed. It was this social relationship that brought about and upheld the misereable social conditions, the recurring famines etc. that characterized much of the agricultural life of the Ethiopian peasantry. Besides the feudal relationship, the capitalists' mode of production has, particularly in the last few years, increasingly penetrated into Ethiopian agriculture. International monopoly capital with the help of the national ruling class had been financing the development of large scale farms in agro-businesses. This phenomena has given rise to the emergence of an agricultural proletariate. Seen in international context, this situation has given a rise to the phenomenon of uneven development. As a result of the numerous peasant uprising that took place in our country the contradictions of class relationships in Ethiopia's agriculture were manifested in a fierce class struggle. And as we witness today, this primary contradiction is being resolved through a class struggle in an attempt to advance the socialist transformation of Ethiopia's agriculture.

So much, very briefly, about the situation before the revolution. Now, to sketch a possible strategy for irradicating the underdevelopment phenemona in Ethiopian agriculture, I will suggest the following:

Although underdevelopment is a product of an international capitalist world economy, development policy still has a basic national framework and our analysis of the problem must start from the prevailing concrete objective conditions in our country. The dynamic interconnection between agriculture and the other sectors, like industry, play a vital and, at times determining role in the overall development of agriculture. If we are to start our analysis from the existing concrete objective conditions, then we may have to ask the following questions:

What are the major tasks and the possible longterm strategy for the development of Ethiopian agriculture?

Now, let us talk about the major tasks. As we know, the historic Land Reform Proclamation of March 4, 1975, which effected the nationalization of rural lands lays the foundation for the rapid transformation of Ethiopian agriculture. It's longterm implication is undoubtedly of great importance to the national economy. By this act a potential force with a tremendous energy has been unleached. With proper planning and guidance the peasantry's labour power coupled with the rural agricultural resources could generate surplus products for financing the development of the other sectors. However, our immediate task is food production in a planned manner. Like any other country Ethiopia has to feed its population. Both the natural increase in population and the recent severe famine that ravaged the country call for an accelerated intensification of food production both through intensive and extensive farming methods. We must be self sufficient in food grains and food production must be accepted as the guide line in a foundation for agriculture. The development of livestock and dairy farming so as to augment the food supply of the nation should also be accorded a high priority. Agricultural research has a very vital role to play. It also calls for the rapid transformation of the productive forces in the reorganization or reform of existing institutions which otherwise could be responsible for stagnation in the national economy. It also requires the establishment of efficient marketing and distribution systems. Without these it might be difficult to increase total food production in general and a market for food surplus in particular. State farms have a vital role to play in the production of food grains. Besides their traditional role of providing agricultural production for export markets, State farms with a defined policy could raise the total food supply by employing more modern techniques of production. Some of our river basins are ideal sights for the establishment of State Farms using irrigated agriculture. I must confess at this point, that there is no systematic study, that I know of, that indicates the role of State Farms in socialist Ethiopia's agriculture. This is a subject that warrants extensive research work in its own right.

Next, food production: What is the immediate task? The next immediate task is to design:

(1) a strategy for a comprehensive development of the Ethiopian livestock and fishery resources;

(2) a strategy for a rational exploitation of forestry resources and a strategy for the establishment of allied industries like paper and pulp industries; and

(3) a strategy for the comprehensive application of soil and awater conservation practices--most of all for efficient utilization of our water resources for maximum production.

And we also need a strategy for the conservation and preservation of our wildlife resources. This is just a review of the immediate task, Now, let us look into the longterm strategy, although not longterm in the that it just follows the immediate task. Unlike the semi-feudal and the semi-capitalist economy, our new economic order requires a conscious policy and development strategy and longer range development planning. Seen in this complex the long term strategy towards the development of agriculture is organically interrelated and interconnected with other industries.

If the primitive socialist accumulation that obtains from agriculture is meant to finance both itself as agriculture and the development of industry; especially the capital goods sector, then a much more rapid and sustained development of agriculture will be possible. Because as the British Economist, Morris Dope, puts it" a rise in agricultural productivity is apt to be contingent upon a certain degree of development in industry, e.g. to supply agriculture with machinery, with fertilizers, with power and with trasport facilities."

For the reasons noted above, agriculture is a traditional source of primitive socialist accumulation. In the context of Ethiopia's agriculture, how is this task to be carried out? It is prefered if the primitive socialist accumulation, as obtained from Ethiopian agriculture, is carried out by the Central Government through the employment of various mecahnisms to siphon off the economic surplus. The way to define economic surplus is really very controversial, but for our analysis here it is a surplus that remains from total production after subtracting the socially necessary consumption. Undoubtedly there will be some room for private saving to take place in agriculture but this will be insignificant and not sufficient to fuel the process of capital formation. There are a number of ways by which this surplus, that is an economic surplus, of total production over socially necessary consumption can be obtained. I will only mention here, those which are intensively employed by most socialist countries.

The first method is to increase taxation. Traditionally part of the agriculture output goes to the Central Government in the form of agricultural taxes. I submit that it may be difficult to syphon off that part of the output which was formerly going to the landlords in the form of land rent as it will now get subsumed into the increased "on the farm consumption" by the peasantry. Nevertheless, taking into consideration the possible increase in consumption by the peasantry after the land reform, it will be possible to design and elaborate an agricultural tax system that will enable the Government to take a higher proportion of the growth yield from agriculture than has been done in previous years. The assumption behind generating an agricultural taxation revenue by increasing the taxes is that, although part of it goes to finance current public consumption, a larger proportion will go to increase capital formation.

The second method for increasing accumulation is by manupulating the terms of trade between the agricultural and industrial sectors. We all know that, unlike that of a capitalist economy the Government of a socialist country will have the power and means to control the general level of prices in a planned manner. This is possible for the simple reason that most of the means of production are either in the hands of the Government or collectively owned by the people. Therefore, in this complex the Government can employ atleast two methods to extract resources from the agricultural sector. Government can purchase agricultural products at a low prices and secondly it can sell industrial godds to the agricultural sector at higher prices. Through the use of these methods, agriculture could make a substantial contribution to overall accumulation. This practice, however, could raise a number of fundamental questions, such as: how long can we keep the terms of trade adverse to agriculture, and won't an artifically depressed agricultural price system be a disincentive to the peasant producers. In my opinion, these are legitimate questions that beg further analysis. It will have a multifaceted implication if the terms of trade are kept too low against the agricultumal sector. Periodically, Government must reappraise its price policy and should exam the effect of the terms of trade on production. As time goes by and the economy begins to show a sustained growth, Government should improve the terms of trade in favour of agriculture. To effect all this, Government should establish as a priority, state trading agencies, which will be reasponsible for purchasing and supplying all agricultural products and industrial goods, respectively, to the rural sector.

The last method for increasing accumulation and capital formation is to encourage self financed investment within agriculture. Inorder to increase production and productivity of labour in agriculture Government should encourage the peasants to utilize part of their economic surplus to improve some of the instrument of labour.

Now we have been discussing the short, the intermediate and the longterm strategy. To excute this strategy we definitely need an organization. Now let us discuss the development organizations. To increase production and particularly to effect rural transformation, one needs development organizations and institutions that are compatible with the prevailing political, social and economic realities. As I indicated at the outset there are organic inter-relationships between politics and development at the field level. There is now a crying need for the reorganization of the existing bureaucracy and administrative system to be responsive to the political and social changes that have recently taken place. This centralization of administration and civil meetings are pre-requisites for rural transformation and socialist construction. There ought to be a development organization at every regional level, even that of a Wereda, that could identify the constraints and problems in agriculture, in communication, in health, in education etc. that beset the region. This organization should be such that it can plan and implement development programmes in an integrated fashion. This kind of organization enhances the democratic participation of the regional population in the preparation of development plans. The formulation and excution of such regional development plans and programmes should be designed to involve the local socialist party and its cadres. In a nut shell the establishment of these development organizations will evantually serve as the developmental arm of the socialist party. The provisional services by the various Government agencies to the local inhabitants should also be channeled through and in consultation with these regional development organizations.

Now, what kind of organization do we envisage for the farmers themselves--let us go down to the basic organization. It has been noted above that the purpose in the establishment of these development organizations is to cater for the welfare of the broad masses of the peasantry. This brings us to a discussion of the kind of institution or organization that best contributes in raising the agricultural productivity and enhancing socialist transformation. I believe--this is my belief alone--that we should carry out a step by step progress towards the distant goal of collectivization, and this is the basic organization that I envisage at the local level. This process is dialectical in nature and it goes through time and space and its realization depends on the political and economic development of the society. It should be envisaged that within the existing Peasant Associations marketing and credit cooperatives could be established by the voluntary will of the individual farmers. Extension, credit and marketing services could be provided to the farmers through these cooperatives. As the political consciousness of the peasants develop these marketing and credit cooperatives will change or be transformed into producers cooperatives where some of the means of production will be owned by the cooperative, and gradually, when the members are oriented to the philosophy of socialist ownership, these producer cooperatives will be transformed into advanced producer cooperatives. At this stage farmers will be reimbursed on the basis of the labour-time they expended for production. Almost all the means of production including land are at this stage, i.e. at the advanced producer cooperative stage, owned collectively by the farmers for their common use. Further more the advanced producer cooperative stage is a transitional stage to the final one which is the collective or commune. At this final stage the return to the land of the capital contributed will be eliminated. It should be pointed out that the realization of collectives depends upon substantial material support from the industrial sector of the economy. Cooperatives not only serve economic purposes; they also have a political role to play. The process of socialization could best be achieved in rural areas by the promotion of cooperatives in economic and political components. It is through collectivization that the nation's resources should be mobilized and its technical basis of production improved. Cooperatives will provide the essential framework for Ethiopia's socialist economic development.

Discussion

The chairman thanked the speaker for his stimulating speech in which immediate, intermediate and longterm strategies for development had been outlined. He commented that as regards research the obligations for immediate results had not been altogether fulfilled and there was a long way to go. However, regarding the development organisation in the Institute of Agricultural Research, there had been a lengthy discussion the preceeding day at the annual staff meeting of the IAR on how the Institute should be reorganized. The meeting discussed ways and means of setting up regional research centres which fits well with the recommendations and plans for decentralisation at Province, Awraja and even Wereda level as outlined in Ato Mulugetta's paper. It is felt that each area should participate equally in the development of agriculture and that a regional scheme will help in achieving this.

The speaker was asked about a most important tool required for the realisation of stable development and this is trained manpower. The questioner wanted to know if this need had been assumed, if not he would like to know what means the speaker envisaged to minimize this basic necessity or if he had some strategy in mind for producing many more trained personnel be it at the immediate, intermediate or longterm level.

Ato Mulugetta replied that he was neither minimizing the need for trained manpower nor overlooking the seriousness of the problem that faces the country at this moment. It had been very difficult to tackle all the facets of development in such a brief time. It is the speaker's opinion that the present way in which the educational system is being handled does not fit the needs of the country. The problem is right at the bottom, at the Wereda and Kebele level and there had to be a strategy for expanding education at these levels for both skills and higher level education. In the immediate future it may be unavoidable to continue using the existing traditional educational system in order to produce the necessary manpower. But in the longterm decentralization was essential in order to meet the manpower requirements at the local level where personnel for extension, marketing, health including, maybe, such people as bare-foot doctors, etc., were needed. This kind of manpower could only be met by bringing the educational facilities down to the Wereda level and this could only be envisaged through organisations such as cooperatives, as was indicated in the paper. At this point in time, the need for manpower is very critical and it must be clearly understood that without trained personnel it will be very difficult to move this vehicle which we call development and to sustain its momentum.

The speaker was asked to clarify the differences between peasant associations and cooperatives. There was considerable confusion in some peoples minds about the roles and relationships of these two types of organisatinn whether they were complimentary or contradictory.

Ato Mulugetta replied that he was only giving his views and there was no official opinion at the Planning Commission. He was well aware of the controversies as he had been involved in some of the discussions on the roles of peasant associations and cooperatives. Peasant associations had arisen as a result of the Land Reform Proclamation and there was a very strong need for this kind of association. At the outset the Ministry of Land Reform and Settlement did not have either the manpower or the finance to bring about the tremendous task of Land reform. Therefore it was felt that the best means for effecting land redistribution and to maintain security, i.e. to fight their class enemies, was for the people to handle things themselves and thus peasant associations were created. The proclamation defined the duties and responsibilities of the peasant associations. In production the associations have got a number of options but, as is well known, collective or cooperative production has tremendous advantages. Thus initially there will be a production unit but the assumption is that eventually cooperatives will be developed by the will of the people. As the people become more politically conscious the cooperatives may take over some of the political functions now vested in the associations and eventually the peasant associations will weather away. But these are only assumptions. At the moment there are not many cooperative being started and the role of the peasant associations is very crucial for implementing land reform. There is a need for land redistribution in some areas and this can only be carried out by the peasant associations in consultation with the Ministry of Land Reform. In examining the history of the Chinese Revolution it is found that peasant associations were formed to meet the political needs of the revolution and they gradually weathered away as the socialist communist party was strengthened. The cooperatives gradually became stronger and most people joined the cooperatives so that they gradually took over the function of the peasant associations.

It was commented that the peasant farmer is the centre of our society and our basic aim should be to meet his needs and improve his standard of living. Thus the Government should do everything possible to meet these objectives. It thus seemed that if agricultural produce is bought at a low price and industrial products are sold at higher prices this will work against the basic objectives of the revolution. It would be better if the Government was prepared to subsidise the agricultural sector.

Ato Mulugetta replied that this was a very legitimate warning but we have to start financing our own development using our own resources. This development finance will therefore have to come from the economic surplus. Thus economic surplus is the saving that can be collected from the economy without substantially affecting the socially necessary consumption of the population. One way to do this is to manipulate the terms of trade between agriculture and industry. But this is a very delicate instrument to handle because it could have

a negative effect on production in agriculture if the prices for agricultural products are too greatly depressed. However the investment that is needed for industry will, broadly speaking, be generated from agriculture. Thus this issue is like a two edged knife. The point is on how to handle this at a policy level. Definitely production must be encouraged by giving the necessary services, incentives, etc. But at the same time, in order to derive the necessary investment savings to start a socialist accumulation, surpluses will have to be extracted from the rural areas. In Ethiopia this is now possible because of the implimentation of the Land Reform Proclamation. It might well be possible for the Government to extract an amount equivalent to what used to go to the landlords in the form of rent either as a tax and/or by manipulating the terms of trade. It has been the experience of most socialist countries that after land reform the peasants increase their consumption and this is fair enough. Thus possibly the most practical way to extract the surplus is to manipulate the terms of trade, but this is a very sensitive instrument to handle.

The speaker was asked whether he was talking about an open or closed economic situation regarding the price system. He replied that he felt that a closed system was out of the question and inappropriate as we were part of the international community and goods had to be both exported and imported. Ato Mulugetta then went on to expand on the use of terms of trade and taxation. He was aware that the Government had a proposal for a large and strong marketing and storage project which will handle the terms of trade. However it must not be forgotten that agriculture cannot be divorced from other sectors. If we get bogged down in one aspect then it is easy to lose sight of the development process that we would like to have for the country. Thus if we can syphon off the surplus from agriculture, industry will be able to provide the necessary machinary, fertilizers and other producti tion inputs to agriculture. This cycle is continuous both quantitatively and qualitatively. Regarding taxation, the present information is very sketchy. However, the Ministry of Finance is now studying methods to revise taxation, particularly in agriculture. The implimentation of a taxation system for agriculture will have two problems; one is the needed organisation and manpower and the other is the organisation of the peasants. However as cooperative develop it will become easier to impliment taxation at the Wereda level.

THE RELEVANCE OF AGRICULTURAL RESEARCH TO THE FARMER

by

John C. Phillies, P. Ag.
(UNDP)

I am most grateful to have the opportunity to say a few words at this seminar. The exingencies of ones employment tend to draw one away from ones technical base and professional foundations as time goes by, and one ends up in the realms of planning and administration. Much of my time is spent in discussing with the Planning Commission and others just how the United National Development Assistance Funds should be spent. Thus it is a rare luxury to have the opportunity to talk about ones subject to an audience of colleagues.

As I have been away from practicing agriculture for some years, I am not going to put forward any detailed scientific pronouncements. His Excellency, the Commissioner of the Commission for Science and Technology has pointed out the need for agricultural research and Ato Mulugetta has spelt out a brilliant socialist strategy to achieve a better standard of living for our farmers. Basically, I want to ask a few basic questions about agricultural research in general and what we are doing here.

What is it all about? What are you Agricultural Research Workers trying to do? What is the end point of your work? Are you finishing in the right place with answers, knowledge, techniques, material that can be readily used? Do you have the correct training, experience, equipment, assistance to identify correctly the problems that need to be solved? Do you, when working on your own specialised problem stop to think about the wider problems which you are trying to solve?

In its simplest form the science of Agriculture is the varying of the balance of nature to the advantage of man, so that his supplies of food and clothing are more secure.

There are five main foundations to Agriculture. The Land, the Plants that grown on the Land and the Livestock associated with the Land and Plants, the human population which develops or exploits the first three and lastly the Climate.

Under "Normal Conditions" a balance of a kind is maintained. However, an excess of the human or livestock population or a change in the climate can upset this balance. The science of Agriculture can minimise these adversities and go further by ensuring that the plants and animals can be produced in sufficient quantities to provide surplus for the use of the human population that does not have the opportunity to live on the land.

The biggest challenge to agricultural science today is the explosion of population. In particular the population that produces no food and is therefore, parasitic on the primary producer.

The Agricultural Scientist must start from first principles, with the basic inherent fertility of the soil, the basic productive capacity of his germ plasm, the basic availability of moisture and heat, the basic skills of the human population. He must weave them into a farming system that puts all the inputs to optimum use. A system that satisfied the needs of the human population yet at the same time regenerates and improves the basic fertility of the land.

The task is immense and has, therefore, resulted in specialisation. With specialisation, unfortunately has come the temptation of narrowness of outlook, jealousies and a forgetfulness that a specialist must still be aware of the forest while he concentrates on own his particular tree.

To take the simplest of examples, a plant breeder produces a high yielding type of maize. This maize takes more nutrients out of the soil so needs fertilizer. Unfortunately, in breeding for high productivity, certain resistance to plant disease and insect attack is lost. Thus, chemicals to fight the disease and insects are necessary. To harvest the crop, special harvesting techniques and equipment have to be developed, new crop storage and marketing facilities have to be created. The whole affects the life of the people. So, to make use of the new variety, a major change in the farming system is required. The interaction of all these things are necessary if the high yielding maize is to be value to the community.

If a new unit of progress is injected into the farming system without considering its effect on the whole system, after perhaps one crop year, the results will be counterproductive. Are you really helping a farmer by giving him a high yielding type of maize that exhausts his land because he cannot afford the fertilizer; that is liable to attack from a disease he has never seen before; that when harvested gives him such abundance he can't store it because the crop storage technique available to him is inadequate, and the marketing system can't cope?

Not only will such action lead to deterioration of the land but also will breed mistrust in the eyes of the farmer for those who have the ability to help and guide him.

How many agricultural scientists spend sufficient time with the farmer to understand his basic way of life, his needs and his traditional farming system?

Too often one sees demonstrations of new techniques which fail because the basic existing farming system and culture have not been understood and too much change in system is attempted at one time. Attempts in ploughing in stubble in North Yemen failed as it deprived the farmer's wife of her chief source of fuel. The introduction of a new type of cotton in the West Indies was made much easier by the specialists knowledge of the local customs of planting by phases of the moon. Often text book demonstrations have failed because the specialist demonstrator had not basic farming knowledge.

Let us not forget the fundamental importance of the interactions of all our specialisations and their importance in the farming system. As in all walks of life, agriculture gets hit by popular crazes. A few years ago, the plant breeders gave us the green revolution. More recently the agricultural economists have dominated the thinking in agricultural development. In the climate of social change that is with us today, it is likely that with the immediate future the Sociologist will call the tune in agricultural development and the accent will swing to simplistic methods of immediate benefit to the small farmer.

How do we stand in Ethiopia? Are our research programmes geared to answer the problems of the drought? The overall food supply of the country? Is the basic knowledge available on which to base the new farming systems which will be necessary as a consequence of the progress of Land Reform?

It is up to the Agricultural Scientist to be flexible enough in his views, to be prepared to meet any challenge and solve any problem. The one thing he must not do is shut himself in his lab, isolate himself with his animals or build a wall around his trial plots. He must listen to the problems of his colleagues and with them work for the improvement of the overall farming system bearing in mind the basic point is getting the knowledge to the farmer. As the previous speaker has said development cannot be diverced from politics. Neither can it be diverced from the reality: the present knowledge and way of life of the farmer.

Discussion

The chairman thanked the speaker for his stimulating talk and opened the floor to questions.

The first questioner commented that we are often told, read about and discuss the role of some traditional blocks in implementing new ideas and new methods. He felt that we were placing too much emphasis on finding where the moon is at a certain period of the day,

instead of examining the situation that exists in the day itself. He suggested for a change that we should try and attack some of these dragging traditional blockages and not place too much importance on the difficulty of the situation. From his limited experience, he had been shocked at how much the farmers can understand and respond to new methods and thinking. He thought that we, the agricultural research community, should be a little more courageous in breaking apart from the imprisonment of the traditional blockages.

Mr. Phillips replied by saying that the important thing is the first step. But if we are working in the dark, it is difficult to know where to take this first step. For the successful introduction of new ideas one has to, if possible, eliminate as many of the known scientific blockages that are likely to occur. Therefore, if one has a full scientific understanding of the present situation that exists, i.e. superstitions customs etc. that are likely to influence change then one is more likely to be successful in bringing this about. The first step is local knowledge and full understanding and this step is frequently forgotten. The scientist is more often interested in the x, y, z's of a problem.than in the a's and b's that must come first.

The second question was directed to the speaker and His Excellency, the Commissioner of Science and Technology. It was possible to approach the problems at two levels: reorganization, such as that now being undertaken by the research institute, only met the problems half way. There is a need for a clear identification of priorities at a much higher level and a very clear commitment by the Government at that higher level. The priority should possibly come down through the Commission of Science and Technology in collaboration with the appropriate ministries and development organizations and other development projects in different parts of the country. If these priorities come down as broad but very clearly supported policies for research, the Institute could then be asked to pull together, from the various research organizations in different parts of the country, a team of the appropriate people, i.e. the appropriate manpower, to tackle such a problem at the complex level it has been suggested. Is this is at all possible or has it been given some thought?

His Excellency replied, that he believed that the setting of research priorities in the agriculture sector is not something that can only be left to the Government. He believes that the people in research know the problems of agriculture only too well and must be part and parcel of this process. Other than that, it is envisaged to set up an agriculture research council where the priorities of agricultural research will be in line with Government development policy. The Government will set out the broad outline for national development including agriculture development, but the details of such priorities in agricultural research must be left to the agricultural sector itself.

Mr. Phillips commented that he felt the identification of priorities should originate with the end users, the farmers of Ethiopia. The end point of agricultural research is to supply food and other raw materials for the country. Thus, the identification of problems and the needs in the agriculture sector must be the number one task.

Two points were made from the floor. In the first a speaker reminded the groups present that in integrating scientific efforts, disciplinary jeoulesy should be abolished so that problems could be tackled in a very integrated fashion.

Mr. Hamersley, the Chairman for this speaker, commented that at the IAR staff meeting on the preceeding day, the staff has spend a considerable time discussing ways and means for more efficient integration between disciplines in order to better coordinate research work.

MAKING AGRICULTURAL RESEARCH MORE RELEVANT TO THE PROBLEMS OF SMALL FARMERS

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First, I wish to thank the organisers of this seminar for the opportunity given to me to speak on the problem of how to make agricultural research more relevant to the problems of the small farmers. Truly, the awareness is gaining ground that agricultural research is becoming increasingly detached from the problems of farmers (small or large) and that this does not augur well for the future of farming on the continent of Africa and in fact in the whole world. Recently, an expert committee was set up in Britain to look into ways and means of making agricultural research in that country production-oriented. Early this year (24 - 28 March 1975) the Association for the Advancement of Agricultural Sciences in Africa (AAASA) held a conference in Dakar, Senegal. The theme of the conference was "Making Agricultural Research more Relevant to the Peasant Farmers" All these go to suggest that agricultural research might not be performing its legitimate functions to peasant farming.

Unfortunately, no agricultural scientist has been able to come forward with an acceptable formula on how to make agricultural research more beneficial to farmers. Many opinions have been expressed, but it appears that the present generation of agricultural research workers have inherited a way of approach to agricultural research that will make reorientation toward utility difficulty. By virtue of our training, it appears that we owe more allegiance to the discipline of our specialisations than to the less academic field of practical agricultural research. It appears that we are most fit in an unfit situation. Therefore, before we can conduct research that will be relevant to the problems of farmers, our method of training for an agricultural career needs to be reviewed. This need was recently fully appreciated by the Second General Conference of the Association of Faculities of Agriculture in Africa, 27th October - 4 November 1975, Cairo, Egypt. The Conference passed a resolution in which the gross in-adequacies of the practical content in agricultural syllabuses were spotlighted. In this age when a child enters school at the age of six and goes straight through the secondary, the undergraduate, and the postgraduate courses in agriculture without any period of living on a peasant farm, it becomes most essential that at one stage in this continuous chain, the child ought to be fully exposed to the technology of peasant farming. It is after this is done that he or she will be expected to conduct research that will be relevant. The training for an agricultural career that will enable us conduct research that will be relevant to farming must of necessity be practical and applied.

Assuming appropriate training with adequate practical content that will enable a Ph.D. (Agronomy) holder to grow Teff as efficiently as that old man who has successfully grown Teff continously on the same piece of land for over 10 years, it must also be accepted that a newcomer is only qualified to become a student of the peasant farmers and in front of whom he must humble himself, learn from the farmer, understand the problems of peasant farming and then use the knowledge of his academic training to design research projects that will yield results that will be relevant. He must also be prepared to return to the peasants periodically for orientation and updating of his knowledge of peasant farming. With my over 25 years in agricultural research in different parts of Africa, I am yet to see a B.Sc. Agricultural University graduate (leave alone the M.Sc.'s and Ph.D's) who will be humble enough to learn the technology, the pattern, the merits and demerits of peasant farming from the peasant farmers. Our attitude, due to our complete ignorance of peasant farming, is to condemn peasant farming as primitive and those practising it as conservative. The question arises "How can one do research that will be relevant to something that one neither understands, has knowledge of nor admires?"

What we find in most cases is that research workers sit in their offices, go into a trance, day dream, and with the figment of their imagination design research projects that are meaningless to farming. In some cases, such projects may be meaningful to the discipline, but since such workers are not institutionally well places, such projects are so badly executed that the results are also irrelevant to an academic discipline.

The agricultural extension service has a part to play in this regard. In a few countries where agricultural extension services have been organised, one finds that responsibility for extension was often divided among several agencies with resultant confusion, conflict and without serving the purpose for which the service was instituted. In some cases there are no communications between the extension and the research services. In a few cases, the mode of operation is a one way flow of information, that is, from research to extension to the farmers. An effective and properly organised extension service, which is indispensable to agricultural research, that will be relevant to the problems of practical farming should serve a two-way communication channel among Research workers, Agricultural Administrators, Policy makers, Farmers, and Agrobased Industries. It must be capable of adequately informing the research workers on farmer's problems as well as carrying adoptable results from the research scientists to the farmers. The extension service must of necessity be a party to the formulation and execution of relevant research projects. This requires the research workers who must listen to extension agents to emerge from their isolationism and ivory tower and move towards the farmers and extension workers whom in turn must reciprocate.

Appropriate training for research and formulation of relevant research projects are not sufficient to make research relevant to peasant farming. In many countries of Africa, agricultural research projects are executed through experiments conducted on government experimental stations. These stations are, in many cases located in out of the way places that are not visited by farmers and the extension workers. When results from such experiments are passed to farmers, they are accepted with some strange feelings. Since the extension workers do not follow all the processes leading to obtaining the results, they are incapable of presenting the results to the farmers with all the relevant details that will enable the farmers adopt them. The solution one can suggest for this state of affairs is that the research specialist, the extension worker and the peasant farmers must all combine to execute research projects so as to make the results meaningful and acceptable to peasant farming. The approach must be "conducting research together with the farmers for the farmers."

As economic investors, farmers are reluctant to take unnecessary risks. Peasant farmers are extremely vulnerable to taking risks. To avoid any element of doubt, it behoves any research worker who expects the result of his work to be meaningful to farming, to conduct his research with farmers, so that when the results are obtained, the farmers know all steps that have been taken to obtain the results. This done and provided the results are correctly interpreted, the farmers will show less reluctance to adopting them.

The question of appropriate interpretation of research results is very important in making agricultural research relevant to farming. Many relevant research results have been rendered irrelevant by inappropriate interpretation. It is customary to conclude the analysis, interpretation and conclusion of most agronomic experimental results by the empirical phrase "the result is statistically significant," and for most agricultural research scientists, that ends the analysis. This could be one of the reasons why farmers, who are economic investors, feel very reluctant in adopting research results. The farmers as investors want results to be interpreted in terms of dollars. They want to see the costs of all inputs including the cost of the farmer's enterpreneurship, cost of post-harvest operations, marketing etc. tabulated against gross income. They also want an allowance to be made for unexpected mishaps. After all these had been done, if the agricultural research worker can show that in terms of dollars, the results being recommended are statistically significant, farmers will no doubt accept such results as relevant.

It is not enough to ensure adequate training, identifying, and execution of research projects with the farmers and extension workers for the farmers. In other words, it is not sufficient to satisfy the prerequisites for making agricultural research relevant to farming during pre-harvest operations, farmers need to be guided and assisted with post-harvest handling of their farm products. A farmer who without adopting recommendations for increase production, has to sit by the road side for days on end to dispose of his 20 kg of carrot will feel reluctant to adopt any recommendation that will increase his production to 40 kg without a guarantee to him of a reliable channel of disposal. Therefore to make agricultural research relevant to the problems of peasant farming, the adequately trained research scientist, the extension specialist and the farmers must work closely together throughout the different phases of farming taking the decisions to farm, selecting the farm site, preparing the site, obtaining the appropriate seeds, sowing the seeds, tending the plants, obtaining necessary inputs (fertilizers, pesticides etc.) harvesting, and post-harvest operations (processing, storage transportation and marketing). For each innovation, for every new production technology, each farmer must be successfully taken through these various stages before agricultural research can become relevant.

One other important point is for agricultural research and extension workers to appreciate that farming is a complete industry and therefore it is no use conducting research in isolated islands of disciplines. There must be strong links between research and extension, and research specialists must work in complete interdisciplinary teams to conduct research the results of which will be relevant to farming. The question that arises is "What is a complete interdisciplinary agricultural research team for a crop." There is no fullproof answer to this question. However, the success of the Green Revolution team indicates that a complete interdisciplinary agricultural research team for a crop should include the traditional Plant Breeders, Geneticists, Agronomists, Soil Scientists, Entomologists, Plant Pathologist, Chemists etc, but more importantly, it must include Psychologists, Agricultural Economists, Communication specialists, Nutritionists, Processing Technologists, Domestic Scientists, Statistians etc., all working together on each project as a team. It is becoming apparent that most of the research done is the past in many parts of Africa were incomplete because they were done on a disciplinary basis. It was almost impossible to put the odd pieces from the various disciplines together, and therefore; the uncorrelated results became irrelevant to the problems of practical farming.

Another area needing careful consideration if truly agricultural research is to be made adequately meaningful to farming is the criterion for assessing agricultural research workers for career advancement. Some governments merely use the job descriptions and job evaluations which are tenable in other branches of government to assess agricultural research and extension workers. This is wrong and it is certainly counter-productive, because such an approach induces top-class workers to go out of research and extension to other units of government to earn high salaries. When however advancement in rank and salary adjustments are related to evaluations

of performance, the possibility of career patterns within agricultural research becomes guranteed. The question that next arises is "What is evaluation of performances".

In many parts of the world, evaluation of performance is based on the quality and number of publications a young scientist makes in scientific journals (most of which are in any case not widely circulated). Invariably results that would be obtainable from investigating the simple and practical problems of farmers are not academic enough for publication in the so-called scientific journals. Certainly the journals are scientific journals meant for the ivory tower scientists who main contribution is to extend the limits of scientific knowledge. The agricultural research worker on the other hand is to produce practical results that the peasant farmer of Africa can adopt.

In our society, any agricultural research worker who opts for the second alternative, that is, producing non-publishable but applicable practical results for the farmers, will be regarded as mediocre. He or she will either not move or move very slowly along the career ladder.

Realising this, every agricultural research worker tends to establish himself as a good non-mediocre scientist to be able to move fast on the career ladder. The result is that we are all efficiently or inefficiently conducting academic research that has no relevance to practical farming. This is not the fault of the research worker but that of the research administrator/assessor who is using the incorrect yard-stick.

Relevant agricultural research demands a unique type of salary, promotion and fringe benefit administration that may not be possible within the customary bureaucratic civil service systems. In agricultural research an individual has little incentive to be creative and productive if such a scholarship is unrelated to rewards. This is an important area that the administrators of agricultural research in Africa must pay carèful and immediate attention to if agricultural research in Africa is to be made relevant to the problems of peasant farming.

In conclusion, Mr. Chairman, in addition to adequate training, inter-disciplinary team work in research, doing research with the farmer for the farmer, and extending research to cover all pre- and post-harvest operations, devising appropriate criterea for the assessment of agricultural research and extension workers for career building; the suggestion is made that research is needed in different parts of Africa on how to make agricultural research more meaningful (relevant, beneficial) to peasant farming. This research must be speedily conducted and the results applied with dispatch. We must all realise that the self-sufficiency of Africa in relation to agricultural products now or in the immediate (or foreseeable) future DEPENDS entirely on improving the productive capacities of the peasant farmers of Africa.

UTILISATION OF SOURCES OF RESEARCH FINDINGS IN AGRICULTURAL DEVELOPMENT PROJECTS

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1. INTRODUCTION

In this brief paper I would like to promote thought and discussion as to whether adequate use is made of the accumulated research findings on agriculture which is scattered around the world in Departments of Agriculture, Research Institutes and similar organisations.

Recently a friend quoted a statement attributed to a pathologist named Krantz in which he said, "The world is littered with vast graveyards of useless scientific data' and my friend added, "and this is a form of pollution".

In one sense I go along with this cynical observation because information which is not disseminated to all who might benefit is wasted. I wish to consider how this information can become more readily available to those who can use it.

Today in the developing world there are innumerable development projects. They all have the prime objective of improving the standard of living of the indigenous farmer and to increase the agricultural output of the country concerned. This objective is one of immediate urgency. Sometimes perhaps the approach to the problem of development is the immediate instigation of a research programme with the assumption that nothing useful is known and that before the farmer can be reached with valid recommendations a full scientific investigation must be under taken. This implies years of work and meanwhile little progress can be made in development as such.

It is suggested here that whereas scientific research work designed specifically for the realisation of the objectives of development will always be an essential requirement in the long-term, much greater attention should be paid to the information available from past research and the spin-off from present on-going research in order to make recommendations which can have an immediate impact in the areas of greatest need.

If this type of information was systematically screened from country and worldwide sources, documented and computerised where possible by an international body such as FAO in such a way as to be available as packages for specific needs, an invaluable service would be performed for those who do not have time to wait for the outcome of protracted

research. It is emphasised that the extrapolation of agricultural practices from one ecological zone or one set of circumstances to similar areas or needs in another place is not a substitute for eventual careful research evaluations but will permit early development with a high probability of success using tried techniques.

2. COMPONENTS OF AGRICULTURE

a. Crops

All of the important food and commodity crops of the world have been investigated in considerable detail at research centres covering all ecological and climatic zones. At least twelve international centres are functioning today to continue this work on a very large scale and are using the most modern methods for the collection of data. Most people here are familiar with some of those centres in particular those dealing with cereals, rice and potatoes to mention only a few. Vast resources of varieties and genetic material are available for many crops for utilisation in newly developing areas and are being disseminated where need arises. One of the most important functions of FAO and such centres is to make this and other material available, but not without discrimination as to known range of adaptation. Highland maize is not suitable for lowland areas and vice versa, the disease complexes are different. Cultural practices are worked out for most and can be recommended for particular circumstances. With careful consideration of local soil and climatic conditions perhaps only slight variations will be required in giving recommendations to farmers with confidence in the newly developing areas.

However, it is likely that in formulating new projects and the setting up of programmes for new research institutes that such questions as rate of seeding, spacing and cultural practices will be investigated from the beginning as a matter of course and yet so much is known which is of direct benefit.

It has often been shown that introduced varieties compare unfavourably under local conditions, that is, with a minimum of inputs, with local cultivars. Full attention should therefore be given in the early phase of programmes to determine the best use of such local material under improved practices. Where they are unsatisfactory or where the limit of utilisation has been reached, a careful introduction of exotic material will have to be made and subjected to a research investigation. If full information concerning the range of adaptability of material is available, as is being suggested should be the case, then the amount of material to be handled can be greatly reduced and useless introductions avoided. Breeding programmes surely should only be undertaken, at least initially, for specific purposes which are not fulfilled by the material at hand, such objectives would clearly concern disease and pest resistance, nutritional value, yield etc. It is of fundamental importance also that this breeding work should be carried out in the areas where the crop is intended to be grown.

Cotton is a useful crop to use as an example since a great deal is known about all aspects of its cultivation. In any new development area where it is proposed to grow cotton it should be possible to specify the manner in which it is to be cultivated and the varieties which are most likely to succeed. The experience available already for both rainfed and irrigated cotton is almost unlimited and well documented. For the past 54 years the Cotton Research Corporation has carried out research in all parts of Africa under all conditions where the crop can be grown and the findings have been published. INEAC and IRAT, the Belgian and French organisations, have done likewise. The vast research facilities of the USA have placed on record similar research findings and continue to do so.

Cotton varieties well tried and proved for all requirements of quality and environmental growth response and other specific requirements are readily available. The Cotton Agronomist charged with responsibility for initiating the development of the crop can utilise all this information and material for early recommendation. Trials on limited numbers of selected types will be necessary to establish those best suited. Under irrigation conditions where water is available all the year round an optimum date of planting has to be established; under rainfed conditions this is largely determined by the rainfall pattern and growing season. Breeding new varieties is not an early priority. This is borne out by experience in the Awash Valley where established commercial varieties have given top yields. Cotton cultivars usually respond to selection for local adaptation and this source of variability should first be considered.

An early requirement in the development of the cotton industry in any country is to establish the requirements of that country in terms of quality and production for local consumption and to consider the needs of prospective buyers if export is ultimately intended. This aspect of healthy and profitable growth of the industry is neglected sometimes and the experience of others should be fully utilised in setting up a Cotton Marketing Board to define the requirements and to guide the breeders and growers.

Similar parallels could be drawn for other crops which have had world-wide attention. I have been informed of an extremely successful campaign for country-wide increase in production of wheat in Pakistan. With international assistance the whole range of information on wheat cultivation and varieties was utilised in a production drive by Government. Concurrently all necessary research was on-going and policy was adapted as new information became available. The end result in a bare three years was a surplus of wheat in the country.

b. Livestock and Forage

The numbers of cattle in the most important cattle-rearing underdeveloped countries are increasing and the ability to feed them decreasing. World prices for meat are nevertheless escalating and the vast majority of the world population does not eat meat at all but has to obtain protein requirements from pulses or other less costly sources. The export of carcasses of meat can be an important source of foreign earnings for many African countries if the animals can be properly fed and marketed.

Quite rightly much research is undertaken in Africa today in up-grading local animals by cross-breeding with exotic species from Europe and elsewhere. We are engaged in such work in our own Institute. It is the view of many animal breeders that this is the only way to make a real impact on improving cattle stocks for milk and meat production. We all know however, that many years must pass before the benefits of such work can reach the peasant farmer and then only a small percentage of them. Such cross-bred animals cannot realise their potential without appropriate improved feeding. The revolution in farms' practices with regard to fodder production to this end is likewise a lengthy business.

The need remains however, for all those engaged in rapid development to make an impact on higher production from animals today and that implies the utilisation of existing experience working with indigenous beasts. It has been demonstrated quite simply many times that meat and milk production of local animals can be appreciably improved with better management. This is being demonstrated very ably at present at Melka Werer and other places on cattle, sheep and goats.

Work of this kind has been continuous in Africa since as early as 1900 and the reports of workers in this field must to a very great extent be gathering dust on library shelves. It seems to me that there is a tremendous waste of effort here if this knowledge cannot be used to shorten the time taken to make an impact upon peasant farmers' production.

The utilisation of native grasses and forage by conservation methods would seem to offer an immediate benefit before more long-term screening of introduced varieties can be effective and in this field again developers and extension workers can draw upon a wide-range of knowledge from East African countries, Australia and South America. A transference of their techniques to suit local conditions would surely promise early success. I am not suggesting that this is not being done but simply drawing attention to another agricultural area where repetitive research may be unnecessary if the available information is brought to the attention of all who need it.

c. Farming Systems and Agricultural Machinery

Under this heading we consider a most important aspect of settlement and development. It is not sufficient to introduce food crops and machinery to newly-settled people or people whose existing way of life patently needs improvement. The increasing awareness of this as a vital area for attention is realised today by the governments of developing countries. It is a socio-agricultural problem and the most important aspect of it is its urgency. Results are needed immediately and not at some distant time in the future. Much excellent work is in progress here in Ethiopia at CADU, Angar Gutin, Gode and WADU at Wallamo Sodo to mention a few; many more are in being or planned.

In this endeavour above all it is necessary to take advantage of what others have done successfully elsewhere. This can be studied and used to advantage for immediate benefit. I call to mind the enourmous success of the Gezira Scheme in the Sudan where farming systems and Government inputs and organisation are well-defined and documented. In Zaire, in the past, many years of careful study went into the structure of villages and farming communities for many ecological zones. This too was recorded and is available. The success and failures that such pioneers encountered can guide present developers.

With regard to machinery use whether it is the modern tractor or improved implements much has been done which is of immediate use on State and peasant farms. Many years of mechanised farming practice are available from Nigeria and other places. There have been many failures and partial successes and these all provide lessons for new schemes.

The amount of research and implementation on improved animal-drawn equipment which has been done in Senegal is well-known. With very little change in technique and design of tools it would seem that their experience is of immediate use in other countries. The specialist in this field will know where to get his information but this does not invalidate a systematic collection of all data that those engaged in this class of work can utilise and to make sure that it reaches them. It is unlikely that one person will be aware of all that has been done, if this is the case then it is possible that a vital piece of information which would provide a short-cut to progress may be missed.

Perhaps the most difficult aspect of applying new farming systems and tillage techniques with specially designed equipment will be to convert farmers from their traditional ways. Even in this area the approach found successful by others may enable more rapid progress to be made if these are known.

d. Soils and Soil Fertility

The disciplines involved here are clearly more basic and that the use of knowledge on soils in general may be of very limited usefulness in development areas. I would be very much interested to know the views of soils people on how the assembled experience of workers in other countries could be of immediate assistance in development. The evaluation of soils on development sites clearly have to be made for particular areas. Perhaps it is in the methods by which this can be rapidly done that much can be learned by past experience.

In the broader aspects of land evaluation the advantages of the new technology of remote-sensing is apparent for world-wide use.

e. Crop Protection

With regard to pests, diseases and weeds each area must be evaluated in terms of its own spectrum of problems. Whereas research work is of obvious necessity in these fields there is a vast accumulation of knowledge which is increasing all the time that enables useful practical approaches to be made to development areas. Cultural practices, times of planting and rotations all have been shown to be important factors in crop protection and this knowledge is of immediate use when making recommendations for development. A simple illustration of a proven practice is that for the control of Pink Bollworm in cotton by the enforcement by Government of a close-season in planting cotton. In most cotton-growing countries where this pest is a problem enforcement is practiced. Unfortunately we do not have similar legislation in Ethiopia although it has been advocated for some years past. In this current season Pink Bollworm has been present in the crop in the Middle Awash due to the late presence in the fields of the previous season's cotton crop. This could have been avoided if the obligatory clearing of the land by a certain date had been law.

The large chemical companies spend considerable sums of money on testing their products and with judicious acceptance of their information crops can be treated according to their recommendations. The relative merits of various products is a matter for research testing and must take time, necessary though it is acknowledged to be.

Much the same story applies to diseases and weed control. Specialists in all these fields need no instruction as to how to obtain information but there would seem to be a case for packaged information to be made available from all sources for the use of those whose duties include crop protection but who are not primarily trained for this purpose.

3. SOURCES OF INFORMATION

These are almost unlimited. In all countries of the world where there are well-established institutes of agricultural research and departments of agriculture the accumulation of research data dates back many years. The research which has been conducted in these places covers every ecological environment and they have, in their archives, experimental results on all aspects of agriculture. Much of this research has been investigated many times.

The universities of the world are rich in basic research which no doubt contains a great deal that could be applied if it were widely known. Too often such work does not get beyond the institute where it was carried out.

This points to a need that all who engage upon agricultural research should do so with a clear desire to see that it is used and made available to the widest possible public. There is a practical usefulness and a personal satisfaction to be gained from this.

In all major fields of work there are specialised journals ready to publish the findings of research workers. The reports and journals of individual institutes are also repositories of much valuable data but these are only of use if publication is speedy. It has always been the endeavour of our own IAR to get research data into print in the Progress Reports at the earliest possible date but I was once associated with an agricultural research division which was many years behind in publishing results and thus rendered them very much less useful.

4. UTILISATION OF INFORMATION

Where proper sources of information are available they will serve two important purposes. In the first instance it will give a solid background to the planning and executinn of rapid development of agricultural schemes, which is the main purpose of this discussion, and in the second it will provide sure guidelines for the choice of non-repetitive research programmes.

I know that dedicated research workers would not be satisfied with anything less than a thorough acquaintance with the work of others so far as they are able to obtain it from their libraries and information contacts. Development and extension workers may not have access to the same facilities nor the time to digest such information if they had. In order for such people to be fully informed there seems to be a need for an information service on which they can draw.

5. DISSEMINATION OF INFORMATION

This brings us to the all important question of the dissemination of information. How is it to be made available in easily assimilated form for the particular worker? What is required for the scientific researcher may be different from the need of the extension services. Information, as everyone knows, is found in journals, reports, abstracting services etc. but it is literally impossible for any one individual to have access to all this information and to screen it even if it were available to him. There is a need for a central organisation which can sift and collate in usable form all knowledge. This is an enormous task and may well be difficult of achievement in the near future.

Considerable progress has already been made for various disciplines to collect and computerise data. To quote just a few examples there is AGRIS an IRAT/FAO project for cereals, vegetable crops and tuber crops. This service will supply full information on cultivars in relation to ecological adaptability. There is INFIC the International Network of Feed Information Centres which has computerised data on livestock feeds. There is an interesting development from Beltsville, Maryland, USA which was brought to my notice, where taxonomists and agronomists have collaborated on the production of a Crop Diversification Matrix. This deals with a 1000 species and has a computerised data retrieval system for giving the biological parameters for field operations for these species. An international centre (IBGR) is making available information on genetic resources for crop species. A further centre (IIIC), the International Irrigation Information Centre is coming into being in Israel for making available knowledge of irrigation techniques for arid land farmers. Many other large organisations are collecting their information in similar ways. However, there would seem to be a need for a co-ordinating body to draw together much of these sources of information for the use of development workers.

The FAO Current Agricultural Research Information System (CARIS) seems to come closest to this need and aims at a closer awareness between scientists of work in hand. It is intended to set up CARIS Regional Offices in all Member-States to facilitate liaison between the CARIS Coordinating Centre, at FAO, Rome, and the research workers or institutions.

It is suggested that perhaps for the future only an international organisation such as FAO could begin to tackle a task of such magnitude. The FAO Documentation Centre is available to supply on microfisch copies of requested literature or to supply literature covering aspects which may be specified.

However, ideally what is being asked for is the facility which will enable the field worker to pose a set of questions relevent to his terms of reference and the organisation supplying the service to be able to supply a set of relevent answers which are distillations of known research. This may, in its simplest form be a list of varieties for a particular crop which it would be profitable to test under a given set of conditions or a set of parallel experiences applicable for a development project which would repay study before finalising a development programme.

Information of this kind could be made available as a package for a particular need. It would enable the correct priorities to be placed on investigation in those areas where the least was known.

6. CONCLUSIONS

Most people will rightly say that the subject of this paper is selfevident. It is not intended as a criticism of research work; the need for such work is continuous, problems generate problems. However the attention of the world and the developing world in particular is centred on a vital urgency to help those in greatest need and in this area agriculture is a number one priority. One of the fundamental ways in which to achieve this is in the correct use and availability of information.

Everyone here who is concerned with research in agriculture has a clear duty in his objectives; he has to ask himself continuously whether what he has learned in his work can be utilised and if so how can it be transimitted to those who can reach the farmer. Unless a positive answer to this question can be found then the work is a waste of time.

FAO was originally conceived as an organisation which should supply information on agricultural development for the betterment of all peoples of the world. This objective should still be paramount. The means by which this can be achieved have only been touched upon. It is outside my competance to draw up a blueprint for future action but I believe that the time has come to take stock of what we already have and what is daily being acquired to make the best and most profitable use of it.

DISCUSSION

The Chairman thanked Mr. Saunders for his interesting and enlightening paper on a subject which is often taken for granted. The Chairman commented that investigating what research results already exist is not a waste of time and should be undertaken more often. We should also do this as the spring board for what to do next. It is often forgotten that what somebody has started should not be left in dark corners or on dusty shelves. It is an investment just like money in the bank which we should exploit for the betterment of Ethiopia in particular at this time. He then opened the floor for comments and questions.

It was commented that the paper had covered where research findings are available, but the speaker had not really cautioned us sufficiently about the implications for environmental conditions. He said that even in European countries there is a lack of institutional framework to accomodate inputs such as fertilizers and other chemicals which may be harmful for the environment. Should we postponed such questions in order to deal with the present crisis.

Mr. Saunders replied that the real purpose of the paper had been to illustrate the feeling that we do not make adequate use of existing research results for development programmes, i.e. for increasing the production of the peasant farmers. What you have said is very important and when I first wrote this paper, I did touch upon the use of insecticides in the section on Entomology. However, I was entering an area where I am not an expert and therefore I probably could make some misleading statement. However, you are quite right to raise this problem. Work has been carried out particularly in the United States on the damaging effect of chemicals on the environment. We must caution all our workers who use these kinds of chemical to be aware of the damaging effects that have been seen in areas where unlimited quantities have been used.

The comment was made that on many research stations Annual Reports are produced which are only useful for research workers and there are many types of reports and technical papers produced by the Institute of Agricultural Research and others which again are only really of any use for technical personnel. The problem that concerned the questioner was how these research findings can get to the farmers where they are needed. He felt that even at the institutional level there was no system for monitoring the materials in these reports and investigating the technology and other improvements suggested. He felt that we should now take policy steps in order to make this information generally available otherwise these reports will remain unused for a very long time.

Mr. Saunders replied that he had not got much comment to make, This was a statement of fact and he could not add much to it. The Chairman also felt that there is a need for a better communication system may be in a form of agricultural journal. The Chairman asked the questioner to expand on his theme.

The questioner replied that he was not referring to an agricultural journal in particular, what he wanted to see is a communications system particularly for extension workers so that materials could more easily be passed directly to the farmers, in a way they would understand. We have to know what information is coming in so that the extensioners, the development agencies and the farmers can also be aware of what information is available. Perhaps we have to start through an international organization. The concept is that we should be both linked to an international organization and other development agencies and also to the farmers. Information can go in and go out and be used. At the moment there is no such organization.

Another participant commented that most of the publications are produced in languages farmers can not understand and use. He wondered why we did not produce more materials in Amharic, Orominga or other indigenous languages. He was not denying that the value of the publication did not depend on the language in which it is written. But he felt that Ethiopia should try and produce more material in languages that the farmers can read.

Another speaker from the floor commented that we should be cautious in taking the results from work in other parts of the world. Environmental conditions are so variable that it is often difficult to directly apply the results from one region to another, even within the same country. He felt that we should have access to information on results but we should then carry out observations before making recommendations to development agencies and other end users.

Mr. Saunders replied that the point was well taken. However, he was pointing out in his paper that if we had accumulated all the results available for a particular crop or situation then we could save ourselves a lot of time. He never implied that we should not do research or that research was invalid, but such an investigation on existing research results might cut out useless investigations and give better guidance on where we can begin our research and therefore get quicker results. Even now in project developments all over the country, these are going on without prior research. People are being settled, land is being developed and surely this could be done more efficiently, if all the information on similar areas and the crops which are envisaged to be used was available to the people implementing the projects. It is simply coming up with the information from the other areas in order

to enable speedy development to take place. This does not take the place of research, research still has to fulfill its obligation of filling the gaps in this knowledge as the problems are identified. Returning to the preceeding questioner, Mr. Saunders commented that the Institute had already got some 20 publications produced in Amharic and others were in the pipe line.

Another participant commented that the papers in the mornings session and this paper has indicated that we should leave research and concentrate more on extension. The commentator felt that there is still a need for reasearch work, perhaps there is a missing link between research and extension.

Mr. Saunders replied that he hoped that he had made if fairly clear that he was not attacking research but only making a plea that all the work done by the competent research workers in various countries should not be lost in the archives of the various institutes where they have worked and are working. In fact, this is much bigger job than any one organization within a country can undertake. This needs to be done at an international level, where all results are kept together and critically examined and the backbones of them picked out and made available for early development. Not at any time would he suggest that research work should stop or that the research people are not useful. This is a misconception entirely. But many people like yourselves who have done research work over many years, have not always had your work fully appreciated and it has not always reached the audience that it should have done. He was calling for a rescue of this work both past and present and a use made of it immediately for development projects.

The next participant wanted to make a proposal. We have a very large number of development organizations, agencies and institutes working in the country and which produce a large range of publications between them. If the publications section of the Institute could just collect all the titles which are published in different forms and put out a list every half year so that we, the research workers and others, can see where there are titles that interest us. We could then write to these organizations requesting for their publications. This would greatly assist both research and development in the country. Mr. Saunders replied that he felt that this would be part of the project called CARIS, which was likely to set up the liaison office in this country. Then it would be possible to collect titles of research publications and pass it around for others to see. The publications section in the Institute is very new and has hardly got off the ground, and hardly got organized, but he felt that this would be one of its functions.

Point of information. Shortly after the seminar Ethiopia signed the agreement to become part of the CARIS project and the CARIS liaison office for the country was located in the Institute of Agricultural Research.

RURAL DEVELOPMENT THROUGH SORADEP (SOUTHERN REGION AGRICULTURAL DEVELOPMENT PROJECT)

By

Mr. A. Borderon
(General Manager of SORADEP)

It is a pleasure to have this opportunity to present the major principles which were adopted by the Southern Region Agricultural Development Project in helping in the betterment of the conditions for the small farmers in the project area.

The following paper places more emphasis on the relationships between the research and extension programmes and on the contents of the research programmes than on the methodology in extension.

Awassa Farm - A Regional Pole for Development

Right from the outset SORADEP was based on research programmes which had their emphasis on practical rather than fundamental research. Programmes were oriented to the major crops grown in the area surrounding Awassa with special attention being paid to maize and red pepper. The immediate target was to define clearly:

- adaptation of varieties to the area;
- proper cultural practices; and
- a seed multiplication programme.

It is well understood that these were not the only tasks that the Awassa Research Station carried out; but they were the most important ones.

Fortunately the research station was part of a wider organisation--the Awassa Agro-Industrial Share Company. This was fortunate because the results from trials at the research station could be tested on a large scale at the Awassa Farm before being extended to small holders' fields. The risks entailed in testing the results from research are much more easily carried by a large unit such as the 4,000 hectare farm than on the one to three hectares of a small farmer.

It was not until the yield of maize had reached at least 60 quintals a hectare on the Awassa Farm that it was thought safe to use the results as a basis for a regional agricultural project.

Maize improvement - the priority

Following are the reasons why maize improvement was chosen to be the first target for SORADEP. These reasons are not intended as comparisons or critisms of other extension systems such as model farmers minimum package programmes or very intensive and comprehensive programmes with the mass action on which the programme of SORADEP was based. However, for those who know something about agricultural development schemes in Ethiopia, SORADEP appears to have some rather original features.

Briefly the following are the main principles which led to the action taken by SORADEP.

First Principle: the improvements must be appropriate to all farmers in the area concerned.

Maize is grown by almost all farmers in the project area as both a food crop and as a cash crop. All farmers were thus interested in producing more maize and thus improving maize production would fulfill this first principle.

Second Principle: the improvements must attract most of the people quickly with a significant economic return.

This principle is closely related to the first and it implies that diversification of crop production is kept as a second priority. In concentrating on one crop all efforts can be directed to the extension of a package of improvement for that crop which also makes it easier to train both extension workers and farmers properly.

Third Principle: the improved techniques should not be sophisticated.

For example, row planting of maize has been found to be one of the factors for increasing yield. This technique has been found easy to apply using the local 'maresha' plough.

The target was to increase total maize production in the area by 15,000 tons within four years; this would be an increase of 25% in the total production of the farmers in the area.

The Integration of Research and Development

Travelling throughout the 7,000 square kilometres of SORADEP quickly reveals that the area is heterogeneous. Soils include volcanic pumices, dark loams, grey clays and red sandy loams; there is one month's more rainfall in the south than in the north; altitudes range from 1,500 metres to over 2,000. This heterogeneity gives a wide range in the ecology of the area. An initial survey has defined eight ecological areas within SORADEP. Thus it was not possible to apply the fourth principle---that of homogeneity---to the regional development programmes.

Thus one of the early decisions taken by SORADEP was to establish multilocational experimental fields in as many of the ecological areas as possible within the given budget and supervision capacity.

This situation then raised a question about the suitability and use of the Awassa Research Station. Would it not have been better to spend the budget on demonstration fields in order to reinforce the extension activities?

Although the Awassa Research Station provides data which only fits the immediate surrounding area of Awassa, it has been found that this data averages out for the whole SORADEP region In fact 70% or more of the work is suitable everywhere and thus the work of the station is far from useless. However it has also to be remembered that this data has to be refined for the different areas.

It was also generally agreed that there was no better demonstration site than a farmer's field where the farmer himself applied the advice of the extension agent to the best of his ability.

For these reasons the research station was kept and built up and its activities were progressively extended first to three experimental fields in 1971 and to five in 1972 which are located in different ecological areas within the SORADEP project area.

SORADEP and the Awassa Research Station maintain a close relationship by:

- combining to discuss the annual research programme;
- SORADEP carrying out in the field the decisions taken using the lay-outs prepared by the station;
- the station collecting the rough data from SORADEP, analysing it and giving the interpretation of the results to SORADEP.

The Institute of Agricultural Research has also shown confidence in the ability of the experimental department of SORADEP by sending international, national and pre-national trials to be carried out on the experimental fields as well as at the research station. Thus the data collected from the experimental fields have been added to that for the nation as a whole.

Peasant Extension Workers Trained by the Project

The fifth principle adopted by SORADEP was that "in order to reach a large number of people quickly with improved techniques, the extension network must be very dense".

This is very easy to say but not so easy to manage, particularly finding the many extensioners needed and the cost involved. By 1975 the Extension Personnel in SORADEP was made up as follows:

Ambo or Jimma or equivalent graduates	3
Awassa Training Centre Graduates	11
6th - 7th grade students	101

This balance in the extension personnel is most probably the main feature which makes SORADEP different from other projects, particularly the number of sixth to seventh grade workers. These workers are called Instructors. They are selected and recruited from amongst the people for whom they will become extension workers. Thus they know the local people well and speak the local language. The use of these people enabled a very strong relationship to be built up between the farmers of more or less formal villages and the Project. This strong relationship is holding true for the newly formed Farmers' Associations However some other conditions also had to be fulfilled in order that the extension workers could be efficient in their work. These conditions relate to training and work organisation. However, it is not the intension of this paper to go into details on these points.

Overall Adherance to Simple Cheap Techniques

As a result of adhering to simple cheap techniques (the third principle) SORADEP has far surpassed its target for maize production. In the 1974 season the increase in production was 33,000 tons and for 1975 it is expected to be around 45,000 tons. These figures are based on production in 1970. (The target for 1974 was an increase of 15,000 tons)

From the initial 10 quintals a hectare, yields had been raised, depending on techniques, to:

17.57 q/ha for seeds of fourth generation produced by the farmers.
32.27 q/ha for selected seeds sown in rows at the recommended planting date and given proper weed control;
43.92 q/ha for the same as above plus fertilizer.

The above figures are based on crop samples from 1974.

It is thus not surprising that the response of the farmers was impressively large as can be seen by the number of farmers participating in the project.

1971	- 1,600 farmers covering	1,200 hectares
1972	- 6,000 " "	6,300 "
1973	- 13,000 " "	11,600 "
1974	- 18,000 " "	14,265 "
1975	- Farmers' Associations covering	26,521 "

It is felt that these figures indicate that the farmers are fully confident of the SORADEP system. But in the near future there are some doubts that SORADEP will be able to fulfill its requirements and that it may become inundated with unsatisfied requests.

There are also other points now worrying SORADEP. The chief of these is being able to maintain the potential of the natural resources in the region and at the same time produce more under advantageous conditions for the farmers.

Emergency Needs - Seed Production and Crop Processing

A Feasability Study for SORADEP Phase II has estimated that by 1979 the seed requirement for the farmers will have increased to 14,000 quintals of selected seed while the farmers will be keeping 4,250 quintals from their own grain production.

It is now being asked if there is anything prepared to meet this seed demand in Awassa which will be ready in time. Perhaps this is the direction that the Awassa Farm should take, i.e. to become a seed production centre for the region.

The same Feasability study also assumes that, if everything proceeds according to plan, the total increase in maize production could probably reach 157,200 tons by 1979 (total production at that time being 223,000 tons). If this production level is reached serious consideration should be given now to the possibilities for the farmers to sell their crop. One possibility would be to set up a processing unit at Awassa.

For several years SORADEP has been suggesting that the overall regional development organisation should include:

research	- it exists
seed production	- it exists but works unsatisfactorily
extension	- it exists
processing	- still pending

New Packages and Test Farms

For the time being it would be possible to continue using the known techniques to keep up the level of production per unit area and to increase the total production while reaching more and more farmers with improved techniques. But it must be said at the same time that all the area covered by SORADEP suffers from over population, fragile soils and overgrazing with large herds. Thus SORADEP should not continue in the same easy way that has so far established itself. If this is done the soil will easily become over exploited and this could lead to a disaster in the region within less than fifteen years. Already decreasing fertility has been observed in many of the soils in the SORADEP area.

Thus SORADEP has been making plans and taking the next steps to improve the farmer's technology and conditions. The most important consideration is to find a solution which will at least maintain the soil fertility. It has been considered that it is technically possible to integrate cattle husbandry and crop production in one single system which will still be totally manageable by the farmers.

In order to study this integrated farming system, it is intended to establish Test Farms. These Test Farms must be representative of the other farms in the area in all respects, e.g. family size, land available, distance from a water source and from market places, etc.

The target of this programme is to find the possibilities available to the farmer to:

- integrate cattle husbandry with food and fodder crops',
- introduce fodder crops into the cropping system;
- make maximum use of animal manure.

This programme will also be designed to define the progression for extension innovations to farmers in the form of package programmes. The programme will need to find out how to grow fodder crops in association with other crops; how to use to the maximum the by-products of cattle husbandry, particularly manure which has so much value but at the moment is spoiled or wasted by so many farmers.

The programme will also need to define the systems which fit both economically and physically into the local situation. Finally, and most important of all, the findings from the Test Farms will enable progressive extension packages to be defined which will enable improvements to be introduced at each farm level.

Conclusion

Extension should never exist without proper research. But research people must not lead extension activities into wasting natural resources, especially the soil. However the first aim of research should be to give an immediate answer to the problem of rapid production increase. The second aim should be to solve the problem of maintaining the potentials of rural areas by diversifying the means of production and evolving systems that fit within the ecological and sociological conditions of the area for which they are intended. It must never be forgotten that research must be oriented to the promotion of the farmers welfare. This must decrease their difficulties and must not change them into the slaves of technology.

DISCUSSION

The Chairman thanked Mr. Borderon for his presentation which had been given from his heart. He felt that if more people approached their work in this fashion there would be more to give to our farmers.

The most pertinent question and picture that had come out from the papers that has been presented so far was the linkage between research and extension. It was felt that there was a great deal to be learnt from the SORADEP experience. It was not necessary to look outside the country to find a proper linckage between research and development which was down to earth and working for and with the farmers. It can not be denied that a lot of research has been going on for a considerable time, but there has not been a good linkage between research and extension. Eventhough most research stations have some connections with extension, the linkage leaves a lot to be desired. It is often said by the people in extension organisations that the problem is with research; and the people in research say that the problem is in extension. We have to come down to earth and attack the problem at the weakest point. Perhaps it would be appropriate for the body, met together at the Seminar, to put more pressure on the Government to bring research and extension under one wing. If this could be done as it has already been done at SORADEP then we could render far more service to the farmers. The General Manager of the Institute replied that he felt this point should be left to the closing part of the meeting which was going to be devoted to general discussion, where this point could be put as a resolution from the meeting.

Mr. Borderon was asked what the relationship was between SORADEP and Institute of Agricultural Research. Mr. Borderon replied that it was a long story but he would try and cut it short. SORADEP was set up under the Ministry of National Community Development and thus was somewhat apart from the Ministry of Agriculture. Now this problem has been solved as SORADEP has been put under EPID. Previously inorder

to get in touch with the Ministry of Agriculture he had gone around and seen people; at the same time he had been in need of things such as publicity for SORADEP. Thus SORADEP got the opportunity to grow national and international types of trials. This did not cost money from the project; only provided more information for the Institute. As for the future, he thought and felt that a dicision was needed for the Awassa Experimental Station to be made into a Regional Station. Taking into consideration all the multi-locational experimental plots we feel we will be able to provide much information in collaboration with the Institute of Agricultural Research. However at the moment SORADEP does not have direct links with the IAR. The SORADEP project is well known at the Planning Commission. Infact many of the other regional development projects are now copying some of the features of SORADEP which made it unique. In our opinion not least is its extension approach through groups which now fits with the present philosophy. instead of the model farmer approach, which is used by other comprehensive projects. This is a distinctive feature of SORADEP. The second unique feature is its training of extension people. Mr. Borderon felt that it was high time that we now thought in terms of people themselves trying to solve their own problems. This brought him to his main point on how to meet the manpower requirement for settlement projects. At the moment we are looking at this problem in a very conventional way. That is sending people to training schools and giving them some kind of certificate at the end; and then taking them back to the project. He felt that this was still necessary to some extent but the general line of thought is that the people who are going to work at a local level should be given their training at that level. This is exactly what SORADEP is doing in training extension people. They select from the local people, they train them in their own language and send them back to work within their own locality. This approach could well be used in other comprehensive projects both present and future. Another unique quality of SORADEP was its linkage with Awassa State Farm and the Experimental Station. This gave the region a packet of services. This approach could well be applicable in other regions of the country.

A participant made one comment on the development of SORADEP. Inorder to bring about this development they had to use the manpower that was available even if they are only six-grade complete. It is well realized that a sixth grader does not have the background of somebody who has completed his education, but if we take such people and we train them and they are also trained by the farmers then in four to five years they make very valuable extension workers. If we were to wait for all the technical inputs and manpower requirements to be fulfilled we would not carry out any development. We have to work with what is available and this is what SORADEP had done and proved that it can be successful.

The question was, what was the ratio of extensioners to the farmers? Mr. Borderon replied that this ratio varied from one area to another. There is an individual contact system i.e. the extensioners contact individual farmers either in the field or in advising them. The maximum ratio should be one instructor for 200 - 250 farmers. In the SORADEP area this is also qualified by the density of the population. If the density is great then the ratio could be higher, and vice versa. However, since the change that has been brought about by the Land Reform Proclamation, where Farmers' Associations have been formed, we estimate that we could follow many more farmers than was possible previously. There is no reason why one instructor could not follow four peasant associations say covering 400 - 600 farmers. What we intend to do is to give more responsibility to the farmers. This is only possible when they are formed into groups, in their own localities with their own leaders. Then it is possible to reach the farmers through their own organization with only the use of technical supporting staff and even without the use of extensioners.

One final question was allowed in which it was asked, if the experience of SORADEP which covered only 10,000 hectares could be duplicated in other parts of the country. Mr. Borderon felt that a scheme similar to SORADEP could easily be developed in many other parts of Ethiopia. For example an area close to Awassa, the Arba Minch area, was ready to be develpped in a similar fashion. There is a state farm at Arba Minch, around this farm there are many more peasants. The main difficulty would be that the altitude in the Arba Minch area varies greatly, but this a mere technical difficulty which is rellatively easy to solve; it just takes time. In a unit such as SORADEP, the Project Manager and the Head of the Extension staff can reach the remotest area in a maximum period of 2-hours under certain conditions. This is one of the criteria that enables SORADEP to work. If a larger area than that is envisaged then it is very difficult to implement proper control through-out the area. Even though this type of scheme demands a small number of intermediate instructors, in SORADEP we have only 13 - 15, the real bottleneck is the local extension worker. However, in SORADEP we have found that we can solve these problems by training people from the localities. Also, we are not asking either the instructors or the extension workers to introduce very sophisticated techniques. The training could be done within each project to fit the local needs. This type of project has been tried in the highlands of Madagascar, Upper Volta and Senegal as far as Mr. Borderon was aware and there may have been others. There are also similar projects in Western Africa which have shown similar success.

AN EVALUATION SURVEY OF RURAL SETTLEMENT SCHEMES IN ETHIOPIA 1975 - 1976

By

C.E. van Santen, Agricultural Economist

RRC/UNDP/FAO: Assistance to Settlement Project

This paper reports on a national evaluation survey of rural settlement schemes, presently undertaken by the RRC/UNDP/FAO Assistance to Settlement Project.

The paper is introduced by a discussion of some general issues related to rural settlement and their role in the development process.

The paper is concluded with a brief outline of the methodology adopted for the survey and the progress to date.

I. INTRODUCTION

1.1 Rural Settlement Schemes existing to date in Ethiopia

To date, there are reported over sixty rural settlement schemes in Ethiopia. These schemes are in various stages of development. Some have been in the implementing stage for over ten years while others have been recently created or are still in the planning stage.

At least ten different Government Agencies and eleven private organisations are involved.[1] At present it is known that over nine thousand settlers, in some forty-four projects have already been allocated a plot or a share in a communal plot, while plans exist to settle some thirty thousand settlers in existing or newly planned schemes. In addition the new 'National Land Settlement Authority,' whose proclamation is expected soon, plans for an annual settlement rate of between five--and ten--thousand settler families.

1) Government Agencies include: MNCD, MOA, IAR, AVA, WADU, CADU, MLRA, LMB, MOI & RRC. Private Agencies include: UFFRO, RA, SIM, SD, ECMY, APM, LM, UNHCR, and at least 3 local groups.

1.2 Settlement Schemes and Rural Development

The contribution which settlement schemes can make to rural development is, at present, widely accepted.

It can be noted that basically all aspects relevant to achieve integrated rural development apply also to the establishment of rural settlement schemes. Planning for both general rural development programmes and settlement schemes include the introduction of improved methods of agricultural production, the introduction of small scale rural processing industries, improved social and technical infrastructure and new forms of socio-economic organisation of the rural population, whereby ideally this population is increasingly involved in the management of the new developments in their communities.

The question then arises, as to why there is a special need for the creation of settlement schemes, which are considered to be expensive tools for development when compared with regular rural development programmes whereby no migration of rural population is foreseen.

There can however be indicated a number of situations, in which only the more concentrated approach for development, inherent to settlement schemes, is expected to achieve rural development.

These situations can be listed as follows:

A. When the need exists to settle or resettle certain groups of the rural population. These may include:

1. Pastoralists, nomadic or semi-nomadic, when they are affected by drought and have lost most of their livestock;
2. Farmers from overcrowded zones, in Ethiopia particularly from some of the highlands;
3. Landless and former evicted tenants;
4. Some groups of semi-urban unemployed, school leavers etc.
5. Rehabilitated invalids, e.g. former lepers;
6. Certain groups of refugees.

B. The presence of zones with a great potential for rural and agricultural development, but which are presently under populated because of certain physical constraints, which can only be overcome by a concentrated effort and which in many cases points to the need of establishing settlement schemes.

Included are:

1. Zones with a heavy tsetse and malaria infection;
2. Zones with a sub marginal rainfall, but with an irrigation potential (the availability of water through wells or rivers);
3. Zones with a low accessibility through the absence of road systems.

However, in view of the high costs involved, a resettlement approach appears justified and should be confined to those settlement schemes from which it can be expected that they will achieve, within a reasonable time, viable communities and which are thereafter able to sustain themselves with a minimum of outside assistance. The relative high inputs, inherent to the settlement approach, become more justified when settlement schemes are able to act as centres of development for the surrounding areas, whereby new technologies are tested in these schemes and through demonstration in these centres the diffusion of innovation processes is accelerated in the neighbouring zones of these settlement projects.

1.3 Types of Settlement Schemes

A preliminary investigation indicates that there exist a wide range of types of settlement schemes in Ethiopia. One could ask if it is possible to define them under one conept. And to some it may be even difficult to see them as one coherent group.

Among their objectives they may include a wide variety of purposes from; emergency food production schemes for the relief of famine; resettlement of highlanders from over-crowded areas; settlement of rehabilitated lepers; opening up of tsetse fly infected areas; solution of political problems, to schemes aiming at integrated development, just to name a few.

To illustrate this point, Chambers in his study: "Settlement Schemes in Tropical Africa" presents a number of difinitions of settlement schemes, which basically appear all relevant.

Time does not allow us here to go deeper into this matter. But with Chambers, we agree that the following aspects are relevant to all types of settlement:

- The movement or migration of population;
- Elements of planning and control by a 'Change agent' (= the settlement agency);
- Incorporated in the objectives, the aims to raise the standard of living of the settlers.

In this context a settler may be defined as a person who participates in a settlement scheme by occupying a plot or holding a share in a communal plot in his own right.

Types of settlement can be determined from various angles:

- By origin of settlers:	highland farmers, pastoralists, invalids, unemployed and from different geographic regions:
- By location of reception:	Rainfed or irrigated areas, areas formerly farmed by large holders; or regions unused or underused due to physical constraints. Zones with good or poor accessibility.
- By objectives:	Technical (agronomic), socio-economic or political.
- By responsible agency:	Government or Private Agency
- By nature of inputs:	High, medium or low level, e.g. ranging from the supply of only land and food in the initial period before the first harvest and some basic inputs, to a high level of inputs, including cleared land, housing, sophisticated agricultural inputs on credit; marketing facilities and a social infrastructure including health care, education, road system, etc.

1.4 Human and Technical Factors

Development through settlement involves a wide spectrum of human and technical issues, which often are to a great degree intermingled.

The human or social factors concern:

1. The push effect contains the negative factors at the point of origin of the settlers: Why do people want to leave? The anti-push factors are those which influence people to stay in their original residence.

   The pull effect contains the attractions of the new location: Why do people want to move to the new location? the anti-pull effect relates to the factors why people do not want to move to a new place.
2. Related to these points are the effects of the diffusion of innovation processes, which includes the issues involved which regulate the adoption or rejection of new techniques and practices.
3. A third point includes the formation of new communities in settlement schemes, It concerns the ability of the settlers to work together under unfamiliar circumstances, with new practices and above all with others who may have different cultural and technical backgrounds. Furthermore the newly formed community must build up a rapidly increasing capability for taking an active role in the decision making process and the management of the new community leaders.

The technical factors involved include physical, agronomic and economic issues:

- soils, climate (rainfall, temperature, sunshine etc.) topography, vegetation.
- physical constraints: tsetse and malaria infestation, sub marginal rainfall, in-accessibility.
- Population density, traditional and potential economic activities, farming systems.
- Infra structure: health care, watersupply, education, supply agricultural inputs, credit and marketing, communications, roads etc, public administration.

This list is far from complete and it only indicates some of the most relevant factors.

1.5 New Developments: The Impact of the "Land Reform Law"

To the above discussed wide variety of issues, which are involved in the settlement scheme approach, new developments can be added, which are resulting from the implementation of Proclamation No.31 of 1975: the Public Ownership of Rural Lands Proclamation, or the 'Land Reform Law'.

Three basic matters are related to settlement schemes:

- Redistribution of lands
- Formation of Farmers' Associations (Gebere Mahabir) and rural cooperatives
- The introduction of collective farming

Redistribution stems, in some cases, from settlers who were formerly evicted tenants, who wish to return to the lands formerly occupied by them (CADU), in other cases they hope to enlarge their plots through the law (MNCD and SIM projects). But the most important result from the redistribution of lands is the creation of a number of settlement schemes on nationalised large scale farms, (CADU & WADU). Hereby opportunities are created for rural population which were not available before.

The formation of Farmers' Associations can be observed in practically all settlement schemes in existence. In some cases settlers join a neighbouring association, in others they have formed their own. But in all cases it appears that an organisational structure is rapidly built up, which enables the settlers to participate and eventually manage and direct the developments in their own farm communities.

The introduction of collective farming is a common feature to practically all new settlement schemes, created since the proclamation of the 'Land Reform Law'. Hereby settlers work together on the common fields, under guidance of their self selected leaders.

In all settlements schemes created before the Land Reform, collective farming has been discussed and is anticipated to be undertaken for the next crop season.

In some cases it is suggested to pool all lands; in others, settlers will dedicate part of their time to the collective farm plot of their community and use the balance of their time on the home-stead plot.

These developments are very recent, making it difficult at this point to assess fully their value, but it is clear that the implementation of 'The Public Ownership of Rural Lands Proclamation' or 'Land Reform Law' is already having a very important impact on rural life and the development of settlement schemes.

1.6 The need for assessment of the existing experience with settlement in Ethiopia

In 1970, when discussing the role of settlement schemes in integrated rural development in Ethiopia, Weizmann indicated the need of the settlement planner as follows:

> "Information on the existing settlements should be systematically collected and evaluated; the factors deterring or stimulating their growth identified; and subsequently, guidelines for larger programmes should be laid down by using, above all, the findings of practical experience now being accumulated in Ethiopia". (From an ILO report to the Government of Ethiopia on Integrated Rural Development, Geneva 1970).

Since then, and maybe before, many authors have indicated the need to evaluate the existing experience. Here only one other case is mentioned, as it is particularly related to the present national evaluation survey of existing settlement schemes in Ethiopia.

In a report of a Survey and Project Preparation Mission of the Relief and Rehabilitation Commission,--November 1974, one of the recommendations pursues this point:

> "A review of existing settlement schemes is needed in order to ascertain the real costs per settler; the relative merits of individual versus communal or co-operative farming (if any); and other factors, so that the best use can be made of areas selected under (1) above."
>
> (N.B. the report discusses in a foregoing recommendation the need to pinpoint areas which are suitable for intensive settlement under full control, as uncontrolled haphazard development of new areas on a no-cost voluntary basis should be discouraged.)

The point is further supported by the fact that in a loan agreement between the Government of Ethiopia and the International Development Association (The IDA of the World Bank Group) in June 1974 for Drought Rehabilitation, funds were set aside for surveys and technical data collection on settlement and related subjects.

Therefore the conclusion can be drawn that the need exists to systematically collect and evaluate the information on the existing rural settlement schemes, to identify the factors deterring or stimulating their growth and to use this knowledge for planning new settlement schemes.

1.7 The present situation of data on Settlement Efforts

A preliminary study of the available documents on settlement in Ethiopia, covering some 120 titles and including the references available with Government and Private Organisation revealed, however, that, to date, little information has been systematically gathered on the subject and no attempt has been made to collate this experience on the national level.

Some existing documents on settlement in Ethiopia are dealing with discussions on land settlement policies in Ethiopia. They are desk studies whose value is often mainly historical in light of the recent developments. Other documents study a specific aspect of settlements or are related to the description of a particular p project or groups of projects. Again others deal with plans for the creation or development of specific settlement schemes.

Of all the documents referred to, only three pertain to evaluating a specific settlement scheme, of which one is related to the WADU projects and two to the AVA projects.

However among the long lists of documents on settlement, one has to be mentioned, which offers a first and courageous attempt to assist the settlement planner. It is "A Preliminary Survey of Settlements in Ethiopia--"by Gail S. Simpson prepared for IDR in 1975 and as far as I know, available only recently. This report contains an extensive description of some 20 settlement projects presently in operation in Ethiopia and offers in the concluding remarks a brief evaluation of factors which determine success and failure of settlement projects.

1.8 The Evaluation Survey of Rural Settlement Scheme in Ethiopia

Assessing the previous dicussions and concluding that planning and implementing new settlement schemes can only be carried out rationally if the experience gained to date is incorporated it has been decided to entrust the evaluation survey of rural settlement schemes in Ethiopia to the RRC/UNDP/FAO," "Assistance to Settlement" Project.

This project has the objectives "to assist the Government of Ethiopia in building up a national settlement organisation, capable of initiating, planning and implementing settlement projects" and which in the short run is "to assist the Government to site, plan in detail and initially manage agricultural settlement schemes.." and can therefore be considered as a suitable body for carrying out the study.

The project is furthermore located in the Relief and Rehabilitation Commission, an organisation which supports and participates in the implementation of settlement schemes. Also the strong ties of the project with the Interministerial Working Group on Land Settlement has to be mentioned. This latter group is preparing the way for the National Land Settlement Authority, which is expected to be proclaimed soon.

The basic objective of the Evaluation Survey of Rural Settlement Schemes in Ethiopia is to provide a catalogue of the experience obtained to date with such schemes.

The results of the study are intended to assist with the planning of new settlement schemes and the coordination of the developments in already existing schemes.

1.9 A Proposal for a Pilot Settlement Project - Lower Didessa Valley - Wollega Region

In this paragraph an illustration is provided on how the preparation of a proposal for a settlement scheme can be assisted by utilizing the experiences from already existing projects.

The proposal for the Lower Didessa Valley - Pilot Settlement Project has been prepared by the "Assistance to Settlement Project". In preparing the project proposal members of this project systematically investigated (and simultaneously pretested the questionnaires for the settlement survey) four existing settlement projects in and around Wollega Region:

Dimtu Project (ECMY), Anger Gutin (SD), Ano Gambela (ECMY) and Tolle (MNCD).

Some of the main issues on which information is obtained from these settlements are the following:

- Pattern of settlement, including location of houses, size of plots.
- Farming systems, including recommended crops, rotations, and management practices.
- Tsetse control
- Oxen ploughing
- Soil conservation
- Afforestation
- Building construction

Though the Lower Didessa Project is not to be considered as an imitation, numerous experiences of these four projects are included in the design of the new project.

II. METHODOLOGY AND PROGRESS OF THE EVALUATION SURVEY OF SETTLEMENTS November 1975

The study aims at measuring the ratio between inputs by settlers and settlement agencies and the returns obtained by settlers and the community and it will also investigate the social and organisational factors involved in the settlement schemes.

To this purpose the study includes:

- A study of existing documents on settlement in Ethiopia
- Interviews with all agencies involved in settlement, in particular with the management of settlement schemes, if existing.
- Interviews in selected schemes already in operation with a random sample of individual settlers.

The progress to date is the following:

- The study was started in May 1975. A work plan has been prepared and agreed upon by the concerned agencies, including the RRC/UNDP, the Interministerial Working Group on Land Settlement and the World Bank Group.
  A preliminary study of existing documents available with Government and private agencies, has resulted in a tentative bibliography of 120 titles and a provisional list of settlement projects, which to date includes 66 settlement schemes. Questionnaires for settlement agencies & management and for individual settlers have been prepared and pretested. Initial contact with all agencies and organisations involved in settlement in Ethiopia have been established and preliminary visits to some ten projects have been made.

  Recently funds have been allocated for the field work and processing of the data by the Ethiopian Government from funds of the loan agreement between the Government and the IDA of the World Bank Group for Drought Rehabilitation Loan - June 1974 and from the UNDP. Most of the senior staff is available and arrangements for enumerators have initiated.

  The actual field work was started on November 3, 1975 and a report on the evaluation survey is expected to be available in 1976.

DISCUSSION

The Chairman thanked Mr. van Santen for his paper and said that we all looked forward to the progress in his work and to seeing the results of the settlement evaluation survey published. This work is of great importance for Ethiopia at this time.

A participant commented that he felt that it was high time we had such evaluation surveys carried out so that they could provide a basis for recommendations on the best way to proceed with settlement and development for the country.

The questioner was not quite clear from Mr. van Santen's paper about whether they were considering other aspects of settlement apart from the economic factors. Mr. van Santen replied that apart from the economic aspect that the survey was studying, they were also taking into consideration the social and organizational aspects of settlement. He realized that these aspects were very important and he hoped that the survey would pay attention to all of them. Perhaps the organizational aspects were the most crucial for settlement development.

Mr. van Santen was also asked, if they had considered the types of farming to be implemented in settlement whether this should be on an individual basis or in groups. He replied that the form of farming was likely to change rapidly in the next few years and that the collective approach would be the one most commonly promoted. From the purely agronomic point of view, whether it is collective farming or individual farming the problems are similar. It is certainly true that we hope to improve the results from the new settlement schemes which are being promoted on a collective basis. And in this the experience from the existing settlement schemes will be extremely valuable.

APPROPRIATE TECHNOLOGY RESEARCH

By

Ato Teclemariam Berhane, IAR
and
Ato Abera Mekonnen, CADU

The CADU Agricultural Engineering Section, since its inception in 1967, has been charged with the responsibility of improving local implements and introducing foreign materials for testing and developing new implements. During the first three years field tests were carried out with locally available tillage implements and several imported animal drawn implements. Since late 1969 field tests on various implements, development of new designs of machines and implements, and prototype production have been carried out for soil preparation, threshing, winnowing, seed cleaning, grain storage, grain weighing, transportation, artisan training, and setting up of artisan workshops.

In some cases the target plan was achieved with great success, however, in many cases the achievements were not very significant. In the area of land preparation, the spike-tooth harrow has been very successful both around Chilalo and in other parts of Ethiopia. In the area of transportation, the ox-cart and donkey-cart are relatively successful in areas where roads are available. These implements were successful because they offered obvious advantages to the users. Other implements such as the CADU plough, wooden thresher, seed cleaners, winnowers, etc. did not get much acceptance perhaps due to the lack of investible capital on the part of the farmers and due to the availability of alternative but crude local implements and methods.

Unlike other agricultural inputs (improved seeds, fertilisers, pesticides, and herbicides), agricultural implements are long term investment undertakings. Return on investment on agricultural implements cannot be realized in terms of increased yield in one or two seasons; it takes several years. Agricultural implements mainly reduce human drudgery and enable timely field operations. One may argue that increased yield could be obtained and major losses could be minimized as a result of timely field operations. However, due to the lack of obvious advantages that such agricultural implements offer and their relatively high costs, peasant farmers whose opportunity to meet costs and ability to invest are negligible have been very reluctant to accept them readily.

There are two factors which affect land preparation in terms of power input: (a) the pull required in ploughing is greatly increased in dry soil and can rise to 4 to 5 KN for a single tine operating at a depth of 100 mm, and (b) the performance of individual draught animals varies greatly with their weight and their physical condition, which is often poor during the dry season. The farmer is, therefore, obliged to delay land preparation until the draught requirement falls to a level at which his animals can operate. This forced delay frequently means late planting and consequently loss in yield.

grain production in the lowland areas and any growth in the farmers' financial capacity to store grain for rather longer periods in order to better exploit the seasonal changes in grain prices. This investigation had been carried upto 1970 only and was discontinued since then due to the staff shortage. Underground storage is not included in this investigation.

On top of the above activities the section has done some work for different sections of CADU; spraying for animal husbandry and breeding section; ox-pump for water development section; and it has played a big role in training extension agents and artisans.

The activities that the section is concentrating on at present are:

plant protection	- dusters;
soil preparation	- A blade cultivators, wrist adjuster plough;
transportation	- assessing for available power and harnessing system;
crop handling	- silage chopper, seeder.

The advent of the farmers' associations, farmers' cooperatives and government policy to strengthen the agricultural base will, hopefully, remedy the past experience and create a better future for agricultural implements. So far, the research efforts in CADU have been concentrated on animal and stationary engine powers which the individual farmer could afford to possess. However, in socialist Ethiopia the problem of investible capital would be tackled through joint effort. It has been observed that optimum power input for agriculture in the USA is 0.6 KW per hectare sown. The present level of power input over much of Africa is about 0.04 KW/ha and it is suggested that a tenfold increase in the existing level, to 0.4 KW/ha, is necessary in order to achieve reasonable productivity. If a pair of oxen exert about 0.4 KW, approximately 4 million pairs of oxen will be needed for cultivation purposes in Ethiopia. This indicates that there is a need for engine tractive power such as the two wheel walking tractor to be introduced to the peasant agriculture in Ethiopia. This could be the basis for advanced mechanisation to be developed gradually as more experience of using engine power are gained by the peasant farmers' association and government development agencies. The two wheel tractor is expected to fill up the gap between the small percentage of highly sophisticated mechanisation level and the large percentage of primitive animal power level. Italy, Japan, India China and others could be a source of two wheel tractors for further testing and adaptation here.

In November 1974 the IAR convened a general meeting of all the people directly or indirectly involved with the provison of agricultural tools and implements. In that meeting, a general concensus was reached that a national institution which would be responsible for the improvement, coordination of efforts, and development of small tools and implements was necessary. A steering committee was then formed to finalize the matter. After long and elaborate deliberations, the committee came out with a project proposal and submitted this to the Ministry of Agriculture through the IAR General Manager in April 1975. This proposed institution was expected to be the centre for all agricultural engineering work in the country.

An Italian Government Delegation visited Ethiopia during October 1975 with the view to exloring possibilities of participating in various national development projects. The proposal for the establishment of an Ethiopian Agricultural Engineering Institute was met with particular interest. Following a tour of orientation to the Asella area on October 23/24, during which CADU facilities related to agricultural engineering were inspected, detailed techniaal discussions were held at the IAR Head Office and resulted in concrete and specific proposals towards participation by the Italian Government.

The visit of the Italian Delegatinn was concluded by a meeting with Ato Yoseph Muletta, Permanent Secretary in the Ministry of Agriculture, who expressed satisfaction with the progress made in this matter and again emphasized the urgent need for a national agricultural engineering institution.

NOTE: the following is a short impromptu explanation about some tools that were put on display for people to examine.

Mr. Whiteman gave a very brief description about the implements that are being considered for the dryland farming programme at Mekele. Where he had worked before in Botswana, it had been possible to develop a dryland farming system which enabled them to achieve up to 30 q/ha with only 250 mm of rainfall. This was the result of applying both an improved cultivation system and an improved cropping system enabling correct soil and water management practices. What was done in Botswana was similar to what has been done in other dryland farming areas. They did away with the conventional mould-board plough and went across to the use of chisel and sweep, (rather similar to some of the tools that were on display). These implements were coupled to a wheeled tool-bar pulled by two oxen with low draft requirements.

When he came to Ethiopia he thought that he would be able to implement the same system; however, soon after arriving he found that the situation was very different. It was obvious that the farmers' situation and the soils were different, so he started with what every farmer has got and that is the local 'maresha' plough, and looked at what has to be done to the soil. Now the ploughings that the farmer does, apart from the first one which is a soil breaking operation and the last one in which

he buries the seed, appeared to be weeding. Therefore, the first tool which was designed was one which would both improve the efficiency of weeding, i.e. the percentage kill of the weeds, and cut down the amount of time needed in doing this operation. This tool had been tried once and found to work; there were still a few problems but these could be sorted out. At this stage, this tool was simply to demonstrate an idea rather than a recommendation.

Another requirement was to have the action of the soil engaging tool consistent with both soil erosion control and plant production. One method to cut down or prevent soil erosion is to have a system of ridges and furrows which are tied and put on the contour. Therefore, a second tool had been designed and made which will simply bolt on to the local 'maresha' and which will make large ridges and furrows. This system gives the farmer a multi-purpose plough-bar tool costing him only a few dollars.

DISCUSSION

The Chairman commented that this was an extremely interesting topic and applogized for having to cut the addition by Mr. Whiteman and the time for questions so short.

The first participant commented that he felt that one of the major problems was getting improved implements for land preparation. However in designing improved implements we were forgetting one of the major problems of our farmers and that was the draught animals. Even where we have developed improved implements one reason they have not been taken up by the farmers is that the animals do not have the power to draw them. He felt that the animal science people should be involved in developing more powerful draught animals and this would also necessarily involve the pasture and forage people to make recommendations for feeding such animals. He also had a second point; do we have a good measurement for a hectare? When we make a recommendation for seeding rate and fertilizers it is on a per hectare basis. Can the farmers really apply these recommendations.

Ato Tekelemariam replied that he felt that we had the animals but they were not properly fed or properly taken care of. Apart from these problems the agricultural engineering research unit has plans to test the draught power animals in different parts of the country. They would also compare the draught power of the traditional breed with the cross bred animals that they have at Assela. Apart from this the unit was considering introducing intermediate types of implements such as: two wheeled tractors that are something between the traditional implements and high powered mechanization. The unit was not only looking at the implements; they were very concerned about the power sources available.

In reply to the question about the problem of applying correct rates for seed and fertilizer Ato Teklemariam commented that this was possible with very sophisticated machinery which could be adjusted to the right seeding rate, fertilizer input etc. but the use of such machinery was very costly. However it is possible to get a very fair approximation by doing applications by hand but this was time consuming. The social and economic aspect of this problem was more difficult to tackle.

It was commented that agriculture engineering covered very much more than the development of implements. Is there any work being done on soil and water conservations? Structuring of lands? Farm buildings and farm improvement with small generator systems, irrigation? It was replied that at the moment at Assela we are concentrating on implements. However, when the new Institute of Agricultural Engineering is established this will include all the disciplines that you have just mentioned. At the moment soil conservation is being carried out under EPID and probably other work is being carried out in various institutions. The main reason for asking for the establishment of the agricultural engineering institute is to bring all these things under one roof and then there can be a concerted effort on all the disciplines that have just been mentioned.

NATURAL RESOURCES

ETHIOPIAN CROP GENETIC RESOURCES: A BUILDING BLOCK FOR PROSPEROUS AGRICULTURE

By

Dr. Tadessa Ebba,
(Plant Genetic Resources Centre)

Introduction:

The main objective of this paper is to discuss:

a) problems associated with crop genetic resources;
b) uses of genetic resources in crop improvement programmes;and
c) the dwindling of Ethiopia's Genetic Resources wealth.

The genetic diversity in many Ethiopian crop plants is enormous and many of these variants are rare and do not exist anywhere else. This is a fact that has been testified to by many outstanding biologists, among whom Vavilov of the USSR, some fifty years ago, expressed the situation as follows. "On the whole terrestial globe, the Abyssinian centre is distinguished by its diversity of forms of hulled barley, violet-grained wheat and series of agricultural endemic plants".

The wealth of crop genetic diversity that this country possesses is very essential for current and future cultivar improvement programmes through breeding. Many of the primitive cultivars of different crop species, on which our people largely depend for their food at present, are in real danger of becoming irretrievably lost as high yielding cultivars are released from research stations and/or introduced from outside and as a consequence of population growth and general advances in agriculture.

The concern over the loss of genetic diversity is not limited only to crop plant species; it applies to plants of all kinds and animals which are threatened with extinction. However, in terms of priority and importance, the relatively few crops that supply man with most of his food merit special attention. Thus this paper will focus entirely on the problems of crop genetic diversity.

Genetic Resources and its Utilisation in Crop Improvement Programmes:

Originally man used to obtain his food from wild plants and by hunting animals. One of the outcomes of man becoming settled was the domestication of some plants and animals which provided him with a more stable supply of food and other raw materials. This then was the beginning of agriculture. Some of the first plants to be domesticated, such as wheat, have now been being used by man for nine-to-ten thousand years and a delicate balance or equilibrium had been established with factors in their environment such as parasites, weather, soil. A good example of such a relationship is the establishement of a gene-for-gene relationship between the crop-host and its parasite in which some cultivars of a crop species are susceptible to one or more races of a parasitic species and resistant to others. Even since their domestication, food plants have been undergoing continuous evolution. This has resulted in a lot of variability which enabled the crop plants to adapt to variable and often changing environmental conditions. It is this diversity in crop plants, a result of both natural and man-made selection over thousands of years, which are the natural resources upon which present and future crop improvement depends.

The main aim in preserving the genetic diversity in crop plants is its use in breeding programmes. The degree to which a plant breeder can improve the yield, quality and adaptability of a given crop entirely depends on the amount of variation that exists in that crop species. It is like a person who wishes to build a three-storey house but runs out of building materials after the completion of the second storey; he can only have a two-storey house. This is similar to a plant breeder who has a limited genetic variability in the crop he is working with.

In this country populations of a specific crop, such as wheat, teff, barley, sorghum, coffee, display differences in plant height, stem thickness, earliness, tillering capacity, resistance to parasites and many other traits from valley to valley, hill to hill, with differences in altitude, soil moisture regimes, cultural practices and social isolation. The crops also posses flavours and textures adapted to local tastes and customs. These are invaluable materials for the plant breeder for they are irreplaceable in effective genetic adaptation to local conditions and requirements of the local market when compared to introduced cultivars. Above all, the native genetic resources can be used as raw material from which cultivars can be synthesized which are resistant to parasites as well as having higher nutritional values.

The degree of genetic wealth in Ethiopian crop plants is evident from the following example. From the studies done with the Ethiopian barley collection at the United States Department of Agriculture, it was found that the collection possessed genes for resistance to various diseases. Of the world collection of barley with 6,689 entries, 117 had

resistant gene(s) to Barley Yellow Dwarf Virus (BYDV): out of these 117 entries 113 (97%) were collected from Ethiopia. Several of these collections were also resistant to many other diseases such as smuts, mildews, leaf rust and Septoria. Some of these collection also have a high lysine content. Another example is the recent discovery of sorghum lines which were collected in Welo Province which have a high lysine as well as a high overall protein content. This very important crop genetic variability must be tapped and used in the construction of prosperous agricultural development.

The Dwindling Genetic Resources:

Among the many sorts of genetic resource material that are becoming extinct, one of great and immediate importance to man is the gradual disappearance of diversity in cultivated plants. Natural as well as artificial selection and thus the continuation of evolution is dependent on the amount of variability present in a population. Variation in cultivated plants allows selection for valuable goals such as parasite resistance, high yield and better nutritional quality including higher protein, starch, oil and vitamin contents. Considering man's absolute dependence on food plants, variability deserves absolute protection. Once lost it is irreplaceable. The loss of the original source of breeding material would mean not only that improvement of the present cultivars would be restricted, but that new types of hybrid cultivars of crops could not be developed to cope with population growth, new disease or insect pests which suddenly become rampant.

The rate at which variability in Ethiopian crop plants is disappearing is alarming. The latest expedition, 1969, from the N.I. Vavilov All-Union Institute of Plant Industry of the USSR was only able to find a fraction of the races of some crop cultivars in Ethiopia described by Vavilov and his co-workers earlier in this century. This indicates that the rate at which genetic resources is disappearing is increasing. To-day, in areas like Ada and Chilalo, progressive agriculture, aided by the 'green revolution' and improved technology and often blindly conspiring with greed, hunger, population pressures and above all ignorance, deliberately replaces the low yielding primitive diversity of wheat with the narrow genetic base but high yielding, inbred uniformity of Kenyan and Mexican wheats. But, of course, at this time the major part of the agriculture in Ethiopia is still at a pre-scientific stage and our farmers are still growing primitive cultivars. However, to both hope that primitive agricultural practices will continue and to neglect the genetic gold mine which this country, as an evolutionary 'cradle region', possesses would be a mistake. This genetic heritage must be preserved for present and future use.

The Nation has recognised the need for protecting and preserving our crop genetic resources and wildlife. As an outcome of this recognition a Plant Genetic Resources Centre is being established in Ethiopia. It is hoped that this Centre will save germ plasm materials from vanishing.

The Centre will have the following five main functions.

1. To organise expeditions; collect and provide long term storage and maintenance for germ plasm materials.
2. Establish scientific exchange of materials and information with similar centres in other parts of the world. (introduction).
3. Carry out theoretical studies, in collaboration with staff from Universities and Research Institutions, on systematics, classification, evolution, nutrition, resistance to parasites and the history of cultivation in order to develop the groundwork and methods for plant breeding. (evaluation).
4. Documentation and Information.
5. Participate in the management of genetic reserves.

With reference to point 3 above, the Centre will not be assembling and keeping materials just as museum pieces. There is little purpose in assembling materials unless they are effectively used and preserved. The efficient utilisation of genetic resources requires that they are adequately classified and evaluated. This is a task which needs the participation of diverse specialists and therefore needs collaboration on both a national and international scale.

DISCUSSION

The Chairman thanked Dr. Tadessa for his paper and said that he felt no one at this meeting could deny the importance of preserving our genetic resources.

The first questioner wished to know how far the new Plant Genetic Resource Centre has progressed. He felt that development for preserving our genetic resources had been at a standstill because this same topic had been discussed seven years ago and so far nothing has been done to implement the preservation of our genetic resources. Dr. Tadessa replied that 95% of Ethiopia's population is involved in farming and 85% of our national income comes from agriculture, but the people who are making decisions for the country are lawyers and graduates from the business college. Dr. Taddessa did not blame them for not being able to fully understand the problem in agriculture, especially that of conserving our natural resources, but in a nut shell this is our problem. There is bureaucracy and at this stage there is a high rate of turn over of

personnel in different ministries, different people have different opinions, e.g. take the word permit and allow, for us this word means the same thing but to lawyers these two words mean quite different things. At this stage, it appears that they are playing at words in the different ministries. At the international level, Dr. Tadessa would particularly like to thank, Dr. Melak, the Dean of College of Agriculture for his efforts in getting the bilateral agreement arranged with the German Government. Dr. Melak visited Europe early in 1975 and while there he met concerned German officials and they very quickly drew up the terms of agreement for a unique bilaterial arrangement in setting up a Plant Genetic Resource Cantre. But now the development is being held up for one reason or another and as of now we do not have a Plant Genetic Resources Centre established. Dr. Tadessa also thanked Ato Mulugetta of the Planning Commission for his efforts in getting the Planning Commission committed to this new enterprise. As of this date the Government was commited to 100,000 Eth.$ for the development of this project in this current year. We now have the money but something is still missing to get this project underway.

Dr. Tadessa had pointed out that one of the functions in establishing a genetic resources centre was to keep valuable germ plasm in stock until it could be used by plant breeders. At the moment we can not make use of our genetic resources because we do not have sufficient manpower to do this. He then asked Dr. Taddessa if he could indicate whether the wild progenetors or the very distant relatives or simple forms of some of the important crops are found in Ethiopia. Dr. Tadessa replied that he thought we do not have the wild progenetors of wheat and barley but at this stage this is not very important. What is important is to preserve the diversity which Ethiopia's agro-climatic conditions have brought about in these crops after they were introduced to Ethiopia. This is even true for maize in the southern parts of the country. This existing diversity is possibly more important for breeding than the existance of wild progenetors. For some crops such as yams where wild plants have been collected from Sidamo and Welega we obviously have wild progenetors or wild types growing in the country eventhough yam as a whole has its origion in Asia; this material is important. Then we do have crops of Ethiopian origin, such as coffee which are very important in the world today, and teff; for such crops as these we have wild progenetors. However more important than the wild progenetors was the preservation of the great diversity in these crops. This did not minimize, however, the importance of the wild progenetors.

It was commented that Dr. Tadessa had characterized the activities CADU, EPID and other mass distributers of new seed as carrying out genetic suicide. This is a very courageous statement, however where we are pressed to develop and extend research result how can you justify such a statement in the light of the pressing world need to feed the expanding world population. Dr. Tadessa replied he felt that man was not the only species with a right to live on this planet, if we destroy the natural balance that has been developed over millions of years by destroying such things as the variability in our crops, he felt that man's existence would come to an end as well. He was not against increasing yields or against developing new varieties but he is for preserving the very important plants which formed the basis for developing these new modern varieties. It is thus possible to do both, we can preserve both our natural resources and at the same time use this as a gold mine in constructing a meaningful agricultural development. Previously questions were raised about the environment and exhausting our land in using high yielding varieties, yet, the prospect for obtaining more fertilizers is getting dimmer. This problem has to be seriously considered.

A question was raised concerning the second objective of the Plant Genetic Resources Centre; this connerned the exchange of scientific information. In principle the questioner was all for exchanging genetic material between international centres, but he and others had experienced some difficulties in carryingout such exchanges. As we all know, Ethiopia is the cradle of diversity for many important agronomic crops. We have genes that are worth millions of dollars and we should share these with the rest of the world, but this had to be done on a reciprocal basis. He wanted to know what the policies of the Plant Genetic Resources Centre would be regarding the protection of certain types of important plants. For example he had tried to develop Pyrethrum at Alemaya and had written to Kenya for seed. The answer given was that Kenya could not send any seed because they did not want to promote competition in another country. He had been informed that a group from Kenya came to Ethiopia to collect plants of coffee for developing resistance to Coffee Berry Disease. From this material they had been able to raise resistant plants but this material is not allowed to comeback into Ethiopia. Dr. Tadessa replied that he considered that the exchange of materials should be undertaken on a mutual basis. There are certain crops such as spices where Ethiopia claims a monopoly, even if the PGRC becomes an International Genetic Resources Centre, we will still claim monopoly for some crops such as coffee which are very important to the national economy. It will be upto Ethiopia to decide which crops it can give and which ones that it will have to withhold. When the centre is established an advisory committee from all sectors will be set up which will decide of such points. As has been pointed out many expenditions had come to Ethiopia in the past and had gone away with very important material. For example the agronomy section had written to the USSR to ask them some of the materials that had been collected from Ethiopia but they had had no reply. This is probably unfortunately true for several other places. Thus we must do this conservation for ourselves. We cannot protect ourselves without the establishment of the resources centre. Infact in drafting the agreement with the German Government we have included this point, "We will either negotiate or exclude some of our important plants from the exchange programme, eventhough, we will be able to preserve them in the Centre".

The job that the Genetic Resources Centre is undertaking is tremendous and the speaker could not imagine how the centre was going to be able to do justice to all the crops which claim Ethiopia as their centre of diversity. It is assumed that you will be able to do justice to all crops, but how is this material going to be utlized? will it be the function of your centre to do this or will it become part of the country wide research programme? Dr. Tadessa replied that the studies will be done in collaboration with different specialist e.g. the sorghum programme will be carried out with Dr. Berhane at Alemaya a College. The information that is gathered from such studies will be compiled and documented at the Genetic Resources Centre. Anyone, such as the sorghum cooperator or someone working with another crop, may then contact us for materials and information. For example, if we are asked for material of a sorghum with a height of 2-meters, with seeds of 11% protein and a certain percentage of starch, then by using a computer retrival system we will immediately be able to pick out such material if available. The centre will not have all the necessary types of researchers or specialist needed, it will collaborate with other organizations such as the University and the IAR in order to do this. The information will be documented at the centre and this will provide the basis for plant breeding programmes which have a certain goal in mind.

It was commented that the Ethiopian Genetic Resource warranted some stronger remarks. The genetic resource available in Ethiopia is unique in many respects. It is not only the centre of origin for some of our endemic crops but it is also a very important centre for many types of cultivated plants. Due credit should also be given to the Crop Genetic and Ecology Centre of FAO, in particular its past Director, Dr. Leone and then later on Mr. Pichen and Miss Verner Bennett of FAO who have given Ethiopia tremendous support in the early recognition of its tremendous wealth of the genetic resource. The Vavilov Centre has been a special source of encouragement in the establishment of this genetic resources centre in Ethiopia, Mention should also be made of some of the earlier workers from the USDA. The Director of the Indian Agricultural Research Institute had also helped in giving world wide recognition to the genetic wealth of Ethiopia. In a recent meeting in Washington, he had said that "The Ethiopian people would do not only themselves a dis-service but also the rest of the world by ignoring their genetic wealth. If they refuse to share this wealth with the rest of the world it could be an even more disastrous situation than that of the oil embargo". He was aware that the genetic resources were disappearing at an alarming rate and he was therefore happy to see the establishment of the Plant Genetic Resources Centre.

A spokes-man from the Soviet Scientific Phytopathological Laboratory informed the meeting that they had not been aware of the request from the agronomy section, Holetta. However, in establishing the laboratory in Ethiopia they had already brought back and distributed some seeds of varieties of wheat and barley which were originally collected in Ethiopia.

WILDLIFE MANAGEMENT PROBLEMS IN ETHIOPIA

by

Ato Andeberhan Kidane
(Wildlife Conservation Organisation)

Introduction

Ethiopia began its Wildlife Conservation Programme is 1965, with the establishment of a chartered Wildlife Conservation Organization. The conservation programmes of the Organisation are based on the following principles:

1) to conserve the precious heritage of Ethiopian wildlife resources for the enjoyment of the present people and the generations to come;

2) to preserve the wildlife, particularly the endangered species, from depletion and consequent extinction for the continued development of the Ethiopian economy, education and for their scientific values;

3) to protect and develop the wildlife resources of Ethiopia as a potential tourist attraction.

With these goals in view the WLCO has done an encouraging number of investigations into the flora and fauna of selected parts of Ethiopia.

Since its inception the WLCO has made a modest endeavour in setting up administrative machinery and training some Ethiopian personnel in the field of wildlife management.

In accordance with the Legal Orders No. 54 and No.59 of 1969, the WLCO has established two gazetted National Parks, the Awash National Park and Simien National Park, respectively. In accordance with the Legal Order No.65 of 1970, article 3(1) the WLCO has proposed seven more national parks, two wildlife sanctuaries, twelve wildlife reserves and eleven controlled hunting areas. The first three conservation areas comprise 4% of the whole country. These are encouraging strides in the management of Ethiopian Wildlife. However, it is a pertinent fact that the WLCO is faced with chronic, ever increasing problems which need immediate attention on a national level. Following are some of the problems and obstacles in the sound management of Ethiopia's wildlife.

Habitat Destruction:

The wildlife situation especially with regard to our larger wild animals, is very different from that which prevailed a few decades ago. Generally, large mammals throughout Ethiopia have undergone a serious decline in numbers mainly due to habitat destruction or alteration of the ecosystem as a result of undisciplined agricultural practices and forest exploitation. Ethiopia is endowed with agricultural areas, of high potential but destructive mis-use of such areas by shifting cultivation and cultivation of steep slopes without sound soil and water control are leading to the over-spill of the human population into less favourable rainfall areas. Steep slope cultivation in Chercher, Bale and Simien Mountains progresses unabated. This type of land use in these mountains and other similar areas will, in the end, make them uninhabitable not only for the Mountain Nyala (Tragelaphus buxtoni), Walia (Capra walia) and Semien fox (Simenia semensis citernii) which are already living in such small "ecological islands," but for man himself. It is also worth mentioning that the Nyala and Walia habitat cannot be made into highly productive agricultural or grazing land. The prevailing temperatures of the general Nyala and Walia habitat are too low for vigorous plant growth, and the cold wet rainy weather is certainly not conducive to good health in domestic stock. (Brown 1966).

A very rapid agricultural take-over deterimental to wildlife is taking place in the Ethiopian Rift Valley which was once teeming with a fabulous wildlife population. Currently, a critical stage has been reached on the Senkele and Siraro plains, the home of the Swayne's hartebeest (Alcelaphus buselaphus swaynei). The Swayne's hartebeest is one of the rarest sub-species of wild animal in the world. It is to be found only in Ethiopia (Senkele and Siraro plains) and the total number in Ethiopia is now under one thousand. The fine pasture land of Senkele, which was once used by both the Swayne's hartebeest and the Arussi and Sidamo pastoralists is now almost entirely under mechanised ploughing for a quick return by the government and the local people. Agriculture experts admit that despite the fertility of the black soil, its shallowness (maximum 30 cm), demands heavy fertilization after the first year's crop. This is self evident from a comparison of the standing crops of the controlled maize plantations and those of the peasants (Stephenson 1975). Translocation efforts of the Swayne's hartebeest by the WLCO have not proved successful either in the Awash National Park or the proposed Nechisar National Park, and the remaining population does not allow for chancey experiments with further translocation. The uncontrolled expansion of agriculture and the resultant change in the ecosystem, has brought this last stronghold of the Swayne's hartebeest suddenly to the threshold of extinction.

Shifting cultivation in many parts of Ethiopia is a common practice. In Harar region, particularly in Gursum Awraja, shifting cultivation has spread like wildfire in the past five years. In the proposed Harar Elephant Sanctuary, shifting cultivation and heavy acacia tree cutting for charcoal are not only destroying the elephant

(Loxodonta africana) habitat at an unprecedented rate, thus hastening this animal's complete disappearance from the sanctuary, but are forcing the WLCO to invest its conservation funds and energies in futile crop protection measures. Paradoxically, crops in such marginal lands usually fail due to low and erratic rains.

Currently, crop depradation by Warthogs (Phacochoerus aethiopicus) bushpigs (Potamochoerus poccus) and particularly primates has became a major issue among agriculturalists. As a result, the WLCO has been bitterly blamed by different government departments, agencies and individuals, thus adding another costly dimension to its problems. The real cause of crop depredation by these animals is not yet ascertained, but it is probable that it is the result of the cumulative effects of habitat dwindling (due to expanding and shifting cultivation), prolonged drought, and reduced predation by the bigger carnivorous animals. However, the WLCO is fully aware of its responsibilities to the people in this sphere and is giving the problem careful study with the intention of expanding the Organisation to afford the required protection.

Wildlife habitat destruction is not only manifested by expanding and shifting cultivation, but by deliberate deforestation for timber, firewood and charcoal. Ethiopian forests (indispensable wildlife habitats) have been exploited both by local people and concessionaires without restriction and without any deep thought for the future. To day the remaining forests are in the remote and less accessible part of the country, notably in the south and west and to a small extent on the higher slopes of the eastern highlands. Likewise, the remaining wildlife distribution follows the forest pattern and of course, the Rift Valley. These forest are not only indispensable to much of the country's wildlife as their habitat, but they are equally indispensable to the country's people; they are a controlling factor in rain precipitation, in preventing soil erosion and consequently in regulating the shed-off of water from the mountains, so maintaining the output of springs, streams and rivers. They also form an essential part of the unsurpassed beauty of this land.

Exploitation of forests for timber, firewood and charcoal, as is currently practised all over Ethiopia is generally wasteful and destructive. In the Chercher mountains forest exploitation, even to the summit of the mountains, is followed by agriculture subjecting the soil to an extreme type of denundation and forcing the mountain nyala to its doom in this particular part of the country. In the proposed Harar Elephant Sanctuary and the Rift Valley, Acacia forests/woodlands are felled indiscriminately for firewood and charcoal at an alarming rate. Such practices practices still continue unchecked. In due course this will mean the loss of flora and fauna, subjecting the soil to all sorts of erosion and of course diminishing primary productivity.

Mismanagement of Marginal Lands

For some reason Ethiopian nomadic tribes, and for that matter all African nomads, have chosen (or were forced to choose) hostile climatic zones - marginal lands at best - as their grazing lands. Prior to the introduction of modern dams, like the Koka dam, and big scale mechanized farms, like the H.V.A. Sugar plantations and the mechanized farms of the lower Awash Valley; the Karayu, Afar, etc. and Danakil nomadic tribes were living in harmony with their environment. Wild animals existed alongside domestic herds and were tolerated and respected. The introduction of the aforementioned projects, together with the absence of necessary ecological and sociological adjustment and modern range management practices forced the nomadic people to spoil their grazing lands. In the Awash Valley dry-season grazing lands (the former flood basin of Awash river) of both wildlife and pastoralists is under mechanized ploughing, forcing the traditional inhabitants into increasingly hostile conditions. The vegetation of a semi-arid climatic zone which is not adapted to all-year grazing is forced to supply fodder for both cattle and game throughout the year. On the other hand, the nomadic tribes have changed little from their traditional way of life. There has been no serious attempt to persuade or convince them to shed their age-long customs and traditions (such as reducing the numbers of their cattle to the capacity of the range) in favour of modern ways of living. In such a situation then, cattle and wildlife are in severe competition for both space and fodder. The overall effect is then overstocking which definitely leads to habitat deterioration by overgrazing. The complete absence of any form of stock-limitation commensurate with the carrying capacity of the land is the basic cause of the lawless and uncontrolled over-running of the Awash and Nechisar National Parks today.

This in turn is forcing the wildlife to diminish in numbers and some, like the wild ass (Equus asinus somalicus), are obliged to adapt to a different habitat. In the Danakil Desert the few remaining wild ass have inhabited the hills, for only there can they escape competition from domestic stock (Brown 1969). The nomadic tribes are also forced by such circumstances into frequent trespassing into the legally recognized Awash National Park (which has never been cattle-free) and into the mechanized farms. During prolonged droughts like that of 1972-1973, the nomadic people were supplementing their milk diet with carbohydrate food either by doing some manual work at the farms or by asking for relief from the government.

Legislation

A serious handicap which the Wildlife Conservation Organization is facing today is the lack of proper legislation establishing the legality of the conservation areas and law enforcement in the legally recognized conservation areas. Except for the Semien and Awash National Parks, all so-called conservation areas are nothing more than patterns on the map and have been so far the past six years. Even in those gazetted National Parks, human interests have never been extinguished. As a result the WLCO is finding it increasingly difficult to develop and expand conservation areas and to take the necessary stern measures against anti-conservation activities. For instance, the WLCO does not have the legal backing to stop agriculturalists, nomadic tribes and wood cutters from encroaching into non-designated or gazetted conservation areas. But what is worse and incomprehensible is that, whilst the law provides for the prevention of such acts in the gazetted National Parks, legal action has long been virtually impossible because of the lack of support by the Administration and the courts. This in fact means a break-down in the proper process of the law of the land and must certainly be the cause for grave concern at all government levels. Strictly speaking it is practically impossible to take legal measures against a hunter (licensed) who hunts either in a Proposed Park, wildlife reserve or sanctuary instead of in a Controlled Hunting Area.

From another view point, the existing wildlife conservation legislation has served a valuable and useful purpose in establishing the concept of utilization and conservation in Ethiopia and indeed it deserves full credit. With the increasing habitat destruction and the subsequent endangering of our already endangered endemic species, the time has come that not only very urgent legislative measures have to be taken to make the proposed National Parks and conservation areas, by right, to conform to international standards but there is the need for a reversal of emphasis; conservation primarily, with utilisation of wildlife as a logical and desirable consequence. Such reversal of emphasis in Wildlife legislation is also in line with the "Declaration of Economic Policy of Socialist Ethiopia". Under Section "D-Tourism", the government has stated that "It should however be emphasised that conservation of wildlife, birdlife, etc. particularly of the rare species, and the preservation of antiquities will be viewed primarily as national objectives in their own right and not only as a means of attracting foreign visitors". In short the existing wildlife legislation has to be re-framed and particular emphasis should be on conservation. From the re-framed legislation maximum security should be given to wildlife preservation through the establishment of the major conservation areas in law by the highest body of Government in the land; thereby no alterations there to can be effected without the approval of the highest body of Government. Furthermore, such conservation areas should be given additional protection through having their own provisions and restrictions, thus making their sacred status in the minds of the public abundantly clear. The re-drafted law should also equip the officers of the WLCO, on whom is placed the duty of wildlife conservation, with adequate powers for the putting into effect of their duties. Besides, the redrafted law should bring the contool of capturing, keeping and utilising civets (Civettictis civetta) for the production of civet

musk under the control of the WLCO, the only competent body to do so in the light of modern world thinking and conscience. Likewise, the law should bring the control of sport fishing under this organisation which is the best suited and equipped body to do so.

Conservation Education

Broadly speaking conservation education is teaching the public to reconcile ecological needs with socio-economic needs. In countries like Ethiopia where land is grossly mismanaged, the soaring human population is also accompanied by soaring human needs, exerting increased pressure on conservation areas and adding increased threats to the wildlife heritage of the nation. In such a situation the WLCO has realized that a quick national consciousness of the need of conservation is of paramount importance. At present the WLCO has a conservation education unit. Though handicapped by lack of trained personnel and facilities this unit is doing its best to educate the public in the need of conservating the wildlife resources. Unlike those of the developed world conservation problems in Ethiopia are of a rural nature and conservation education has to be directed to the rural mass, and it is here that the difficult part of the problem lies, i.e. to convince the rural masses who live at subsistence level by farming, cattle herding or hunting - to maintain a balance between ecological (conservation) needs and their socio-economic needs. From the experience of many conservationists, the rural masses are not opposed to conservation education, but they always ask for an alternative way of living instead of their "forced" anti-conservation action, such as undisciplined exploitation of forests/woodlands for fire wood and charcoal. It is then obvious that the WLCO cannot give the rural people an alternative occupation with the exception of some elementary advice. But what is very true is that if conservation education is to be meaningful it has to be approached from different coordinated disciplines.

Many, if not most, educated Ethiopians are also as ignorant as the illiterate mass in matters concerning conservation education. This is possibly due to their educational background. In the past the Ethiopian educational curriculum included nothing or very little concerning conservation of natural resources of which wildlife is an integral part. As a result, the products of such an educational setup cannot be blamed for their indifference to wildlife. To date, with the existing mismanagement of natural resources, the time has come that conservation cannot be overlooked and it has to be an integral part of the eudcational setup of the country. In all aspects of conservation, and in wildlife perhaps above all others, Ethiopia must develop a national conscience with a much greater sense of responsibility to her priceless heritage.

Poaching

Poaching is illegal hunting of game either for food or commercial purposes. Poaching, particularly of elephants has been greatly intensified recently because of a sharp increase in the value of ivory, which has become a speculative commodity, a hedge against inflation, and a method of illegally transferring funds from one conntry to another. Ethiopian wildlife has been exploited for subsistence by local people since long, long ago. Even today primitive tribes like the Anuaks and Nuers of Gambella Awraja and the Bume and Surma tribes of the Omo area supplement their diet by hunting game. Traditional methods of hunting never decimated wildlife and possibly it was a necessary factor for controlling the wildlife population. Decline of wildlife population in Ethiopia is not only associated with habitat destruction, but also with the introduction of fire arms which greatly facilitated poaching. Elephants which once were very numerous in Ethiopia are almost exterminated for their ivory. The spotted cats (leopard, cheetah, serval etc.) are endangered for their skins. Today, in spite of the increased anti-poaching measures taken at national and international levels, poaching is still rife in Ethiopia.

A brief glance of the following table (1) shows the current picture of poaching in Ethiopia.

Table 1. Legally and Illegally Hunted Animals in Ethiopia in the year (1967 E.C.) 1974-75

Year	Type of Animal	Legally hunted	Illegally hunted
1967 (E.C.)	Elephants (Loxodonta africana)	4	154
" "	Leopard (Panthera pardus)	Nil	117
" "	Colobus Monkey (Colobus guereza)	Protected	2154
" "	Serval cat (Felis serval)	Nil	240
" "	Cheetah (Acynonyx jubatus)	Protected	53

These figures are known to the WLCO, but nobody knows (except poachers themselves) how many have been taken by illicit hunters.

This warrants that stringent measures have to be taken both by the WLCO and the government. The WLCO has realized the seriousness of poaching in the country and has established an anti-poaching unit. However, lack of legal power (power of seizure and arrest) of anti-poaching officers has hampered the efficiency of the unit a great deal. Besides, to combat anti-poaching effectively the WLCO lacks budgetary backing as well as cooperation from the majority of the public.

Technical Personnel

At this particular moment many Ethiopian Wildlife species, like the Walia Ibex, Semien fox, Wild ass and the Swayne's hartebeest are in iminent danger, and the survival of many is threatened. Thus, if this national heritage is to be conserved for the coming generation, all the existing and proposed conservation projects have to be managed by people who are specially trained in the field of wildlife management and biology. The WLCO has only 12 men trained in wildlife management. But the need of more educated personnel is evident as most of the proposed conservation areas are either not managed or inadequately staffed by trained personnel. The WLCO is also financially handicapped to educate more personnel because the specialized field of wildlife management is currently offered outside Ethiopia. Moreover, the Government was not keen enough in offering undergraduate scholarships, possibly because government officials were not aware of the precarious situation of the Ethiopian Wildlife.

Conclusion

Currently, many endemic Ethiopian species are either endangered or threatened with extinction. Animals like elephants have diminished to a very small population, warranting immediate attention at a national level. Wildlife habitat is being destroyed at an alarming rate, indicating that even the present common wildlife species may be rare or endangered after a decade. The WLCO has tried its best to put wildlife management on a sure footing. But so far it has failed to upgrade even one national park to an international level. Thus in all aspects of conservation, and in wildlife perhaps above all others, Ethiopia must develop a national conscience and a much greater sense of urgency and determination to save this disappearing heritage.

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Discussion

The Chairman thanked Ato Andeberhan for his very interesting paper. He felt that the points raised were crucial for the national economy and everyone should look at these problem as his own problem. He had welcomed this paper with its good content because it had informed many of us who were previously ignorant of this national resource heritage.

A participant from the CADU Forestry Section thanked the speaker for his paper and felt that all will agree with the points raised. One step to help conservation action would be look upon man-made forests as an integrated part of the cropping system. This will entail establishing these forests and weeding and protecting them like other crops. He hoped that a paper on forestry would be presented at the next seminar.

A participant commented on the points 'legal and illegal'. He felt that there were some places such as isolated pockets in Ethiopia where the terms legal and illegal may not have much meaning. These people had lived and grown up in these areas and have to eke out a subsistence existance through agriculture. When the farmer leaves his crop to go away for some social affairs, primates may come in and totally destroy these crops. Would the speaker please comment on this? Ato Andeberhan replied that as far as farmers were concerned, the wildlife conservation organization had given them permission to kill warthogs, bush pigs and primates in order to protect their crops. The Organisation also has a roving force whose aim is to help in controlling pest such as primates. The position of the word legal and illegal refered particularly to the larger animals such as elephants and leopards. Most Ethiopians do not eat elephants, they only kill them for their ivory, neither do they eat leopards, they only kill these animals for their skins. He strongly suspected that the tremendous increase in the numbers of primates which was causing such damage to crops was tied up with the change in ecology of many areas. Many areas which were once forested have been cleared and there is now little cover left on the ground. This situation has encouraged the multiplication of primates and is coupled with a decline in their natural predators such as leopards which has been encouraged by illegal poaching. The Wildlife Conservation Organization has actually circulated to all farmers a bulletin instructing them that they can protect their crops from damaging pests. However, if a farmer goes deep into the forest and clears 2 to 3 hectares say for maize and then comes and complains to the organization that his crops are devastated by primates then the organization can do little to help him.

It is generally accepted that conservation is the most important goal. But in fact many people all over the world depend on animals both for meat and for using their skins for protection. It seems that people must hunt animals because they don't have other reserves or other resources

to give them what they need, and the Government and other Organizations have not yet found a way to entice these people into cultivation or other practices. In Gambella it is possible to cultivate cotton but the people do not wear cotton clothes; they eat fish and other animal products. He felt, therefore, it was very easy to blame the Ethiopians for mis-using their environment when infact they were ignorant of the facts behind this mis-use. Ato Andeberhan replied that, as had been pointed out in his paper, the Wildlife Conservation Organization regards the tribes of the Omo and Gambella regions as primitive. Their traditional hunting methods never desimated the wildlife population and in fact it was possibly necessary as part of natural control. Thus at this time the organization was not against the tribes. However what they were against were the people who went out with machineguns and rifles and kill animals for their skins and ivory. At this time, because these primitive tribes have no other means of livelihood the organization recognizes their right to hunt.

LIVESTOCK

This section was chaired by Dr. Gerald Wiener, who is a livestock breeder of international repute from the University of Edinbourgh, He was in Ethiopia at the time of the seminar as a consultant to the IAR on the animal breeding programme.

Dr. Wiener used the opportunity of the Chair to give some comments comments on genetic resources from the animal point of view. He felt that Dr. Tadessa's message was very important for the animal production people. Livestock is not in anything like the same position regarding loss of genetic material as the plant side is in, but it is very important ant to keep the message in mind. For example, one has only to see the enourmous preponderance of the White Leghorn in the poultry industry all across the world. The vast spread of the Freisian or Holstein breed in cattle certainly across most of the western world and now into large parts of Africa, one begins to wonder if the livestock people should not take note and begin to develop genetic resources centres for animals. Fortunately we are not yet in a position to be worried but as livestock people let us consider what we want or need today or tomorrow may not be what will fit the needs of our grandchildren or great grandchildren in 50 years time.

One of the happy events for livestock production in the past two years has been the setting up of the International Livestock Centre for Africa (ILCA) which has its headquarters in Addis Ababa, Ethiopia.

THE INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA (ILCA): AN INTRODUCTION

By

Dr. Shenkute Tessema
(I L C A)

To increase the availability of new technologies for agricultural improvement the International Bank for Reconstruction and Development (IBRD), also called the World Bank, UNDP and FAO have initiated an organization known as the Consultative Group on International Agricultural Research, commonly known as CGIAR, for the purpose of increasing the agricultural research, education and training effort in the developing world. The main activity is to ensure the organization and financing of international agricultural research institutes and the pursuance of programmes dealing with the increase of agricultural production in the broadest sense of the term.

CGIAR is composed, in addition to the three organization already mentioned, of the main bilateral and multi-lateral agencies, several foundations in the United States and Canada and the Regional Development Bank in the developing countries. It has sponsors and supervisors in several of the international agricultural research institutes, formerly created by United States-based foundations, and also those that have been authorized since CGIAR formed in 1971. Some of these organization such as CIMMYT, ICRISAT, the Potato Research Centre, are well known to the meeting here, and many of the participants here are quite involved in the programmes at these centes. Now the International Livestock Centre for Africa is the latest of the international centres; it is the eigth centre to be created. For your information the others are:

The Wheat and Maize Improvement Centre (CIMMYT):
The International Rice Research Institute (IRRI):
The International Centre for Tropical Agriculture - Columbia (CIAT);
The International Potato Research Centre - Peru, (CIP);
International Crop Research Institute for Semi-arid Tropics (ICRISAT);
International Laboratory for Research of Animal Diseases (INRAD)
and now ILCA which is the acronym for the International Livestock Centre for Africa.

ILCA is an autonomous, non political, non profit making organization, sponsored by the consultative group, CGIAR. It has its headquarters in Addis Ababa and a far reaching programme to assist in national efforts aimed to change the production and marketing systems in tropical Africa; to increase the sustained yield in the out-put of livestock products and improve the quality of life of all the people of this continent. The centre was formally established in July 1974 with the signing of the agreement between the Ethiopian Government as the host Government and IBRD acting on behalf of the consultative group.

The historical background to the formation of ILCA is as follows: CGIAR, taking into account the conclusions from meetings of experts in and from many organizations, set up and established an African sub-committee. The Committee was given the responsibility to further study and make recommendations for the re-enforcement of research and education in the fields of animal health and animal production in Africa. The African Livestock Committee established and fixed the terms of reference of two task forces, one task force supported, by the Rockerfeller Foundation and headed by Dr. Pritchard, made recommendations on the need for a laboratory for animal diseases, especially related to trypanosomiasis and East-coast Fever. The second task force, headed by Dr. Tribe and supported by IBRD, France, United Kigdom and IDRC Canada, were asked to study the needs and make recommendations for an institute devoted to animal production. This second task force visited many countries to review the situation and ongoing research in animal production at national institutions. They also visited Ministries of Agriculture and various donor agencies. The team of the second task force recommended and concluded that an international livestock centre was needed to aid in improving livestock production. The task force gave a clear definition of the terms of reference for this new institute as its relationship to the projected Institute on Animal Disease. The Technical Advisory Committee, commonly called TAC, of the CGIAR and the African Livestock sub-committee, after a review of the task force report, recommended in 1973 that an international livestock centre be established. In July 1973 the CGIAR accepted the recommendation and took action to establish the International Livestock Centre for Africa. The CGIAR selected the Board of Trusties and made arrangements for the final stages in the development. Then the Board of Trusties in concurrence with the findings of the Tribe report ruled that the purpose of the centre is to assist national efforts aimed to change production and marketing systems in Tropical Africa, so as to increase the sustained yield and out-put of animal products and improve the life of the people in this region.

We will now turn to the concepts of ILCA as they are developing at this time, particularly the concept in research. It is felt in ILCA that 'production systems' is felt to be the most appropriate approach. This is a systems approach. This approach is applicable to both biological and socio-economic problems; the systems approach itself lends itself to analysis both in terms of energetics as well as values. Since livestock production systems involve the human population who exploit the environment by means of the livestock kept in such numbers and varieties as to achieve given objectives their investigation requires expertise in animal, human and evaluative sciences. Multi-disciplinary research in the sense of different disciplines involved in parallel investigations is not sufficient. It will be the task of ILCA to develop an integrated research approach which implies as an essential first step, the development of shared prospective and integrated methodologies. Multi-disciplinary research is usually done in parallel, i.e. animal production, pasture and forage, economics, being done in parellel. However in ILCA it is felt that the integrated approach is the only one which will give satisfactory options to the problems.

In the work of ILCA it is felt that there are two new promising fields that apply to this research concept, these are both short term types of study. They are:

a) Studies of the existing systems of livestock production. This should aim to investigate and quantify the production parameters in both the vegetation and the animal livestock population dynamics, soil and water conservation and the human nutritional standards in the area. This study is only on the existing systems of production.

b) Studies of existing and planned animal production schemes. Many countries have planned livestock schemes either as a national effort or institutional effort; these need to be studied. They should aim to monitor the ecological, socialogical and economic changes and impact of development.

The purpose of all research will be to study the possibilities of supplementing the existing systems and/or integrating into these existing systems, recent technical advances taking into account climatic, economic, sociologic and biological factors which at the present time impose constraints in animal production. These are the short term types of studies that have been taken up by ILCA.

A number of longterm objectives of research at ILCA are already apparent:

1) The development of an inter-disciplinary methodology e.g. we heard on the previous day that to introduce efficiency into land cultivation, we need implements, animals, feeds, the farmers' acceptance, the economic situation, and these are all part of the same system in order to get efficiency in ploughing the land. All these disciplines must work together to come up with an inter-disciplinary methodology.

2) Monitoring situational changes and accumulation as time against data. There are many ongoing projects in many countries. For example, Ethiopia has been recently negotiated for a World Bank project in the Southern Rangelands, The Jijiga Rangelands and the Northern Rangelands. It is felt that monitoring the situational changes and time series data on these types of work is very appropriate.

3) Identification of constraints in existing production.

4) Construction of predicting models for changes in production factors by computerized simulation techniques. For example, we take a problem such as the offtake of cattle from a certain area. What factors have to be considered to increase offtake: increasing fertility gives a positive effect; disease gives a negative effect; improving the rangegivesa positive effect; low prices give a negative effect. All these factors are put together and a simulation model is brought out and fed to a computer which produces what offtake you would get if all these factors were considered from many angles.

5) Formulation of anticipatory drought response strategies for long term livestock production. This is a very urgent need and it is felt that studying this problem is within the competence of ILCA.

In addition ILCA shall have an inbuilt capacity and flexibility to respond to immediate emergency situations such as the drought or any other problems that can arise in animal production systems.

To start its work following the instructions from the Board of Directors and by consultation with its staff and all the other organizations involved there were four countries selected for initial studies. These are Ethiopia, Kenya, Mali and Nigeria. These countries are considered suitable sites for the initiation and implementation of ILCA's research approach. These countries represent important zones of livestock production, they also allow what is considered an urgent priority, the analysis of communities seriously affected by the drought. This is of prime importance and the tracing of the adaptation of these people and their livestock to changing circumstances, natural, social and economic. They represent a wide range of variation in all relevant phenomena of livestock production systems such as the ecological zonation; social forms, livestock types and densities; degrees of commercialization; stratification of production development policies and degree of development. These four countries offer these variables and therefore ILCA should start its work in these four countries.

At ILCA the integrated research approach is almost a religion with all staff members. Country programmes or problem solving programmes are not designed by sections or departments; in fact there are no departments in ILCA. Programmes designed always include the ecological, sociological, economic and animal aspects. Obviously in each of these fields there must be experts and authorities so the staff is classified accordingly. At ILCA the staff are grouped as teams. There is the animal science team; physiological environment team which covers range, ecology pasture, soils etc.; the economics team, the socio-anthroplogy team; and the documentations and training team.

The pattern that is now developing at ILCA in working up programmes is as follows: ILCA will make contact with agricultural and Government authorities. This is done before it starts work in any country or area. ILCA's objectives and competence will be introduced to these authorities. The ILCA staff will also visit agricultural institutions and centres to gather information on what is going on in a particular country. ILCA also will gather and document all information on past, present and future research efforts in animal production in these countries. A government and/or ILCA will initiate linkages between the governments and institutions so as to set up priorities and guidelines where ILCA can work. ILCA staff, including all disciplines, will make a detailed visit to the problem areas and develop research programmes in specific aspects of livestock production which are appropriate to an international centre. The detailed programme of work as outlined by ILCA's scientists will then be submitted to the Government authorities and scientists for agreement. If the Government accepts

the proposal then the proposal plus all budgetary implications will be submitted to ILCA's Board of Trusties for approval. If approved implementation will begin as approved. The above outlines ILCA's approach and this infact is how the programmes at ILCA are being developed.

At this time the staff of ILCA is not very large, however, at this time all the team leaders are now negotiating the Mali programme following the steps outlined above. The Kenya programme has also reached certain stages. After the team returns from Mali they will go to Kenya to finalize negotiations.

As regard the Ethiopian programme, we have met with various institutions, scientists and the Government authorities and discussed priorities and guidelines and have agreed on a number of points where ILCA or its competence can be involved. The guidelines as outlined are extensive and there isn't time to go into them now. Many of the livestock people have been involved in drawing up these programmes and they know the guidelines. However, the priority area that was given to ILCA was the drought stricken areas where the country and the people are interested in developing livestock production systems of the nomadic transhumance areas such as in the Southern Rangelands, the Wollo and Tigré drought stricken areas called the North-Eastern Rangelands and the Jijiga area. This is the directive and guidelines that ILCA has been given. The team will travel to these areas in the beginning of December 1975 to look at the areas and present detailed studied programmes for the Government to approve. Then the programme will go to the Board of Directors of ILCA for approval and the budgetary implications.

Now to turn to the situation regarding facilities and staff. The Ethiopian Government has given ILCA a site at Shola in Addis Ababa adjacent to Dairy Development Agency building. This is a ten hectare site where we are going to have the headquarters complex. This complex will have the main laboratories, training centres, sheds and all other ancillary buildings. The total cost of this structure including furniture and laboratory fittings will be in order of US$5,000,000. Schedules for construction are as follows: All the designs and architectural drawings have been finished, submitted to the Board for approval, and approved. The tender for building will be out in March 1976 and will be opened in June 1976. Hopefully by July 1976, building work will commence so that by July 1978 the building will be occupied.

At the moment the staff consists of 17 scientists made up from 14 nationalities, recruitment is on an international basis without any prejudice for any particular country. The staff will increase to 28 by 1977 and the target level for full development is 100 senior scientific personnel in 1979. Obviously ILCA can not recruit more staff before 1978 because of lack of space for our programme. But by 1979 ILCA hopes to be fully staffed and operational.

DOCUMENTATION AND TRAINING AT ILCA

by

Dr. Branckaert, (ILCA)

Documentation:

Among the tasks which have been assigned to ILCA, documentation occupies an important place and in this regard it has been indicated that ILCA should ensure full uniformity with the technical services of FAO.

The Documentation Team will, of course, offer permanent support to ILCA's researchers. In the field of animal production and production systems it will:

1. Provide a question-and-answer service to benefit, in the first place, researchers, centres and departments operating in tropical Africa;
2. Ensure the broad dissemination of selected information;
3. Publish synoptic monographs for direct application.

The goal is to ensure the best use of, and to improve, information received from national and international centres, and to gaurantee them a just return; also to ensure the speedier and easier utilisation of results by researchers and specialists in animal production.

In terms of detail, seven areas were identified in which ILCA should start gathering information:

1. Transhumance;
2. Evaluation of rangeland;
3. Rangeland mapping;
4. Humanities studies;
5. Epidemiology;
6. Zootechnical experimentation; and
7. Fodder crops and rangeland improvement.

Since initiation of the documentation activities did not call for substantial resources, ILCA, in agreement with the Direction of the Documentation and Information Division of FAO, took the initiative of proposing a meeting in Rome of the heads of the main documentation centres in the field of tropical agriculture and livestock.

The prime objective of the meeting was to enable ILCA to set up, together with the other centres, an information network which would prevent duplication and ensure maximum use of the mass of documents already gathered and classified. The second objective was to enable ILCA to

ascertain the state of progress on the Thesaurus on Animal Production using FAO project AGRIS II.

All the participants (FAO - Division of Documentation and Information, Division of Animal Production and Health, Division of Agricultural Production) stated their readiness to help ILCA and put forward proposals.

Accordingly, the Musee Royal de l'Afrique Centrale in Tervuren, Belgium, offered ILCA and forwarded to it in January 1975, bibliographical analyses and summaries relating to the following matters: cross-breeding results; livestock raising methods; improvement of soils; pastureland and feed crops; prevention of disease.

IEMVT in France supplied a list of selected documents on livestock raising which, beginning 1975, can be sent to ILCA in the form of microfiche. In addition, the Institute presented as a gift a provisional thesaurus on animal production in the tropics which may provide a basis for the preparation of a more comprehensive thesaurus.

OMVS in Senegal, the Royal Tropical Institute in Amsterdam, the Commonwealth Agricultural Bureaux, the Documentation Centre of the University of Hohenheim in Stuttgart and the Centre of Veterinary Medicine in the University of Edinburgh proposed a selected list of documents relating to fields mentioned above.

In the field of economics, an initial activity has been carried out with the ECA library; the preparation of a list of available works on animal production. This list contains some 200 reports, half of which were published over ten years ago and are of use only as archive references. Almost 30 reports and studies have been summarized, most of them relating to the livestock-raising industry in the countries of eastern and southern Africa. A start has been made on an economic bibliography on livestock raising prepared from bibliographical sources.

On the basis of the recommendations adopted by the meeting organised by ILCA in Rome, March 1974, the work carried out to prepare a an ILCA classification has been along two main lines: (i) compatibility with the new FAO international systems; and (ii) capability of future automation. Accordingly, a project has been prepared using the categories and codes of AGRIS (Agricultural Information System) supplemented by keywords. (The AGRIS clssification, which is very comprehensive in certain areas, is inadequate as far as livestock is concerned). The use of keywords should make it possible to prepare a thesaurus on livestock compatible with the codified language used in AGRIS II: this would facilitate automatic translation of summaries into several languages. Contacts have been initiated with documentation centres already working actively in the AGRIS network in order to secure detailed information on their methods of indexing and data processing with a view to achieving easier co-operation and benefiting from their experience. For the moment a manual index has been prepared which will make it possible to begin classification and research.

At the January meeting of West African librarians and documentalists, held in Ibadan, ILCA undertook to play the role of specialist centre on livestock in the AGLINET (Agricultural Librarian Network). In December ILCA took part in the consultation of experts on Tropical AGRIS. It is part of the working group on animal production.

The ILCA library has received the following in the form of gifts;

a) Amongst others, complete sets of the following journals and reviews -
   Journal of Dairy Science - 1934 to 1973 and index;
   Journal of Animal Science - 1945 to 1973
   Journal of Heredity - 1920 to 1971
   Dairy Science Abstracts - 1958 to 1970 and index

b) From IEMVT: a set of about 1100 colour slides on livestock in Africa; one print of a 16 mm sound film in colour on livestock and transhumance in the Sabel, 'L'an prochain l'herbe sera verte'; a set of about 100 basic works constituting a basic library; the series of Manuel et Precis d'Elevage comprising eleven titles and a complete bound collection of the Revue d'Elevage et de Medecin Veterinaire des Pays Tropicaux from 1947 to 1974.

c) From the Distribution Service of the Ministry of Co-operation in Paris: about 50 books and publications, including dossiers of economic information on eleven African countries; statistical data and reports on planning methodology; a collection of Techniques Rurales en Afrique and various manuals on extension.

d) From USAID: A.I.D. Research Abstracts; A.I.D. Memory Documents; A Directory of Institutional Resources and A.I.D. Research 1971 to 1973.

e) From the Belgian Government: an ecological index of observation stations in Zaire.

f) From Dr. Pagot: a reference collection of almost 2,000 black and white negatives on 'livestock and the African environment', prints of which may be requested from IEMVT; A set of about 100 books from his personal library and manuscripts.

ILCA has issued a descriptive booklet concerning its origin and activities. Professor Jay W. Forrester of the Massachussetts Institute of Technology has given permission for his book Principlies of Systems (Wright Allen Press, September 1973) to be translated into French and published by a publisher willing to distribute it widely. A translation by Dr. Tacher will be ready for printing by the end of 1975.

Training

The principle that ILCA should organise seminars on topical matters to enable the participants to exchange information and techniques and to coordinate their activities was decided upon by the Board of Trustees at its first meeting.

As tropical Africa possesses meeting and lodging facilities, the Board felt that ILCA could organise, without delay, a seminar on evaluation and mapping of tropical African rengelands. This decision was justified on the grounds that several teams of researchers were working on the subject and that, if there was some convergence in methods, the presentation of the results would be such that specialists in planning and integrated development could be better equiped to make unequivocal choices. In addition, there was a need to evaluate, with complete objectivity, the reliability of certain new methods of remote sensing.

The seminar was scheduled for January 1975, However, in order to avoid over-lapping with the meetings organised by other international organisations, it took place from 3 to 8 March, 1975, in Bamako. It was attended by 82 participants from 18 countries on five continents, including 30 African researchers. The application of active working methods in groups with rapporteurs and discussion leaders led to fruitful discussion. After the general debates, limited-sized discussion groups drafted conclusions on each of the themes. For the six themes on the agenda, 46 papers were received covering 315 typed pages. A visit to the Niono region allowed the participants to see the hydro-agricultural facilities of the 'Office du Niger' and note, on the spot, the quality of Sahelian pastures during the driest part of the year. They were able to discuss the reliability of their evaluation and cartographic methodes.

The Government of Mali provided generous hospitality to the participants in the seminar, who enjoyed excellent working conditions and lodging facilities. As a result of the loan by the FAO office in Accra of simultaneous interpretation equipment, the participants derived maximum benefit from their work. The conclusions of the seminar are currently being disseminated and the publication of the records should be complete by the end of 1975.

DISCUSSION

A participant from the floor thanked the speakers for their clear presentation on the development and objectives of ILCA. He then went on to bring to the attention of the meeting some of the people who had helped in getting ILCA established in Addis Ababa. Ato Yohannes Habte who in 1969, when the location of ILCA was being drawn away from East Africa to West Africa, made a tremendous effort getting Addis Ababa recognized as the possible centre for both ILCA and INRAD. However politics is such that INRAD and ILCA have two separate locations. Another person who has made a substantial effort behind the scenes is, Mr. Hamersley, the Project Manager of IAR, formerly SAA/FAO of UNDP. In the years of 1970 and 1971, when the situation in Ethiopia was rather confused, he and others made a firm stand that Addis Ababa could offer the environment for the development of such an important institution which would not only contribute to Ethiopia but to the whole of the rest of Africa.

Although the idea of ILCA was finally developed from the reports of the consultative groups a number of discussions had taken place prior to the work of these groups. Unfortunately we almost lost ILCA because of our previous Government's lack of action. Therefore it is appropriate to congratulate the present Government on its speedy and forward thinking action in enabling ILCA to be established in Ethiopia. Ethiopians, in general, tend to play a rather a passive role, but having heard of the tremendous possibilities of ILCA, which is probably the number one institution for livestock development in the world, we should therefore give it all our active support. Truly in the past livestock research has been neglected in this country but now we have the chance through our own enthusiastic support and participation in ILCA activities to give Ethiopian livestock research a boost. He concluded by wishing ILCA well in its future ventures and hoping that the Government would give it every support in its activities.

Dr. Shenkute thanked Dr. Melak for saying things that could not have been said by the speakers. He thanked the contributer on the behalf of the ILCA staff for his encouraging remarks and he also thanked Dr. Melak-Haile Mengesha for his own efforts in working behind the scene to get ILCA established. He assured the seminar participants that the present Government is doing all it can and is going out of its way to help ILCA establish itself without any problems at all.

The priority as far as ILCA is concerned for its programme in Ethiopia, is the drought affected areas. Apart from identifying the production parameters, how is ILCA going to help the national programmes? Will it establish research centres or strengthen existing or new research programmes? Dr. Shenkute replied that the priority for ILCA's programmes in Ethiopia were to develop animal production systems for the drought affected areas. At the moment ILCA is negotiating with the Livestock and Meat Board people to monitor and evaluate the nomadic rangeland development programmes. This project is going to be financed by the World Bank in the order of US$40,000,000 and should become operational sometime in January 1976. In this programme ILCA will monitor by taking time series data to see if the development work is going in the right direction. ILCA will do a cost benefit analysis, will study the sociological changes which have occured in that area and the development inputs, such as range development or provisinn of water or

may be even the fattening of livestock in some of the offtake areas. From the analysis of the time series data it will be possible for the Livestock and Meat Board to examine the results and change their approach as and when appropriate. The second aspect of the work there will be to introduce new technologies, for example, to bring new forage species and try them out and do research on the land so as to keep ahead of the development. Thus when the programme is ready to implement new developments ILCA will be ready with some answers for them.

ILCA was asked for further clarification on their programmes - whether they are going to be able to finance the existing programmes apart from carrying out monitoring on the livestock production system. Dr. Shenkute replied that ILCA's approach is a systems approach; they are not going to use the classic approach of studying livestock breeding or nutrition or one of the other fields, as is being done at research institutions. ILCA is interested in taking problems that cover all aspects of an animal production system. It is also within the terms of reference of ILCA to bring funds to research stations but it has to be convinced that in doing this it is filling a gap that can not be done by the existing institutions or by Government. This is covered in terms of reference from the Board of Trusties, to quote: "it will support, supplement and cooperate with existing national and regional research stations, and programmes in developing a fully cooperated programme of production and rangeland research which is related to the urgent needs of livestock development. However, a word of caution, it is not in the interest of ILCA to solve local problems, e.g. a problem that is unique for a very small locality, for example the highlands of Ethiopia have unique characteristics and if the research that is carried out in the highlands cannot be applicable to another area of highlands such as Kenya, then ILCA would give the problems of such an area a very low priority. ILCA is basically interested in research that is applicable on a regional basis, Africa as a region, or the Sahel as a region.

Dr. Shenkute was asked about the utilization of money for land in developing ILCA. Dr. Shenkute replied the 10 hectares of land which had been given to ILCA at Shola was only for head office and laboratory complex. There would be no research per se at this head office ILCA was going to carry out it's research in the areas where it was carrying out it's programme.

THE ROLE OF CROP RESIDUES IN LIVESTOCK PRODUCTION SYSTEMS

By

P.B. O'Donovan
(FAO Cattle Production Officer, IAR)

Although the data to be presented in this paper were not collected in Ethiopia, they have particular relevance to this country. The results of experiments have been purposely selected for those crop residues which are widely available in Ethiopia and for that reason can make a significant contribution to livestock feeding.

Crop residues can play a variety of roles. They may be fed in intensive systems of production in which the particular residue, adequately supplemented, forms the principle feed. Residues may also be looked upon as feeds which 'bridge the gap' during the dry season when natural forage is usually in short supply. In dicussing crop residues, emphasis will be placed on those which, (a) are available in large quantities and, therefore, are economically important, and (b) are low in cost, thereby reducing the cost of milk and meat production.

There is generally a surplus of pasture growth during the rainy months and an acute deficit during the dry months. Every effort should be made to conserve the surplus as silage and/or hay for dry season feeding so that animals will have a uniform feed supply throughout the year.

It is not always possible or a sound practice economically to have sufficient conserved feed for they season. Assuming that this is the case, there is little alternative but to supplement the animals with locally-available crop residues. It is not necessary to feed animals on a very high plane during the dry season if they will graze during the subsequent grass-growing season (Table 1). Animals which maintain their liveweight during the dry season compensate on grazing and this is referred to as 'compensatory gains'. A low to medium level of feeding during the dry season makes the minimum demand on the feed at a time when there is usually little available.

Table 1. Effect of Feeding Level During the Dry Season on Subsequent Gains on Pasture [a]

	Feeding plane during dry season (Feb. 1 - May 31)			
	High	High	Medium	Low
Av. daily gain (kg)	0.66	0.64	0.50	0.0
	High	Grazing (June 1 - Oct. 31)		
Av. daily gain (kg)	0.66	0.29	0.32	0.79
Daily gain (Feb. 1 - Oct. 31)	0.66	0.45	0.40	0.45

a/ O'Donovan et al. (1973)

Cereal straws, of which there are large quantities in Ethiopia are deficient in several nutrients and, therefore, are of little value when fed as the only source of feed. However, very satisfactory results are obtained when they are adequately supplemented, especially with molasses which increases straw palatability. The results of feeding straw-molasses based diets to growing dairy heifers (high-grade Friesian) are shown in Table 2. Straw and molasses combined formed more than two-thirds of the total ration and very satisfactory gains were obtained with ration B. Lower gains resulted from increasing the molasses percentage from 33 to 45.

TABLE 2. Straw and molasses-based rations for dairy heifers [a]

Ingredients, %	Rations [b] A	B	C
Rice straw (chopped)	25	35	35
Cane molasses	25	33	45
Sweet potato chips (dried)	30	18	10
Soybean meal	20	14	10
	100	100	100
Dairy heifer gains (kg)			
Feeding test No.1	-	0.58	-
Feeding test No.2	0.71	0.82	0.46

a/ O'Donovan and Clen (1972)

b/ Urea was added (20 g/kg feed, rations A and B and 25 g/kg feed for ration C) plus bone meal, salt and vitamin A.

It is a well known fact that straw utilisation and animal gains decrease beyond a certain straw percentage in the ration (Table 3). There were no significant differences in performance and dressing percentages between lambs fed either 10 or 20% straw but a significant reduction occurred in the rate of gain when 30% straw was fed. This finding of a performance reduction somewhere between 20 and 30% straw level is supported by results from a number of countries.

TABLE 3. Performance and dressing percentages of fat-tail lambs fed different straw percentages - 93 day experiment[a]

	Straw, %		
	10	20	30
No. of lambs	38	37	38
Initial Wt. (kg)	31.2	32.2	30.8
Final Wt. (kg)	45.6	46.9	42.7
Daily gain (g)	154	159	127
Kg feed/kg. gain	9.8	9.8	11.3
Kg DM/kg gain	7.1	6.9	7.4
Dressing Percentage	54.5	53.5	53.1

a/ O'Donovan and Ghadaki (1973)

It was of interest to determine through experimentation the extent to which straw must be supplemented in order to provide satisfactory nutrition for ewes during early pregnancy. As shown in Table 4, straw supplemented with either 200 grammes of molasses or the latter plus 30 grammes of urea did not prevent a considerable bodyweight loss. On the other hand, the substitution of urea by 200 grammes of cottonseed meal promoted satisfactory gains. The small amount of protein supplement resulted in a significantly higher straw consumption.

TABLE 4. Straw plus supplements for ewes during early pregnancy[a] (Phase 1 - 49 days)

	Chopped wheat straw(to appetite)			Control
	200 g molasses	200 g molasses 30g. urea	200 g molasses 200 g. C.S.M.	Alfalfa hay (1 kg) 200 g. Conc.
Initial Wt. kg	51.0	53.0	52.9	51.4
Final Wt. kg	45.6	47.8	53.8	53.1
Gain or loss in wt.	-5.4	-5.2	+0.9	+1.7
Daily gain/loss, g.	-110	-106	+1.9	+3.5
Straw intake, g/ewe/day	608	718	918	-

a/ Ghadaki, O'Donovan and Behesti (1972)

Some results involving the feeding of molasses have already been presented. In addition to molasses, the sugar cane plant yields a variety of residues. The cane tops, separated in the field, can provide a very useful source of green feed. Cane tops are not fully utilized in Ethiopia, even though the only cost involved is in their collection from the field. Feeding trials were conducted to determine the feeding value of cane tops for both dairy cows and beef cattle; the results are given in Table 5. When properly supplemented, they are sufficient for maintenance and the production of about two kilogrammes of milk a day; maintenance and up to 200 grammes daily weight gain were obtained with beef cattle. The performance was similar to that obtained with average-quality Pangola grass silage. The sugar cane residue called bagassa, presently burned as fuel, can, when mixed with molasses, form the basis of fattening diets for cattle.

Table 5. Composition and Feeding Value of Sugarcane Tops[a]

	DM %	C.P. %	Intake (kg) (dairy cows)	Milk prod. or daily gain
Sugar Cane tops	30	5-6	30-33	Maintenance + 1-2 kg milk
				Maintenance + 0.2 kg gain
Pangola grass silage (average quality)	28	6	28-30	Similar performance to above

a/ O'Donovan (1970)

The production of such large yields of energy from sugar cane has, in recent years, led to the exploration of ways of utilizing whole sugar cane as a livestock feed. Machinery has been developed for separating the outer fibrous part of the cane from the inner more nutritious part called the pith. Other cheaper attempts at improving the nutritional value of whole sugar cane consists of lacerating or bruising the outer fibrous layer and this method is presently yielding good results. Instead of growing pasture and forage crops, farmers may instead grow sugar cane on a small part of their farmers, not just for the sugar factory as is traditional, but to feed their livestock.

Because of the demand for maize grain as a human food, the entire plant should not be used just to feed animals since then the livestock would compete directly with people. There are, however, a number of valuable maize residues. The green residue, directly after the grain harvest, has a high nutritive value, especially if it is harvested before it wilts. It could be fed fresh but ideally should be ensiled to obtain a uniform quality product. Corn stover is the residue remaining (usually wilted to varying degrees) after the grain is harvested. Because of its low protein content, 3-5%, a protein supplement must be added. Up to 50% corn stover may be included in cattle finishing rations. The fibrous part remaining after the grain in threshed from the ear is called corn cobs. Although it contains little or no protein, it may form up to 30% of rations and it should preferably be fed with molasses to increase palatability.

After the fibre is extracted from the sisal plant, the high-fibre residue may be fed with supplements to cattle. There is a sisal factory at Awassa where the residue has been fed experimentally; up to 30 kg of fresh residue was consumed daily. Other residues of some importance in Ethiopia include haricot bean haulms, coffee hulls and pulp.

Most of the residues mentioned are of great importance for livestock feeding in Ethiopia. Consider, for example, the total production of cereal straws, particularly teff, wheat, barley and oats; when supplemented (as shown in the tables) these straws can contribute to the finishing of large numbers of animals, or carrying them through the dry season, when alternative feeds are scarce.

Based on the total production of molasses in Ethiopia and assuming 3 kg/animal is fed during a one hundred-day fattening period, there is sufficient molasses to fatten about 140,000 cattle annually. Assuming, 6 kg of dry matter from sugar cane tops is fed per animal for 100 days, the quantity is sufficient to feed more than 100,000 cattle. Suppose that four fifths of the total bagassa is used as fuel, the remaining one fifth could constitute a basal ration for 140,000 cattle. Likewise each hectare of corn stover could feed 30-40 cattle. Of course all of the estimates given assume that, in addition to the crop residue, an energy and protein supplement is also fed.

From what has been said, therefore, it is obvious that, while crop residues are not a complete substitute for pasture and forages, they can play a very useful role in livestock feeding. Ethiopia has a vast resource in this respect and the wide variety of residues can be fed to good advantage. They may provide essential feed to sustain animals during the dry season or to 'finish' rather thin cattle from over-grazed, pasture for a period of 3-4 months.

RESULTS OF FEEDING TRIALS WITH CROP RESIDUES IN ETHIOPIA

by

Ato Alemu Gebre Wold
(Animal Production Section, IAR)

A wide variety of crop residues are available in Ethiopia and many of these may be exploited for livestock feeding. At present they are only partially utilized or not used at all. Because of their generally low protein and high fibre contents, satisfactory animal performance is dependent on the supplementation of residues with concentrate to provide energy and protein.

Results are reported for three feeding trials as well as observations of silage making. The chemical composition, state of preservation and palatability to livestock were among the criteria for evaluating the silages.

A 116 day 'finishing' experiment was conducted at Holetta involving five groups of eight native animals per group. In each case the residue comprised 50% of the entire ration; the remainder being molasses (20%), noug cake (25%), bone meal/meat meal mixture (4%), salt (1%) and a vitamin supplement. The residues evaluated were teff straw, wheat straw, oat hay, native hay and oat silage (Table 1.). The performance, shown in Table 2 indicates that the highest daily gain was achieved with the teff straw treatment (628 g), followed by native hay (477 g), oat silage (449 g), oat hay (430 g) and wheat straw (352 g). With all, except the oat silage treatment, feed intake was positively correlated with the rate of gain, varying from 6.9 kg/day for the steers on teff straw to 5.0 kg/day for those fed with wheat straw. The rather low feed intake on the oat silage treatment is difficult to explain particularly in view of the satisfactory rate of gain achieved. As might be expected, the most efficient gain (11 kg of feed/kg liveweight gain) was observed among steers fed teff straw and, with the exception of oat silage, efficiency of gains was related to the average daily gains. Feed costs, which at best can be regarded only as rough estimates, varied from Eth.$0.34 for the teff straw treatment to Eth.$0.60; the cost does not include any charge for the residues.

Table 1. Rations Fed[a/], Crop Residue Study, Holetta 1975
(8 native animals/treatment)

Ingredients, %	Teff straw	Wheat straw	Oat hay	Native/ hay	Oat Silage
Crop residue	50	50	50	50	50
Molasses	20	20	20	20	20
Noug Cake	25	25	25	25	25
Bone meal/meat meal mixt.	4	4	4	4	4
Salt	1	1	1	1	1

a/ 'Dohyfral' vitamin supplement (0.05%) was also included.

TABLE 2. Animal performance, crop residue study, Holetta 1975
(116 day experiment)

	Teff straw	Wheat straw	Oat hay	Native Nhay	Oat silage
Av. init. wt. (kg), 17/5/75	186.0	185.0	182.0	184.3	175.6
Av. final wt.(kg), 10/9/75	258.8	225.9	231.9	239.6	227.7
Av. daily gain, g.	628	352	430	477	449
Av. feed intake/day, kg	6.9	5.0	5.5	5.9	9.5*
Kg. feed per kg. l.w. gain	11.0	14.2	12.8	12.4	21.2*
Feed cost per kg. l.w. gain $	0.34	0.44	0.60	0.58	0.60

* Fresh silage weight and supplement.

Carcass data (Table 3) were obtained from two animals on each ration. Dressing percentage was lowest for the wheat straw treatment (47%) and ranged from 51 to 53.7 for the other treatments. Edible meat ranged from about 76 to 80%. Because of the small number of animals selected and the considerable variation in the genetic material, not much reliance can be placed on the carcass data.

TABLE 3. Carcass Data, Crop Residue Study, Holetta 1975.
(2 animals per treatment)

	Teff straw	Wheat straw	Oat hay	Native hay	Oat silage
Av. final l.w. (fasted), kg.	258.0	235.0	239.5	237.5	230.0
Av. carcass wt (cold), kg.	135.5	108.5	122.2	127.5	122.7
Dressing percentage	52.5	47.0	51.0	53.7	53.3
Outside fat, %	5.0	3.0	4.3	2.8	4.7
Edible meat, %	76.4	77.4	76.8	80.5	78.1
Bone, %	17.0	20.2	17.7	16.5	17.1

A second 'finishing' experiment, of 100 days duration, was conducted at Adami Tulu with four groups of ten native cattle per group. The crop residues fed were haricot bean haulms, corn stover, teff straw and corn cobs; each comprising 50% of the ration. The type and level of concentrate supplementation was identical to that of the Holetta experiment (Table 4). In this particular study the highest daily gain was obtained with the corn cobs (541 g) followed by haricot bean haulms (505 g), teff

straw (438 g) and corn stover (409 g). The respective feed intakes, in kilogrammes per animal daily, were 7.4, 7.4, 6.9 and 6.1 (Table 5). As in the previous experiment, the highest feed consumption was observed among the animals having the highest rate of gain. The quantity of feed consumed per kilogramme of liveweight gain ranged from 13.7 to 15.8 and the groups having the highest gains were also the most efficient convertors of feed consumed. Discounting the cost of residues, feed costs per kilogramme of liveweight gain ranged from Eth.$0.42 to 0.49.

TABLE 4. Rations Fed[a/], Crop Residue Study, Adami Tulu 1975
(10 native animals/treatment)

Ingredients, %	Haricot bean haulms	Corn stover	Teef straw	Corn cobs
Crop residue	50	50	50	50
Molasses	20	20	20	20
Noug cake	25	25	25	25
Bone meal/meat meal mixt.	4	4	4	4
Salt	1	1	1	1

a/ 'Dohyfral' vitamin supplement was also included.

TABLE 5. Animal Performance, Crop Residue Study Adami Tulu 1975
(100 day period)

	Haricot bean haulms	Corn Stover	Teff straw	Corn cobs
Av. init. wt. (kg)	193.0	192.5	192.2	190.0
Av. final wts. (kg)	243.0	233.0	234.5	243.0
Av. daily gain, g.	505	409	438	541
Av. feed intake/day, kg	7.4	6.1	6.9	7.4
Kg. feed per kg. l.w. gain	14.7	14.9	15.8	13.7
Feed cost per kg. l.w. gain ($)	0.45	0.47	0.49	0.42

Carcass analysis was performed on two randomly selected animals from each treatment (Table 6). Dressing percentages did not vary greatly between types of residues fed (55.2 to 56.6%). Only small differences were also observed in the percentages of fat, edible meat and bone. Carcass data must be regarded only as guide because of the reasons stated earlier.

TABLE 6. Carcass Data, Crop Residue Study, Adami Tulu 1975
(2 animals per treatment)

	Haricot bean haulms	Corn stover	Teff straw	Corn cobs
Av. final l.w., kg	230.0	196.5	212.0	239.0
Av. carcass wt. (cold,) kg	127.2	109.3	118.5	130.3
Dressing percentage	55.4	56.2	56.6	55.2
Outside fat, %	2.6	2.8	3.6	3.7
Edible meat, %	77.2	75.3	77.4	75.8
Bone, %	18.1	18.8	16.1	17.3

Liveweight increases throughout both experiments are shown graphically in Figure 1. The levelling off in gains after 100 days in the Adami Tulu experiment could, to some extent, be attributed to the wet conditions in the pens at that particular stage of the experiment; the tendency to put on fat, which requires more feed, is also a contributory factor to the reduced gains. The reduction in gains, between day 100 and day 120, in the Holetta experiment, were not nearly as marked.

An experiment was conducted in collaboration with the Awassa Experimental Station to determine the value of sisal residue fed in two different forms to local steers. Sisal residue was fed both in the fresh state and after it had been ensiled with corn stover; each was supplemented with haricot bean haulms, sunflower cake and minerals. Six Boran steers were randomly assigned to the two treatments. Average daily gains were 365 and 279 grammes, respectively (Table 7). Feed consumption, expressed as a percentage of liveweight, was identical for both treatments (2.4), while the respective dressing percentages were 50 and 51.4. The feed costs per kilogramme of grain were 35 and 36 cents. This experiment was merely a pilot study with a very limited number of animals and more detailed experiments are needed with a larger number of animals to evaluate the mixtures critically. The performance of animals throughout the experiment is shown graphically in Figure 2.

TABLE 7. Performance of animals fed fresh sisal and sisal/corn stover silage mixtures

	Fresh sisal waste mixture[a/]	Sisal waste/corn stover silage mixture[b/]
Days on experiment	126	86
Av. initial liveweight, kg	190	253
Av. final liveweight, kg	236	277
Av. daily gain, g	365	279
Ration intake, % of l.w.	2.4	2.4
Dressing percentage	50.0	51.4
Feed conversion[c/]	14.1	21.5
Feed cost/kg gain, cents	35	36

a/ Mixture was 90.5% fresh sisal waste, 4.4% haricot bean haulms/teff straw and 5.1% sunflower cake. (Minerals free-choice).

b/ Mixture consisted of 87.1% sisal/corn stover silage, 6.6% haricot bean haulms and 6.3% sunflower cake (Minerals free-choice).

c/ Kilogram of feed required to produce a kilogram of gain.

An observation trial was conducted in Sidamo Province to determine the quality of silage made from coffee pulp and a mixture consisting of coffee pulp, corn stover and haricot bean haulms. Each of the two silage types was supplemented with concentrate and fed to three native steers. Average daily consumption was 7.8 kg for the coffee pulp silage and 11.1 kg for the mixture. No performance data were collected because of the absence of weighing scales. The trial indicated that silage made from coffee pulp has an acceptable palatability. Because this latter residue is available in large quantities in this part of Ethiopia, much more study on the most suitable mixtures for cattle feeding are required.

FIGURE 1. Liveweight Increases Throughout Experiments at Holetta and Adami Tulu

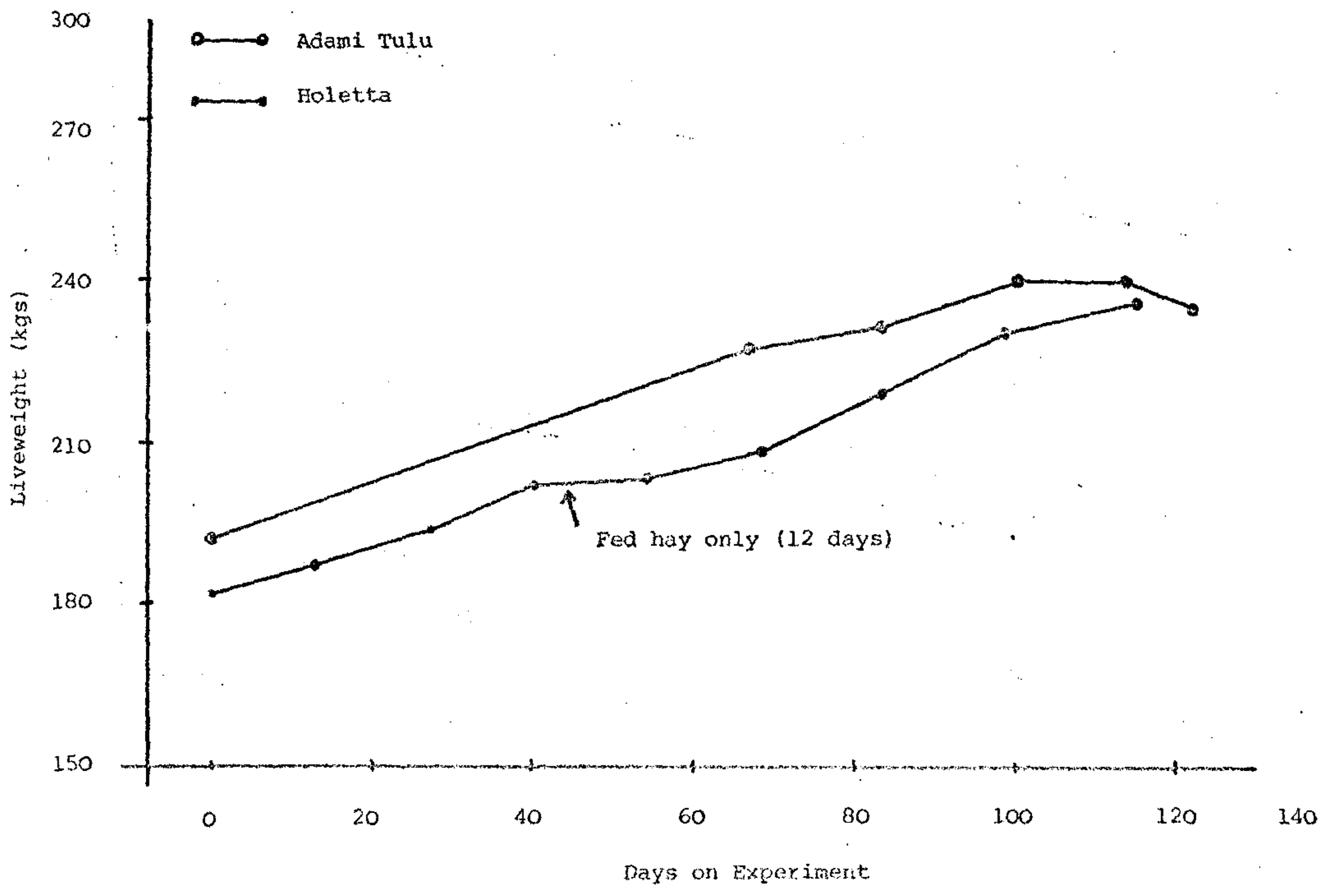
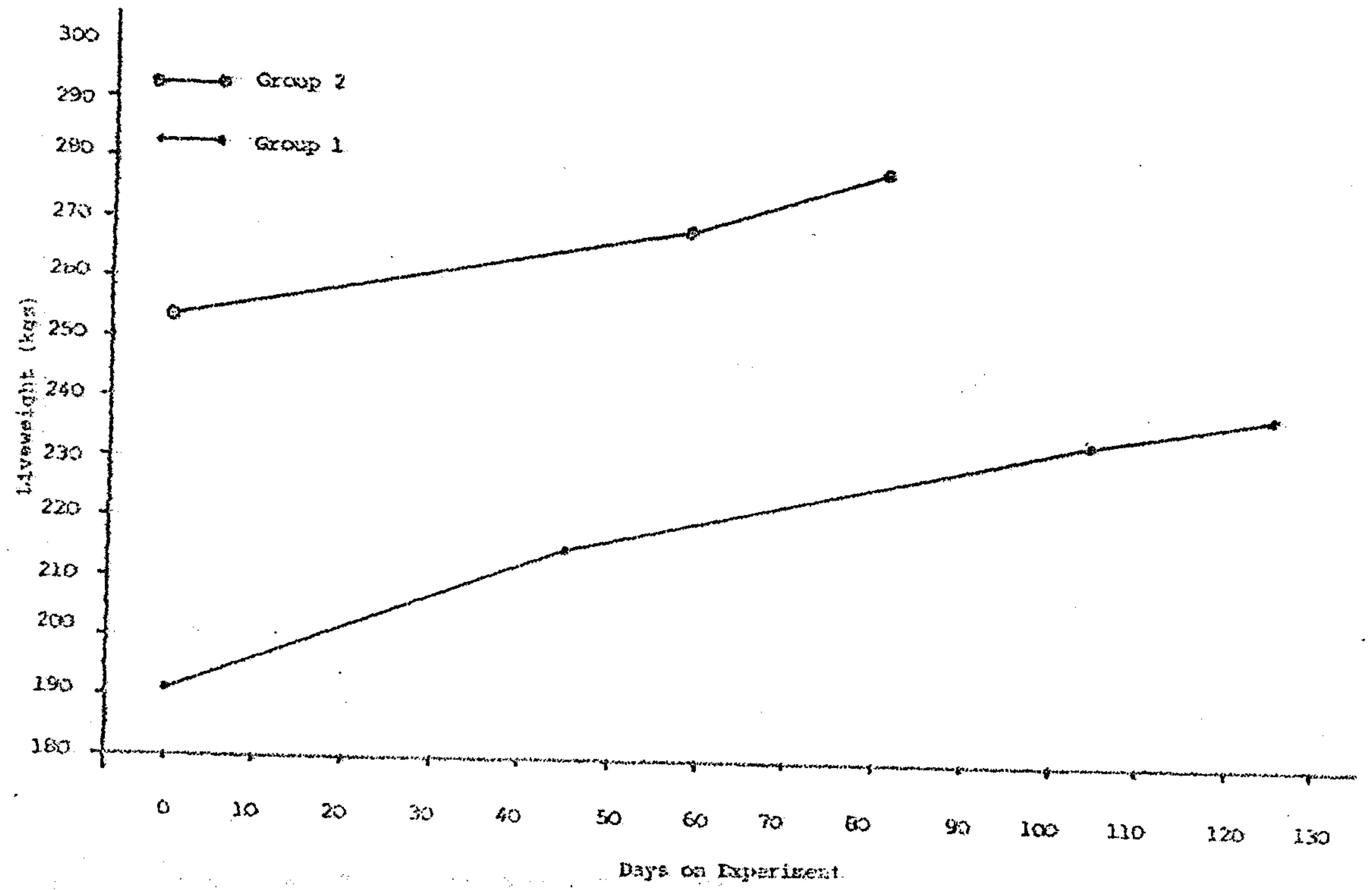


FIGURE 2. Liveweight Increase Throughout Experiment at Awasa



DISCUSSION

The speakers were asked about the economic aspects of their trials with coffee pulp. Ato Alemu replied that this was purely an observatinn to find out if the animals were able to eat these materials. In the coming year it was intended to do an intensive study. The coffee was used as pulp and was kept for 24 hours before it was made into silage.

It was commented that in many parts of the country, particularly areas such as Tigre, the peasant farmer depends very largely on the crop residues for feeding his animals during the dry season. For many of these farmers, even though the nutrient content of this residue is low, this is the only source of feed he has available for his animals and it would be very difficult for him to use such things as molasses and cake to improve their feed.

Dr. O'Donovan commented that the speakers had given a conservativ estimate (30 - 40 animals) for the carrying capacity of corn stover, this was based on liveweight production. In their studies the crop residues had been fed at 50% of the complete ration, this had been purely for a finishing experiment. One could conceivablly feed much more than 50% crop residue if one wanted to just maintain the animals. In fact as had been shown in the paper, animals that are just maintained in the dry period on the maintenance ration when they are put onto natural grazing during the wet season, they outgain the animals that have been on a higher ration during the dry season. This is infact the practice, not only in Ethiopia but in many other areas. As regards the comments on Tigre he was well aware from speaking to other people that this was the only feed available for the animals during the dry season in this and many other areas of Ethiopia. There are many possibilities in the utilization of crop residues and it is not at all necessary to feed a lot of cake. This may have to be the case if you want to finish the animals for selling for meat but how this is done depends absolutely on the circumstances.

A participant from HVA, Wonji-Shoa, commented that 30% tops was far to high a figure for Ethiopia. He estimated that there was only a 5% offtake in the form of tops from sugar cane grown at Wonji Shoa; the slide that has been shown must have been from a region with a much higher rainfall where the growers had to take a far higher proportion of tops. In Ethiopia this is not the case; almost the complete cane is used in processing sugar. Of the tops that are produced in Ethiopia, people do come and collect them on an individual basis for feeding to their animals. With only a 5% offtake it would be a very expensive opperation for the factory to do this on a large scale. In one campaign the farm produces about 60,000 tons of cane and 5% of this is a very small quantity.

Dr. O'Donovan replied that he had been to Wonji and had seen the situation there and he appreciated the fact that 30% was a high figure. This figure has been calculated over a wide range of sugar growing areas. It depended also on the initial yields and he appreciated that the yield at Wonji may be much lower. He had only brought in this aspect because this is a feed that is used in many places. Whether it is possible to use this material as feed or not depends almost entirely on the economics of the operation; if it is cheap to collect tops then it is a feed that is available for practically nothing and it is a good quality feed, as good as Pangola silage. In Wonji there is an almost eight months period of harvest, it is not being suggested that you transport cane tops 100 kilometers but it is suggested that they could be used locally in a feed lot situation. It would be good if an economist could put a figure on this. The speaker from HVA replied that this has been studied and the livestock section was considering it. (This topic is covered further on in the Seminar Proceedings in the paper on diversification at HVA.)

The speakers were asked to comment on which of the residues in Ethiopia has given the best results so far. Ato Alemu replied that you can not make a general recommendation, it depends on what crops are grown in a given locallity. For example if you recommend teff this would be out of the question for the Awassa region. In maize growing areas the corn cobs might be feasible but one has to bear in mind the cost of handling this material and the cost of feeding. In using corn cobs they either are ground so that they are acceptable to the animal or, as has been done at Holetta and Adami Tulu, soak them over night then sprinkle mollasses over the cobs before they are fed to the animals which enable the animals to eat the cobs. In the highland where teff and other crops are grown teff has so far been found just as good as corn cobs and it is often the only type of crop residue available in highland localities.

The speakers were asked about the hemegeneity of the animals used in their trials. Ato Alemu replied that the animals were not homogenous; they were purchased from the local market and this was all the people could do under the circumstances but as a fairly large number was being used in each treatment it has been felt that the differences could be taken care of.

The speaker was also asked why the animals doing best at Holetta had been given teff straw but the group fed on teff straw at Adami Tulu had not done as well as some of the others. Ato Alemu replied that the people carrying out the study had not been able to find a clear explanation for this. There were very many factors involved. Dr. O'Donovan commented that teff straw had been found higher in protein (upto 5-6%) than other straws and this may infact be responsible for the better performance of the group fed on teff straw at Holetta.

CATTLE CROSS-BREEDING EXPERIMENT

by

Beyene Kibede - (IAR - Holetta)

The cross-breeding experiment with cattle started to become operational about two years ago and this is, therefore, no more than a very preliminary progress report on what the experiment is about and provide a look at the first results.

The purpose of the experiment is to find out, for Ethiopian farming conditions, what are the most suitable breed combinations for milk and meat production jointly and what breeding policy to follow after the obvious first cross.

It had been decided, on the basis of the assessment of some of our own zebu breeds in earlier years, that it would be too big and too slow a task to improve the national average level of milk production by using the native zebu breeds alone. It was decided, therefore, to use a combination of zebu and exotic breeds in a cross-breeding programme to find out whether there are:-

- differences in merit among exotic breeds of sire
- differences in merit among zebu breed of dam
- differences among Stations representing different climatic and farming types.

The use of different Stations representing different climates and types of farming is to assertain whether breeds rank differently in overall merit at different Stations and whether, in terms of breeding, what is good for one part of Ethiopia is also good for another.

It was not of course, possible to use all breeds in all possible combinations and, therefore, the choice was restricted to 3 zebu and 3 exotic breeds each of which represents, to some extent, a different type.

Thus for the zebu Barca, Boran and Horro and for exotic Friesian, Jersey and Simmental, were chosen.

The Friesian was chosen because it is the most widely accepted dairy breed and with also very acceptable meat as a by-product.

The Jersey, because it is a small breed, may be at a relative advantage to large breed when nutrition is the limiting factor and also because it may be better adapted to hotter regions. (per kg body weight the small Jersey may well yield as much total milk solids as the Friesian).

The Simmental was chosen because it may be superior to the Friesian in growth and carcass characterstics, whilst giving an acceptable milk yield and possibly the use of the males for draft purposes.

The four locations of the experiment are: Bako, Holetta, Adami Tulu and Melka Werer. At the first two of these Stations we keep the Horro and the Boran and at the other two Boran and Barca. Each exotic breed is used at each Station and we use artificial insemination from a central pool of semen for each breed instead of the large number of bulls which would be needed for natural service.

It had been intended that, by now 150 cows would have been inseminated for the different crosses and calving would be well under way at each Station. However, except at Bako, the programme has fallen behind schedule for one or more of the following reasons:

a) quite a number of foundation Zebu females purchased were found later to be already in calf instead of ready for mating;

b) there have been some infertility problems.

c) the liquid nitrogen plant at CADU, essential to the maintenance and distribution of semen, has broken down.

The total number of calves born so far at the different stations are shown on Table I.

TABLE I. Total number of calves born

	Bako		Holetta		Adami Tulu		Melka Werer	
	Ho.	Bo	Ho.	Bo.	Bar.	Bo.	Bar.	Bo.
Friesian	23	22	16	17	14	14	14	12
Simmental	26	20	14	18	7	13	11	12
Jersey	24	26	11	15	14	10	9	12
TOTAL	68	68	41	50	35	37	34	36

The original plan also called for the production of pure Zebu calves alongside the crosses. This plan was later changed by dropping the pure Zebu matings in favour of increasing the numbers in the cross-bred groups. It is now thought that this was probably mistaken and it is intended to restore the pure Zebu matings as far as possible.

Now, instead of giving details for each Station, it was thought that it would be more informative to show some adjusted averages for the figures so far available on weights at birth and 6 months of age. Only one figure as our base line and deviations for each set of factors for each set of factors from this base line will be presented.

TABLE II. The effects of breed of dam on the cross-bred calf

	Birth Wt. (kg)	Weaning Wt. (kg)	Growth Rate (kg)
Boran	24.3	164.3	140.0
Horro	-1.6	- 12.1	-10.5
Barca	+1.1	+6.7	+5.6

Using the Boran as a base line, you see that relative to the Boran, cross-bred calves from Horro dams were a little lighter in weight both at birth and weaning and those from Barca a bit heavier in weight.

TABLE III. The effect of breed of sire of the cross-bred calf:-

	Birth Wt. (kg)	Weaning Wt. (kg)	Growth Rate (kg)
Friesian	25.4	161.7	135.7
Simmental	- 0.2	- 0.2	0
Jersey	- 4.2	-19.7	-15.5

Relative to the Friesian, the Simmental crosses, as one might expect, have performed the same as the Friesian and the Jersey crosses were lighter in weight at birth and weaning. The magnitude of the difference is of interest.

Comparing male calves with female calves, male calves were almost the same weight at birth as female calves but grew more and were 6 kg heavier at weaning.

TABLE IV: Effect of sex on crossbred calves

	Birth Wt. (kg)	Weaning Wt. (kg)	Growth Rate (kg)
Females	24.3	164.3	140.0
Male	+ 0.5	+ 6.4	+ 5.9

As far as different Stations are concerned, differences have been obtained between Stations as reflected by weight and growth of calves. Using Bako as the base line, the position is as follows:

TABLE V. Effect of station on cross-bred calves.

	Birth Wt. (kg)	Weaning Wt. (kg)	Growth Rate (kg)
Bako	24.3	164.3	140.0
Holetta	+0.3	+ 5.8	+ 5.3
Melka Werer	+1.1	-31.2	-32.3
Adami Tulu	-0.7	-11.1	-10.4

You can see that calves at Holetta grew slightly faster than those at Bako but that growth at Adami Tulu was slower and at Melka Werer considerably slower. Whether these differences are attributable to differences in climate, the types of feed available or more subtle aspects of environment is too soon to say. However, it is useful to have this demonstration of differences because at the beginning, the programme was set up to find out whether what is a good breed combination in one set of conditions is also good in another.

In this context it is especially interesting to find that whilst breeds rank the same at each Station, there appear to be good indications of breed x Station interactions. For example, relative to the average differences seen, the Horro, which on average produced lighter calves, was almost as good as Boran at Holetta. Even more strikingly, the Jersey cross calves, which were on average much lighter in weight were relatively speaking much better at Melka-Werer where one might have expected this breed to have some relative advantages in terms of, say, heat tolerance and hardy conditions and it was much worse at Holetta where the climate is more temperate and feeding is different.

In the future more detailed informations will be accumulated on size, and on traits like fertility, health and survival, and ultimately on milk production and overall merit. The possibility is being investigated of splitting the experiment into two management and feeding levels so as to make the results even more relevant to a variety of farming conditions.

An experiment has been designed and started to test the merits of different zebu and exotic breeds in combinations for varying conditions in Ethiopia. Production is to be assessed in terms of milk and meat and also interms of the important overall lifetime merit.

Perhaps most importantly, but this very much in the future, the experiment ought to provide information on the best breeding policy for farmers to follow in terms of combining the best in zebu with the best in exotic cattle traits.

DISCUSSION

The Chairman thanked the speaker and commented that this was a step in producing better animals which would be able to utilize a better feed and better managements conditions that had been mentioned in the preceeding papers.

Ato Beyene was asked on what basis the collections of the indigenous types had taken place. He replied there had been a study for four to five years on the production potential of local Zebu cattle. When the breeding programme was started it was realized that it would be impossible to cover all the types of the country, therefore they had selected three breeds to represent the three broad zones, Horro for the highlands, Boran for the intermediate zone and Barca for the lowlands. These three breeds were fairly well known and thus could be used quite well in a breeding programme.

The speaker was asked if he has any idea about the level of significance in the differences between the different breeds. He replied that the figures were not amenable to statistical analysis because the numbers so far produced from the cross breeding programme were too few. The figures that had been presented were only indications of what was happening so far. Ato Beyene replied that the reason for the weight of birth, weaning, and growth being the same in tables 2, 3 and 5 were also because the number were very few and it had been thought appropriate to produce an average figure to act as a base line.

The speaker was asked how many research findings from animal work had gone to the farmers. He replied that it was an accepted fact that livestock production research takes quite a long time and the IAR has been carrying on research and nutrition studies for some time. Some of these results may have been extended but this depended on the link between extension and research. As regards the breeding programme, the Institute has been investigating the use of some cross bred bulls which could be distributed to farmers through EPID with backup advice they could be used to breed with local cows in the hopes of improving local milk supplies.

A comment from the floor was that it was felt that if one was giving a cross bred bulls to farmers one had to be aware of the level of management that the farmers were able to give to these animals. The contributor felt that unless preparation was made for the farmer to utilize these better animals then the results from such an effort as this breeding would be wasted. He was only putting this comment as a word of caution. Ato Beyene replied that this comment was very legitimate and the people in animal production research were well aware of these constraints and, given sufficient manpower and resources, they would endevour to fill all the gaps so that any research findings could be adequately used by the farmers when they are passed to them.

It was commented that in table 2 the distinction has been made between the effect of the bread of dam and the milk production of the dam. Ato Beyene replied that Barca is known to be slightly better than the other indegenous breeds in milk production and it was intended to find out what effect this had on the calves The Chairman, Dr. Wiener, also commented that the study will try to distinguish between the effect of the bread of dam on the growth rate of the calf as well as the milk production of the dam. This will be a component of the weaning weight but more information could be gained by analyzing the growth at 2 to 3 months and this will be done later. It was commented that the Barca breed at Melka Werer had not been sufficiently tested before the cross breeding work started. Another factor was that the fodder production for the animals had not become fully available. Recent studies had shown that the Barca cows with half the body weight of the exotic breed were capable of producing 5 kilos of milk a day, this gives about 1500 liters of milk a year.

A PRELIMINARY REPORT ON STUDIES TO EVALUATE THE PERFORMANCES OF ADAL GOATS AND SHEEP

By
Dr. K. Knoess
(Melka Werer Research Station - IAR)

It appears that the livestock in the arid plains of Ethiopia need closer investigation. Breeding and management methods valid for the highlands may not be valid in these arid plains. It is also important to preserve and study the indigenous genetic materials as the environments of the arid areas may not be suitable for exotic breeds. The ability to survive is an important factor in these considerations.

Adal Goats

No data are known on the performance of Adal goats. These animals and camels have proved to be extremely hardy during the recent drought while most cattle and sheep have died. It also appears that goats and camels are not responsible for the major effects of over grazing and erosion since they do not destroy the ground cover of the pastures.

In order to start studies on Adal goats 50 were purchased and put at Melka Werer Research Station. No fodder is grown for them; they live by grazing fallow land and canal banks. The average weight of all the female goats in the flock is 27.7 kg at the time of reporting. A number of kids have been born and their growth rates recorded. The data are given in Table 1.

TABLE 1. Average weight in kilogrammes of male and female kids

	Wt. at birth	No.	Wt. at 2 months	No.	Average daily gain	Wt. at 3 months	Average daily gain
Male	2.5	12	9.6	10	0.118	12.1	0.106
Female	2.3	5	7.6	3	0.089	11.3	0.100

Data was also obtained on the milk yield of the herd. The average daily milk yield upto two months after birth of a kid was found to be 1.202 kg with the highest at 1.544 kg and the lowest 0.789 kg. This yield is equivalent to between 3 and 4% of the average body weight. The average daily milk yield up to three months after birth was 0.925 kg. The milk had moisture and protein percentages of 88.8 and 3.3, respectively.

It has been observed that the Afar have a godd number of goats which exceed the above yields. It has been estimated that the lactation of these goats can be extended up to four months and in pastures where cows will fail, goats can produce milk.

Adal Sheep

This study is also being carried out at Melka Werer Research Station and is in line with the National policy on Sheep Recording and Development as set out and passed by the Technical Committee.

All the Adal sheep were purchased in local markets for about Eth.$16 a head. The flock on the station now numbers about 500. They are maintained on grazing alone; no special fodder is grown for them and they utilize fallow land and canal banks.

All the sheep are weighed weekly and, until recently, the rams ran together with the ewes. Table 2 give the average weights for the adult ewes and Table 3 the weights recorded from lambs born in the flock.

TABLE 2. Average body weights for adult female sheep in kilogrammes

Age	No.	Average body weight
9 months	20	22.8
1-1½ years	73	25.1
2-2½ years	25	27.4
3 years	20	30.5

TABLE 3. Average weights of male and female lambs in kilogrammes

Sex	Wt. at birth	No.	Wt. at 2 months	No.	Average daily Wt. gain
Male	2.65	45	11.6	12	0.152
Female	2.44	48	11.4	11	0.125

All the ewes in milk were milked on one day in the week in the morning and the evening. Only one teat was milked and the amount doubled to give the total milk yield. The average daily milk yield for a period of four to five months was 0.545 kg with peaks after lambing going above one kilogramme. The variation in individual average yields was large; some were as low as 0.200 kg while others gave more than

0.8 kg. The rainy season seemed to have a positive influence on the milk yield.

The Afar milk their sheep for their own consumption. However their stock of sheep was very much depleted by the recent drought whhen many died. The general disappearance of green cover and overgrazing seen round Melka Werer is a result among other factors, of grazing by sheep and cattle.

TAMING, TRAINING AND TESTING OF BULLOCKS AND CAMELS AS DRAUGHT ANIMALS - PRELIMINARY OBSERVATIONS

by

Dr. K. Knoess
(Melka Werer Research Station, IAR)

It is apparent that draught animals have a well justified place in Ethiopian agriculture. This is even more true with the inpliment-ation of the Land Reform Proclamation into situations where capital and maintenance fasilities are short or non-existent.

Experiments with camels and oxen as draught animals were started in April, 1975. The draught cattle used were two Barca oxen, two Adal oxen and one ox and a bull of the type found towards Harer. The purchase price of the two animals bought was Eth.$470. The Adal oxen were found very difficult to train while the Harer type animals were practically trained when they arrived; the Barca oxen were easy to train.

At the same time two camel stallions were bought,one for Eth.$290 and the other, a 'wild' one, for Eth.$160. Both proved very easy to train; even the wild one was trained within a week.

All the draught animals had a daily grazing period and the oxen and bull were given some hay at night.

The two Harer type draught animals weighed 400 and 350 kg and were capable of ploughing 500 square metres in an hour - one hectare in 20 hours. They worked for seven hours a day; four in the morning and three in the afternoon. They were tested with a local yoke and a re-versable plough (Ararrsew Model S.R. - price Eth.$81) bought in Addis Ababa.

One of the camels weighed 581 kg. A special harness was con-structed for the camels which enabled them to pull with their shoulders. The same type of plough was used as with the oxen, only it was adjusted to the height of the camels. These animals were found capable of plough-ing a little more than 500 metres square in an hour; i.e. more than one hectare in 20 hours. These animals also worked for seven hours a day.

The trial was carried out on virgin soil. From these initial results it appears that draught cattle should be at least four years old and camels five years old before they are used for heavy work.

There is a trial being conducted on the use of minimum mechanis-ation for settlers at Amibara in cooperation with IAR. The fifteen Afar settlers are working with seven camels and eight pairs of oxen or bulls. Improved yokes, fixed to the horns and two types of plough are being used in this trial. One plough is the same as that used in the trials at Melka Werer Research Station and the other is the "Brabant" plough imported from Belgium and costing Eth.$500. The work has shown that one camel is as strong as two oxen and also ploughs faster than the oxen. Another point of interest that will emerge from this trial is the re-lative feeding costs for the two types of draught animals. It is also hoped to construct carts that can be pulled by these animals and in-vestigate their use for operating mills and other implements.

DISCUSSION

The Cahirman thanked Dr. Knoess for his short and important con-tribution which helped to remind us of the whole aspect of animal product-ion which is underlined by the paper from ILCA.

The Speaker was asked where he got his oxen from because it was well known Adal oxen are rather difficult to train. Dr. Knoess replied that they had bought 10 Harer type oxen from local markets; these had cost between two hundred and two hundred fifty dollars each. If one of these oxen which is trained, is yoked with an adal ox then it is possible to train an Adal ox but from their experience it had been very difficult to train Adal oxen alone. However if Adal oxen are reared on the farm and hand fed they are a lot tamer and more easy to train. From their experience it had been possible to train an Adal ox within one week by yoking it with an already trained ox.

In a reply to a question on the Adal goats, Dr. Knoess said that they had not carried out a controled breeding programme and therefore they could not give precise figures at this time. Similarly they had not received the results from the Ethiopian Nutrition Institute and could therefore not say what the percentage of fat was in milk from Adal goats. The people use the milk either as yoghurt or they drink it fresh. The goats that had been used in the study had been bought from the local market and these were often rejects from the herd and were, therefore, probably substandard.

Dr. Knoess said that he had planned in his mind to carryout studies of donkeys and mules but implementing these would depend on staff and other resources being available. It is well known from literature that, comparing body weight, donkeys are much stronger than other animals; they are also capable of pulling for a long time.

SOME ACHIEVEMENT WITH FORAGE OATS - GENERAL INFORMATION

By
Dr. K. Ibrahim
(FAO Forage and Range Expert, IAR)

INTRODUCTION

As can be seen from table No.1. Ethiopia can be divided into areas according to rainfall. The areas with more than 700 millimeters of rainfall annually are grouped as 'highlands' and areas with less than 700 millimeters are grouped as 'lowlands'. Of the highlands only 16.6% is cultivated, 9.11% is permanent pasture and the fallow land is a very large figure, 63.04%. In the lowlands cultivated land is only 1.16% and the remaining is rangeland; of this rangeland 25.1% is waste land. This leaves an effective range land area of around 74%. About 60% of the livestock is owned by the highland farmers and the remaining 40% is found in the lowlands. This however is rather a mis-leading figure because of the 7 to 8 million livestock in the highlands about 23 - 27% of the cattle population are working animals. The nomads who represent 8% of the total human population produce 150,000 tons of red meat compared to the settlers who are 92% of the population and who produce only about 20,000 tons of red meat. These figures suggest the important role of the nomads as meat producers both for the urban population within the country and for export.

TABLE 1. Land utilization in Ethiopia

Total area 1,222,000 km^2

Highlands with more than 700 mm annual rainfall	Km^2	% of highland	% of total land area
Permanent pasture	57,000	9.11	4.65
Fallows	394,000	63.04	32.15
Cash crops including coffee	103,700	16.60	8.47
Forest	70,300	11.25	5.73
	625,000	100.-	51.00

Low lands with less than 700 mm annual rainfall	Km^2	% of lowland	% of total land area
Cereals	7,000	1.16	0.57
Rangelands			
500-700 mm rainfall including fallow	100,000	18.43	9.03
300-500 mm rainfall	9,000	15.08	7.39
under 300 mm rainfall	240,000	40.20	19.70
thornbush, wasteland	150,000	25.13	12.31
Total for the lowlands	597,000	100,00	49.00

In the Near Eastern, south Asian and North African Regions, a lot of work has been done in rangeland feeding and range improvement. Unfortunately many of the projects have failed as can be seen if one reviews the history of range research in the last 25 years. The reason for this is that the marketing component of these studies had not been completed or even studied and apparently there is no outlet. With range improvement alone the livestock number has increased. If the marketing outlet is not provided then the range deteriorates because it then has to carry an increased number of livestock. In Ethiopia the highlands have more favourable conditions for natural livestock production than the lowlands, thus the highlands could provide a forage bank which could replace the present 63% fallow and give a good basis for coping with increased livestock numbers. Thus rangeland improvement could be undertaken in Ethiopia without the failures that have been experienced in the Middle East. For this reason work on forage production was started before studies on rangelands were initiated.

Several thousand varieties of different forage species have been tested in the highlands at Holetta Research Station and different highland areas. Out of these, two species, oats and vetch, were particularly promising. Ato Astatke started the work on oats in 1971 and he will elaborate more on this crop later on. Following are some results of specific trials carried during the study on forage oats.

As can be seen from table No.2 the object of the trials was to find the effect of fertilizers on the dry matter yield and nutrient content of five varieties of forage oats. The work was carried out at Holetta. As can be seen from the table the highest dry matter yield was given by variety, CI-8237 and the lowest one from Jasari. Jasari was the commonly used variety before the work on forage oats started. The highest dry matter yield from varieties CI-8235 and CI-8237 was given by applying Nitrogen phosphate at the rate 46/46 kg/ha. The remaining three varieties gave the highest dry matter yield from the application 46/92, N/P_2O_5 (kg/ha). This indicates that the nutrient requirement of the latter three varieties is higher than that for CI-8235 and CI-8237. CI-8237 also gave a high yield with no fertilization and is thus recommended to the farmers because they will not be able to afford fertilizers for their forage crop.

The variety, CI-8235 gave both the highest crude protein content and the highest fibre content. Thus, although this variety has a high protein content, it also has a high fibre content which reduces its digestibility. Crude fibre content is usually an indicator of digestibility but this is not necessarily always the case. Chemical analysis is not a good criteria for judging the quality of forage; this is better done by the assessment with the animals. However, unless animal evaluation can be used in judging the results of the trials, there are two ways to carry out the assessment: the first is by in-vitro analysis which can be used to screen as many varieties as possible and secondly in-vivo analysis.

Another study that was carried out was the effect of seeding rate on the dry matter yield and nutrient content of vetch and oats. The results from this trial are given Table 3. The highest yield of the mixture was given by vetch with oat variety CI-8235 which was also highest for dry matter, crude protein and crude fibre. This was an interesting result and again animal evaluation will assist in finalizing the conclusions from these trials. No significant differences were found between the yield from the high yielding variety of oats, CI-8235, CI-8237 and CI-8251. Thus these three varieties are the ones recommended to be grown in mixtures with vetch. These mixtures not only give higher dry matter yield and quality of forage but the vetch component also helps in increasing the fertility status of the soil.

In Table No.4, the results of a trial on the effects of fertilizers and seeding rates on dry matter yield and nutrient content of oat/vetch mixtures is given. All the mixtures responded to fertilization with phosphate whether alone or combined with nitrogen. In using the mixture of oats and vetch, an attempt was made to avoid using nitrogenous fertilizer which is quite expensive. It is thus hoped that the forage crops will be able to be fertilized with only phosphate or be able to use the residual phosphate from cash crops and thus be used in rotation with cash crops. This trial was done on virgin soil and thus we see that the application of 23/46, N/P_2O_5 (kg/ha) gave a high yield and the nitrogen was obviously an advantage. However if such mixture followed other crops, it is hoped that the fodder crop will not need nitrogen and will infact add to the nitrogen content of the soil for following crops. At this time the Soil Fertility Section is looking into the question of the residual effects of Nitrogen from using local legumes.

Overall the mixture seeded at a rate of 70/25 kg/ha oats/vetch gave the highest dry matter yield and crude protein and crude fibre content. At the moment the high crude fibre content is causing some concern but the other paremeters are rather satisfactory.

Another trial was to find the effects of sowing dates and harvesting stages on the dry matter yield and seed production of the six varieties of oats at Holetta. The results are given in Table 5. From the results it appears that the best harvesting time for forage production is late flowering stage to late dough stage. It also depends on what use the oats is going to be put to, whether it is going to be made into hay, silage or used for direct feeding and if additives are going to be put with the feed. In Ethiopia the situation is somewhat different from the other places, the climatic conditions favour vegetative growth and seed production is much lower. From the sowing date of 15 April, 1974, the variety, CI-8237 gave the highest dry

matter yield when it was harvested at milk stage. From the 1st of June sowing date another variety, CI-8251, gave the highest dry matter yield from milk stage. However, from the sowing date 15 June this variety gave the highest dry matter yield when harvested at dough stage. These results are only from one location and other studies, as will be shown by Ato Astatke, indicate that there is an interaction between location, sowing date and harvesting stage.

Another study on the effect of sowing date on the dry matter, and nutrient content of six varieties has shown that these varieties can be put into two groups. The first group is of three varieties which are consistently high yielding and the second , of three varieties which are consistently low yielding. This second group includes Jasari and Lampton which were the most commonly grown oat varieties prior to these studies. It is hoped that as the results of the studies the higher yielding varieties are those which will now be recommended to the farmers, these are the varieties CI-8235, CI-8237 and CI-8251. The optimum sowing date for two of the highest yielding varieties, CI-8235 and CI-8237, was found to be mid-May. If the rain is short, it is better to plant the seed as early as possible. The optimum sowing date for the other four varieties was the end of May. As can be seen from Table 6 the dry matter yield decreased with delays in sowing date.

In summary there must be an animal evaluation for all forage work, as well as in-vitro and in-vivo methods. For selected varieties there is a need to establish a forage bank in the highlands to solve the problems of over stocking of the rangeland. There is also a need for these results to be tested through extension before recommendations are made to the farmers.

Table 2

EFFECT OF FERTILIZERS ON THE DRY MATTER YIELD

AND NUTRIENT CONTENT OF FORAGE OATS

Fertilizer N/P_2O_5 (kg/ha)	0/0	0/46	0/92	46/0	46/46	46/92	92/0	92/46	92/92	Means
DM yield (q/ha)										
Jasari	44.27	58.32	64.76	61.30	73.60	93.00	80.46	77.16	81.24	70.46
CI-8235	74.34	86.70	93.90	108.80	115.60	113.40	112.17	109.20	121.94	104.00
CI-8237	86.86	94.17	93.63	112.00	121.47	120.10	119.66	116.44	117.47	109.09
CI-8251	77.10	97.37	89.23	109.67	115.80	127.33	97.93	118.74	110.24	104.82
CI-8257	49.93	66.58	67.80	70.50	86.77	103.27	67.27	81.97	110.82	78.33
Means	66.50	80.63	81.86	92.45	102.65	111.42	95.52	100.70	108.34	93.34
C. Protein (q/ha)										
Jasari	2.90	3.95	4.17	4.02	5.09	6.58	6.20	5.87	4.76	4.83
CI-8235	6.63	4.53	4.52	6.19	6.28	6.94	5.20	7.26	7.85	5.82
CI-8237	3.65	3.87	4.15	4.51	5.32	5.57	5.59	6.08	6.68	5.05
CI-8251	3.28	4.28	3.75	4.51	5.57	5.64	5.14	5.30	6.75	4.80
CI-8257	2.42	3.60	3.80	4.94	6.00	6.40	4.78	5.95	5.53	5.00
Means	3.18	4.05	4.08	4.83	5.65	6.23	5.38	6.09	6.50	5.10
C. Fibre (q/ha)										
Jasari	11.72	27.16	21.49	23.45	28.20	35.09	27.51	28.23	30.98	25.98
CI-8235	21.48	31.67	33.98	42.99	40.89	40.14	41.10	43.51	44.51	39.82
CI-8237	29.67	31.72	34.17	40.14	35.63	46.61	45.45	24.35	43.78	36.84
CI-8251	26.67	36.38	31.62	38.01	41.27	31.40	35.61	44.54	43.44	36.55
CI-8257	15.95	23.87	23.34	21.00	31.47	31.62	24.66	28.38	34.48	26.09
Means	21.10	30.16	28.92	33.12	35.49	36.97	34.87	33.80	39.44	33.05

CV% oats varieties (DM yield) : 10.50
CV% Fertilizer (DM yield) : 14.46

The differences in DM yield (q/ha) between:	SE(M)	LSD (5%)
Two oat variety - means :	2.30	6.97
Two fertilizer rate means ;	5.91	11.70
Two fertilizer means for a given oat variety :	13.2	26.16
Two oat variety means	8.27	16.46

EFFECT OF SEEDING RATE ON THE DRY MATTER YIELD AND NUTRIENT CONTENT OF *Vicia dasycarpa* WITH FIVE *Avena sativa* CULTIVARS

Seeding Rate Vetch / Oat (kg/ha)	25/35	50/70	Means	25/35	50/70	Means	25/35	50/70	Means
Oat Varieties	DM yield (q/ha)			C. Protein (q/ha)			C. Fibre (q/ha)		
Jasari	64.77	72.03	68.40	4.45	4.74	4.60	24.26	26.70	25.82
CI-2835	92.14	110.27	101.21	5.96	5.90	5.93	30.56	39.14	34.85
CI-8237	88.67	108.20	98.44	5.18	6.37	5.78	29.91	36.38	33.15
CI-8251	85.20	103.94	94.57	5.04	6.30	5.67	26.92	34.86	30.89
CI-8257	66.94	74.03	70.49	4.78	4.62	4.70	25.39	27.33	26.36
Means	79.54	93.69	86.62	5.08	5.59	5.34	27.41	32.90	30.16
CV% (Mixture)		23.90			20.73			13.79	
CV% (Seeding Rate)		11.23			10.57			15.79	

The differences between	SE (M) q/ha DM yield	C. Protein	C. Fibre	LSD (5%) q/ha DM Yield	C. Protein	C. Fibre
Two mixture means	10.35	0.55 (NS)	2.08	22.55	NS	4.42
Two seeding rate means	3.07	0.18	1.51	6.54	0.38	3.22
Two seeding rate means for the same mixture	6.91(NS)	0.40(NS)	3.37 (NS)			
Two mixture means at the same seeding rate	11.45(NS)	0.62(NS)	3.16(NS)			

Design : Split plot in four replications, the mixture of the vetch and five oats varieties in the main plot and the seeding rates in the sub-plots.

Vetch Variety : *Vicia dasycarpa* var. *lana.*

Fertilizer : 23/23 kg/ha N/P_2O_5 as a basal dressing

Sowing Date : 9 June 1973

Harvesting Stage : At 100% heading stage of oats or 100% bloom stage of vetch.

Harvesting Date : 20 September 1973

Previous Land Use : Virgin Grassland

Table 4

EFFECT OF FERTILIZER AND SEEDING RATE ON THE DRY MATTER YIELD AND NUTRIENT CONTENT OF OAT/VETCH MIXTURE

Seeding Rate (kg/ha) Oats + Vetch	DM yield (q/ha) 70/50	70/25	35/50	35/25	Means	Crude Protein (q/ha) 70/50	70/25	35/50	35/25	Means	Crude Fibre (q/ha) 70/50	70/25	35/50	35/25	Means
N/P_2O_5 (kg/ha)															
0/0	47.50	46.63	38.56	52.17	46.22	3.54	3.50	3.16	4.31	3.63	17.04	17.20	14.63	17.21	16.52
0/46	59.07	61.33	55.60	56.50	58.13	4.47	4.32	4.56	4.74	4.52	22.32	22.82	20.02	20.90	21.52
0/92	60.64	62.14	60.44	59.96	60.80	4.59	4.49	4.55	4.20	4.71	23.61	23.99	22.52	23.70	23.46
23/46	58.03	70.10	64.10	59.20	62.86	4.08	5.09	4.41	5.02	4.65	22.48	28.42	22.16	24.80	24.47
23/92	73.90	73.57	69.00	74.87	72.84	5.15	5.08	4.78	6.49	5.38	29.26	39.30	26.02	29.94	28.38
Means	49.83	62.75	57.54	60.54	60.17	4.37	5.50	4.29	5.15	4.58	22.94	24.35	21.07	23.11	22.87
CV% (Fertilizer)			15.02					18.66					18.08		
CV% (Seeding Rate)			15.43					25.09					17.29		

The differences between:	SE(M) q/ha DM Yield	C. Protein	C. Fibre	LSD 5% (q/ha DM Yield	C. Protein	C. Fibre
Two fertilizer means	3.20	[illegible].30	1.46	6.97	0.65	3.18
Two seeding rate means	2.94( )	0.36( )	1.25( )	-	-	-
Two seeding rate mans at the same fertilizer level	6.52(NS)	0.59(NS)	2.83(NS)	-	-	-
Two fertilizer means for a given seeding rate	6.77(NS)	0.81(NS)	2.80(NS)	-	-	-

Design	:	Split plot in four repliaations, the seeding rates were in the main plots and fertilizer rates in the sub-plots.
Plot Size	:	2m x 5m = 10m²
Varieties	:	*Vicia dasycarpa* var. *lana* and Jasari
Sowing date	;	7 June 1973
Harvest date	:	20 September 1973
Harvest Stage	:	When the oat reached 100% heading stage
Previous Land Use	:	Virgin grassland
Scil	:	Red hill soil

TABLE 5

EFFECT OFNSOWING DATE AND HARVESTING STAGE ON THE DM YIELD AND SEED PRODUCTION OF SIX VARIETIES OF OATS (q/ha) AT HOLETT[illegible] 1974

Sowing Date Harvesting Stage	CI-8235	CI-8237	CI-8251	CI-8257	Jasari	Lampton
15 April 1974						
Boot (DM yield)	51.58	67.00	58.20	52.58	48.05	52.55
100% Flowering (DM yield)	103.90	78.20	74.05	89.40	47.25	52.45
Milk (DM yield)	103.75	133.09	89.33	105.73	62.03	57.56
Dough (DM yield)	108.38	131.03	79.30	93.18	106.25	79.40
Seed yield	4.14	10.36	2.88	4.03	12.63	2.78
11June 1974						
Boot (DM yield)	120.65	78.45	100.73	65.70	67.48	79.60
100% Flowering (DM yield)	136.45	107.90	128.58	75.15	83.13	72.50
Milk (DM yield)	179.90	167.30	178.15	113.33	122.23	123.75
Dough (DM yield)	131.18	142.38	134.68	93.70	138.25	101.00
Seed yield	6.93	15.45	7.02	8.18	9.03	9.09
15 June 1974						
Boot (DM yield)	122.18	98.40	103.03	49.15	58.15	79.10
100% Flowering (DM yield)	149.48	112.83	133.60	70.33	72.25	71.75
Milk (DM yield)	146.78	140.25	155.98	147.33	129.83	131.83
Dough (DM yield)	142.13	149.30	162.75	135.63	132.38	125.80
Seed Yield	7.30	13.85	11.55	9.35	27.1?	13.87

TABLE 6

EFFECT OF SOWING DATE ON THE DRY MATTER, DURATION TO HEADING, YIELD, LEAF/STEM RATIO AND NUTRIENT CONTENT OF SIX VARIETIES OF OATS - (q/ha)

Sowing Date	15/5	30/5	15/6	29/6	13/7	27/7/73	Means
DM yield							
Oats Varieties							
CI-8235	134.27	123.74	106.60	83.57	52.76	37.97	89.82
CI-8237	134.85	110.80*	115.20	97.07	71.80	46.40	96.02
CI-8251	112.47	121.74	104.20	92.25	79.90	41.90	86.41
CI-8257	81.64	126.60	66.10	60.47	57.14	41.38	72.22
Jasari	78.30	101.80	76.64	65.06	58.07	43.96	70.64
Lampton	64.24	94.00	66.83	50.57	67.87	38.90	63.74
Means	96.80	113.11	89.26	74.83	63.09	41.75	79.80

* DM yield was decreased to about 10% due lodging.

Crude Protein							
CI-8235	9.50	7.14	5.58	4.39	2.83	2.15	5.27
CI-8237	9.01	6.81	2.27	4.56	3.67	3.40	5.62
CI-8251	6.66	5.75	5.52	4.17	3.38	2.88	4.72
CI-8257	7.15	8.62	4.63	3.72	3.43	2.57	5.02
Jasari	6.60	7.58	5.06	3.57	3.42	2.85	4.85
Lampton	6.75	7.14	4.83	3.51	3.77	2.53	4.76
Means	7.61	7.17	5.32	3.99	3.42	2.73	5.04
Crude Fibre							
CI-8235	50.93	49.62	41.24	25.60	14.71	10.46	32.09
CI-8237	52.79	43.21	39.28	32.12	19.69	14.84	33.60
CI-8251	45.90	43.38	35.32	23.51	19.72	13.09	30.15
CI-8257	20.40	39.14	22.66	19.55	15.65	11.73	21.56
Jasari	25.16	39.53	28.84	20.97	18.79	13.07	24.36
Lampton	22.64	37.20	25.92	17.13	23.50	12.92	23.22
Means	36.30	42.01	32.21	23.15	18.68	12.69	27.51

These two varieties have given satisfactory results, not only in trials, but also in demonstration plots. However other strains might be useful for different utilization end points. For example, Lampton could replace CI-8237 because of its water logging tolerance and grain yield. Grey Algiers could replace CI-8251 for use as animal pasture. Grey Algiers is a very late strain which provides a lush growth after the end of the rainy season making it possible to extend the green feed period upto the end of November. This season usually terminates at the end of October when the natural pasture ceases to be green.

In the context of this work seed yield refers to production of seed for subsequent forage oat sowing and as feed supplement for livestock as grain. The grain production of forage oats might not compare well with that of barley and wheat but considering the low fertility requirements of oats the wide vertical as well as horizontal adaptation could make them useful as food crops as well. In terms of land utilization this crop could help in the development of the fallow lands and permanent pasture land which are estimated as 72% or 451 sq.km of the highlands.

Field trials and demonstrations on forage oats have been carried-out for the past two years at 22 locations on farmers' fields by the pasture and forage section of the Institute in a cooperative programme with DDA. These demonstrations are intended to show farmers the methods of establishment, conservation and utilization of forage oats. From demonstrations to individual farmers, information is extended to the neighboring farmers through the extension agents of the DDA. An extension bulletin in Amharic was prepared in 1974. Field demonstrations will also be facilitated by the organization of farmers into dairy farmers' associations. At present large scale production, conservation and utilization of forage oats has been the common practice of the animal production section of the Research Institute. Seed oats have also been produced yearly by the farm management section for distribution to dairy farmers, Government agencies, farms and also private farmers both big and small. These farmers are adopting conservation and utilization practices for forage oats on their farms.

DISCUSSION

The Chairman thanked Ato Astatke and Dr. Ibrahim for a very comprehensive and complicated piece of work which has been presented so clearly, in the alloted time.

It was commented that the speakers had demonstrated that we can produce forage, although this had been pointed out as a bottle neck in previous livestock papers. The commentor wanted to know what the problem was regarding marketing, did the speakers mean marketing their research products for the farmers or were they intending to produce forage oats for export. Dr. Ibrahim replied that Ethiopia is number one in Africa

Table 1

DRY MATTER YIELD AND CRUDE PROTEIN CONTENT AND CRUDE FIBRE CONTENETS OF TEN VARIETIES OF OATS in 1970-71 at Holetta

Variety	DM yield q/ha	Maturity	Leaf to stem ratio	Crude Protein (%)	Disease scored	
					Crown rust	Stem rust
CI-8274	98.6	Late	1.75	6.56	++	++
CI-8251	125.8	"	2.00	6.55	-	-
CI-8235	107.9	"	1.85	6.67	-	-
CI-8178	96.4	Medium Late	1.04	6.66	-	-
CI-8234	89.1	Early	0.80	6.36	++	++
CI-8267	109.3	"	1.25	7.95	+	+
CI-8237	111.8	Late	2.00	7.93	-	-
CI-8257	110.5	"	1.31	7.35	-	-
CI-8266	77.8	Early	0.87	5.48	+	+
CI-8185	119.9	"	1.25	5.86	+	+
Mean	104.7			6.60		

For yield

S.E. 64.5 q/ha

C.V. 11.8%

L.S.D. 5% 2.6 q/ha

1/ - = absent

\+ = moderate

++ = heavy

Table 2

DRY MATTER YIELD AND CRUDE PROTEIN AND CRUDE FIBRE CONTENTS OF SIX VARIETIES OF OATS IN 1-72 AT HOLETTA

Variety	DM yield (kg/ha)	Crude Protein	Crude fibre (kg/ha)	Visual leaf to stem ratio	Rust Score	
					Stem	Crown
CI-8251	4753	269	1105	High	0	0
CI-8178	4667	278	1396	High	VS	0
CI-8274	6711	297	2035	High	VS	0
CI-8237	5783	321	1964	High	0	0
CI-8257	8062	418	2390	Low	0	VS
CI-8235	4521	278	1204	Low	VS	0
Variety Mean	5749	310	1637			

0 = Free from rust

VS = Very Susceptible

	Yield	Crude proteinn	Crude fibre
S. E. (M)	746.2	56.1	370.1
C. V.	25.9	26.0	32.0
LSD 05	2248.8	NS	788.6
LSD 01	3068.6	NS	1090.6

Design	: Randomize complete block with 4 replication
Plot size	: Initial 5 x 2m = 10 m^2
Sample plot size	: 5 x 1m = 5 m^2
Basic fertilizer rate	: 30/30 N/P_2O_5 banded with the seed
Fertilizer application date	: 15 June
Insect attack	: None
Sowing date	: 16 June
Harvesting Date	: Various dates depending on the phenology of the varieties
Previous Land Use	: Native pasture
Soil type	: Red

Table 3 The Suitability of Oat Varieties Selected from the World Collection (9054 varieties)

Potential Use	Aregentina	Australia	Brazil	France	New Zealand	Switzerland	Tunisia	Turkey	USA	USSR	Others	Total
	COUNTRY OF ORIGIN											
Hay	2	2	5	1	3	1		1	52	1	2	69
Silage	1	1	2			1			30		2	37
Hay/Silage					1				9			10
Mixture with legumes		1	2				1	1	6			11
Hay/Mixture			6						8	1		15
Hay/Mixture/Silage	1		1			1			5			8
Silage/Mixture									4		1	5
Grain					1				1			2
Grain/Hay									1			1
Grain/Silage									1			1
Grain/Hay/Silage									1		2	3
Grazing									3			3
Total	4	4	16	1	5	3	1	2	121	2	7	165

Table 4

DRY MATTER HERBAGE YIELD OF FODDER OATS AT SEVERAL LOCATIONS IN 1974/75 (DM, gm/ Plot)

Location	CI-8251	CI-8237	Jasari	Grey Algiers	CI-8235	CI-8257	Lampton	Sowing Date
Legetaffo	124	66	64	100	56	80	?	5/6
Legedadi	40	38	26	58	20	36	–	5/6
Bekimariam	18	23	42	44	34	30	26	6/6
Sendafa	182	74	150	64	50	64	76	5/6
Sululta I	30	80	70	66	30	106	102	15/
Kuyu I	90	–	108	62	40	106	70	12/6
Kuyu II	103	64	100	50	136	76	86	25/6
Burayu	–	190	120	32	74	148	234	11/6
Bedi	152	110	110	60	110	100	146	12/6
Mullo II	100	110	90	56	103	114	80	14/6
Addis Alem	240	282	146	90	160	190	102	19/6
Wolencomi	78	90	80	160	108	164	116	18/6
Ginchi	178	106	108	38	164	70	80	21/6
Mean DM gm/plot	111.3	102.8	93.4	67.7	83.5	98.8	92.2	
Density Av. allsites	10	8.5	8.6	9.0	9.0	9.5	8.5	
Length of maturity	Late	Med.	Early	Late	Late	Early	Early	
Grain/straw	<1	>1	>1	<1	<1	●●	>1	
Site Adaptation rank	1	2	4	6	5	3	4	

Table 5

DRY MATTER HERBAGE AND CRUDE PROTEIN
YIELDS OF FORAGE OAT VARIETIES AT THREE
SUB-STATION IN 1974

(DM and Cr. Pr. Ylds in Q/ha)

Variety	Locations							
	Ginchi		Bedi		Sheno		Var.	Mean
	DM	Cr.Pr.	DM	Cr.Pr.	DM	Cr.Pr.	DM	Cr.Pr.
CI-8257	74.3	4.3	111.3	6.8	12.0	0.6	65.9	3.9
Jassari	52.5	2.3	101.8	6.2	23.9	1.1	59.4	3.2
Lampton	52.2	2.6	108.4	6.3	12.1	0.6	57.6	3.2
CI-8237	70.9	4.9	109.0	7.6	20.0	0.9	66.0	4.5
CI-8251	70.9	2.7	115.4	7.4	10.0	0.4	65.4	3.5
Grey Algiers	28.9	1.4	107.5	4.4	9.0	0.6	48.5	2.1
CI-8235	62.0	2.5	10[illegible].9	6.2	22.8	1.3	63.9	3.3

Locations: Ginchi, Bedi and Sheno

Sowing date(s): 20/6/74 ; 12/6/74

Fertilizer rate: 18/46 N/P_2O_5 kg/ha as DAP x 23 kg/ha as Urea

Plot size: 3 x 5m = $15m^2$

Sampling plot size: 2.5 x 3m = $7.5m^2$

Land Use(s) = Cereal-grain legume x cereal - fallow

Replications; Three

as far as livestock production is concerned and number 8 in the whole world. The export of livestock products from Ethiopia is second only to that of coffee. However, considering the number of livestock the production was still very low. He felt that if a forage bank could be developed in the highlands where the livestock could be finished from the lowlands and then exported, this would make a very valuable contribution to the export earnings of Ethiopia. At the moment livestock products are second to coffee but the position of coffee is in question because of diseases. He felt that at the moment there is an oil crisis in the world and that this might well be replaced by a meat crisis in 10 to 15 years time. If Ethiopia was able to increase its meat production then it would be in a very good economic position.

The speakers were asked whether it is not to early to conclude that forage oats which was an introduced plant was disease resistant. Dr. Ibrahim replied that of these the 9,054 varieties that were tested for three years running, 160 of these has shown complete resistance despite the fact they have been grown adjacent to highly infected plants. Also the six varieties that has been worked on for five years had also shown a complete disease resistance within this period. This gives quite a large bank of material upon which to draw for the future. However, the observation was valid and the forage people will continue to watch the disease situation.

The speakers were asked how forage oats, which is an annual, compared with perennial grasses such as Pennisetum purpureum, Panicum maximum and others. The speakers replied that in the lowlands these perennial grasses definitely have a place but in the highlands forage oats was very useful, because it could provide a good forage yield in the first year when perennial pastures of such species as Phalaris, Lolium and Festuca are not quite so productive. However these perennial plants might be more productive over a longer period of time.

It was pointed out in a general way that this research was applicable for the present time. The questioner asked the speakers if they have any feelings about what might happen with forage production versus the need for food production in face of the increase in population by the year 2000. Dr. Ibrahim replied that we obviously will have to comprize, however, if it is possible to eliminate the 63% fallow land, that is 394,000 sq. km., by the year 200. this will be a good thing. Even if 90% of this fallow land will then producing cash crops leaving only 10% for animal production this would be sufficient to materially affect the production of animals in Ethiopia.

CLOSING REMARKS TO THE SECTION ON AN ANIMAL PRODUCTION

The Chairman drew the conclusion that there is a fantastic amount of work required in the terms of testing and in the combinations of things that are required before one can given advice which will be sound and which will have some chance of success in practice. This is the lesson we can take from this work. It is not possible just to do a little bit of something here and there but one has to be extremely systematic before giving advice which will stand some chance of success in the future. He particularly welcomed the remark that it is extremely important in the end to assess all these things in terms of animal performance.

He also made a remark on crop production versus animal production. This is a problem that concerns everyone all across the world, he felt that the quality of life has quite a connection with animal production. We do not just want to eat maize, wheat, sorghum or teff; we also want protein from animals and other things like this.

The other point to remember is the one that Dr. Ibrahim made, the livestock potential of Ethiopia in terms of development is almost unequaled by anywhere else in the world. It may well be that extra investment in livestock production here could bring a great deal of cash in terms of export returns for the country. He pointed out that he was not a prophet but this could well be justified from a good economic and systems analysis of the livestock production potential of the country.

The Chairman concluded by thanking all the speakers and the participants who had contributed to the discussion for this very interesting session on livestock production.

CROP PROTECTION

INTRODUCTION

This section was Chaired by Dr. Dejene Gorfu from Debre Zeit Agricultural Experiment Station. He opened the session with the following remarks.

Since the time of agriculture's conception unfavourable weather conditions, insect pests, diseases and weeds have been the important limiting factors in the production of food, feed, fibre and shelter materials. Throughout the centuries researchers as well as farmers have employed various approaches to understand and control these enemies. Although much has been done in understanding and manipulating these constraints, the struggle, unfortunately, seems to be endless. The papers which are going to be presented in this section will point out some of these problems as they are related to the situation in Ethiopia and most of them will possibly suggest some useful control measures.

SELECTION FOR DISEASE RESISTANCE

By

Dr. Vitali Goncharov, Plant Pathologist
(Soviet Scientific Phytopathological Laboratory)

Despite the achievements in the field of chemical plant protection, breeding of resistant varieties was and still is one of the most advantageous and safe means for controlling a number of the most widespread and harmful diseases. Of prime importance are the rust diseases which cause heavy damage to cereals throughout the world and in Ethiopia in particular.

It is possible to use chemical means of control for covered smut on wheat, late blight on potato, angular leaf spot or black arm on cotton, mildew on grape, etc. This is actually a great achievement in plant protection but it should not exclude the importance of the varietal resistance to diseases.

While not underestimating the importance of chemical means of control, it should be understood that it increases the production costs for a crop to a considerable extent. The introduction of resistant varieties may minimize these expenditures. For example, the development of late blight resistant potato varieties and utilising them on a field production scale has replaced multiple treatments of the crop by fungicides in many countries.

Side by side with the main selection facters in a breeding programme; i.e. the increase in the quality and quantity of the yield of a crop, a not less important role should be given to the breeding of resistant varieties to the main plant diseases.

In the process of breeding resistant varieties, a scientist has to become fully knowlegeable of the evolutionary mechanisms of the two types of living organisms; the host plant and the disease pathogen. This presents the main difficulty in this work.

One may get the impression that all breeders' efforts directed to developing a new resistant variety are doomed to failure, since after the resistant variety is developed a new race of the pathogen appears and the variety loses its resistance. However, this is not really the case.

The process by which a new pathogenic race appears in nature usually has two stages: the first one is the appearance of the new race and the second is its accumulation. The first stage is independent of man's activities. However, despite the number of races which appear, during production on a large scale we always only meet a limited number of them. This is connected with the fact that the second stage of the process - accumulation of races in nature - depends on many factors and first of all on the availability of a crop variety which can be attacked by the new race of pathogen. Thus the second stage of the process is closely connected with man's activities and depends upon it.

The accumulation of the newly appeared race in a large amount results, as a rule, in an epidemic, i.e. mass infection of plants by disease. These conditions are usually created when few varieties with similar resistance are grown over very large areas.

According to conditions, the period covering the appearance and accumulation of a pathogenic race in large amounts usually takes from five to seven years. During this period disease infection of the variety increases gradually, not attaining epidemic proportions and there will not be big yield losses from diseases if the crop varieties are periodically replaced by new ones approximately every seven years. Of course, the development of new varieties must be continuous and the breeders have to develop these new varieties systematically. So it is necessary to keep a constant watch for the appearance of new pathogenic races so that new crop varieties can be developed in time, i.e. it is necessary to watch the dynamics of pathogenic race composition particularly in regionalized and promising varieties in the main wheat growing areas.

Apart from other factors the degree of severity of disease damage depends on the stage of plant development at the time of infections. The

closer this time is to the harvesting stage, the smaller is the amount of damage done by the disease.

At present, breeding for resistance is more often favouring the use of multiline varieties, i.e. the development of a mixture of lines with different genetic resistance mechanisms. Such varieties which have a good resistance to stem rust are being produced in Mexico and in other countries.

Finally in the fight for stable cropping patterns, breeders develop varieties with field (polygenous) resistance, for example potato varieties resistant to late blight. A big advantage of this type of resistance is its stability during the whole period of cultivation of the variety.

Hybridization is the main method of breeding for resistance but its success depends on properly organized evaluation and selection methods for finding the resistant plants.

It is necessary to make the selection on infected ground and even better in specially infected nurseries. Evaluation on naturally infected ground is not always profitable and very often leads to unproductive expenditure and to a prologation of the period of selection. For example, on the Bako Experimental Station the selection of haricot beans for resistance to rust is being varried out. However, even the control, which is a susceptable variety is free from infection, while in the irrigated plot (an agronomic trial) there are infected plants. If the infected plants were transplanted to the trial plot in proper time, the success of the trial in this case would be achieved.

The methods of artificial infections are rather diverse and depend on the aims of the trial:

1. Introduction of infected material into the soil (for resistence to wilt, root rots and other soil borne diseases);
2. Introduction of infections load to the seeds (for example, covered smut)
3. Introduction of infections to leaves, stems, flowers and other parts of the host plant (for example rust, septoriosis, helminthosporicsis).

In order to save time during the dry season work should be conducted in a greenhouse if possible. It is first of all necessary to use greenhouse conditions when one needs to study the resistance of a variety is isolation from the field conditions.

In addition, due to the fact that a number of trials using various crops and varieties introduced from abroad in Ethiopia in cooperation with FAO and other international coordinating agencies, it is desirable to examine the initial seed samples of the new varieties in isolated (quarantine) conditions. For example, experimental stations receive pulse crops and other crop varieties from abroad and sow them directly into their fields. When virus and other diseases appear on these these plants the question naturally arises; 'Where does this infection come from?' Was it brought in with the seeds or was it already existing in the soil or was it introduced by other means?

To conclude, I would like to point out the importance of prophylactic measures directed to avoiding diseases in the field, in pastures and in stores. Here destructive methods directed to the elimination of already existing diseases should only be used as a last resort and as an exception to normal routine prophylactic methods.

DISCUSSION

The Chairman thanked the speaker for the paper and opened the floor for discussion and comments.

It was commented that the aim of improving disease resistance was to improve yield. However it is sometimes felt that if a variety is resistant to a disease it will automatically give a high yield but this is not always so; could the speakers please comment on this. Dr. Gonchorov replied that the agronomist and breeders had to work together with plant protection people, if this is done then it is possible to find varieties which are both disease resistant and high yielding. This has been seen at Kulumsa in wheat varieties. Dr. Dereje also commented that there are various types of resistance, one of which is called tolerance. A tolerant variety is one which is susceptible to a certain degree to a disease but this does not materially affect its yield. These tolerant varieties should not be discarded as they are useful for crop production.

The speaker stressed the importance of isolating new introductions to the country. However, although the importance of quaranteen has been discussed for some time many of the people undertaking research had imported materials and grown them without due consideration to isolation and Ethiopia had become a good harbour of diseases. The participant wanted to know what measures were being taken by the Research Institute and other organizations to improve quaranteen control.

The speakers replied that about a month previous to the Seminar there had been a meeting at the Plant Protection and Production Division of the Ministry of Agriculture where this problem has been discussed. The meeting there had been informed that a proposal has been drawn up to be given to the Government and that shortly the Government should issue a special proclamation or warning about quaranteen services for

the country. The Speakers hoped that would serve to protect the country from the importation of dangerous diseases. Dr. Niemann also commented that such a Government organization would take some time to become effective. He, therefore, suggested that in the meantime each organization such as the Institute and the College of Agriculture should start their own quaranteen services. At the present time, the Institute carries out its own quaranteen survey on all imported material. The agronomist gives samples to plant pathology section and this section analyses them for diseases and makes recommendations to the agronomists and advises them about where they should be grown. If there is some danger of a disease introduction they are advised to grow them in an isolated situation so that the disease will not spread.

A participant commented that he would like the body of this Seminar to bring some influence on this new Government institution for quaranteen. In many countries where there are quaranteen services, materials are stock piled at the headquarters because the quaranteen officers are too afraid to release the materials too quickly and they can remain for months and even years unused. However research people need their materials quickly and if it was possible to adopt safty measures, such as those suggested by Dr. Niemann, when this formal department is established then this department will not only control the importation of disease but also meet the need of the research community which needs these materials quickly.

The Chairman also commented that he was worried because we do not have well combined statistical evidence on the recent problems that could have been introduced. However it was his impression that some of the serious problems that are now being studied are basically confined to experimental fields and this could indicate that this disease had been introduced, e.g. ergot in sorghum and head blight of wheat were basically seen only in experimental fields. Thus the need for quaranteen was a very legitimate concern and it would need the concerted effort of plant protection people, breeders and agronomists to make every effort to control the importation of disease until the quaranteen measures become effective.

It was questioned as to wheather there was any idea on the proportions of introduced and indigenous diseases in Ethiopia. Dr. Gonchorov replied that to study all the diseases that appear in a country needs a very large body of trained pathologists. Even for a disease such as potato blight, which is world wide, one of the problems is when a new variety emerges so does a new strain of the disease. Regarding indigenous diseases the problems could possibly be related to the fact that, in Ethiopia, there were wild relatives of the crops which carry these diseases and thus these diseases had been in Ethiopia for a very long time.

The Chairman concluded this discussion by saying that much work was needed to be done on identifying the plant diseases that had been introduced and those that were indigenous to the country. However at the moment the two major constraints to plant pathology work were lack of manpower and limited facilities. However the plant pathologists should attempt to make an inventory of the disease situation in the country, and from this draw up priorities for research and make every effort to prevent further introductions of diseases.

PLANT DISEASE SITUATION IN ETHIOPIA

By

Dr. Niemann (IAR - Holetta)

It is not the aim of this paper to simply read a list of plant pathogens occurring on the different crops in Ethiopia: it is prefered to show some of the aspects and problems connected with the plant disease situation. For this purpose, it seemed to be more advisable to discuss the diseases from the angle of the different factors by which they are caused.

As everywhere in the world, also in Ethiopia, plant pathology started with the study of the "classical" fungus diseases, such as rusts, smuts and mildews, which could easily be recognized and identified. Without doubt they are very important, especially the cereal rusts. For Ethiopia Coffee Berry Disease, which is in this group has also to be mentioned. However, there still seems to be a lack concerning our knowledge of the more obscure diseases such as fungal root-rots, bacterial diseases, plant viruses, nematodes, and non-parasitic disorders. These groups of plant diseases are often underestimated in importance.

Let us consider the root-rot and wilt diseases which are caused by different soil fungi. For most identifications, isolation and culturing of the causing fungi is required. Identification in the field, just by looking at the symptoms, is generally not possible or at least not sure. Different fungi, mostly having a very wide host range, are included in this group: various Fusarium species (e.g. F. solani, F. oxysporum); Sclerotium rolfsii; Rhizoctonia spp; Macrophomina phaseoli; Armellaria (on coffee and other trees). Phytophthora species, which are important as root-rots in many other countries, are - surprisingly - not very frequent in Ethiopia.

Root-rots and wilts often occur as an interaction with other factors: either on plants where the roots were damaged by nematodes (here the fungi infect the plants through the wounds which were caused by the nematodes) or on plants which were weakened, and thus predisposed to infection by unfavourable soil, drainage, or nutrient conditions. Examples of this are the chickpea root-rot/wilt complex, which is reported in the following paper, and the so called "Dubti Syndrome" in cotton which occured seriously last year at the Tendaho Plantations. Root-rot pathogens, once established in a soil are difficult to eradicate. As they attack the underground parts of the plants control is mostly very difficult to achieve and would, especially, have to rely on cultural practices such as crop rotation, regulation of irrigation and drainage, sowing depth and sowing date. Beside the examples already mentioned, root-rots are important in pulses and horticultural crops and as agents of die-back in coffee.

Among the bacterial diseases, enset wilt, blackarm in cotton, leaf spots in pepper, sesame, sorghum and different pulses (e.g. haricot beans, soybean) have to be mentioned as the most important ones. As for many phytopathogenic fungi, bacteria can also be isolated and grown on artificial media. However, bacterial identification is more difficult and time-consuming than with fungi, because, for the most part, chemical criteria have to be used instead of morphological characters which are sufficient in identifying fungi. Therefore, our knowledge of bacterial plant diseases in Ethiopia is still very limited.

Only eight plant viruses were listed by Stewart & Dagnatchew in their "Index of Plant Diseases in Ethiopia" 1967. In a newer report, 1974, given by Bos on his survey of virus diseases in Ethiopia, 22 plant species which were attacked by plant virueses were mentioned. Unfortunately, so far, only one of these viruses (potato virus Y in pepper) has been correctly identified. This lack is due to shortage of trained staff in plant pathology, who would be acquainted with the specific methods which have to be used for virus identification. Crops in Ethiopia for which viruses already rank among the most important diseases include the different pulses (haricot beans, mung beans, cowpea) and the solanaceous crops such as pepper, potato, tobacco and tomato. Potentially, viruses could also become very important, or even a limiting factor, in other crops such as sugarcane, rice, citrus, cassava, if the respective viruses were accindentally introduced with planting material from other countries. In cereals such as wheat, barley, maize and sorghum there are also virus diseases which, if spread, could become damaging.

Very little is known about the plant disease situation as far as plant nematodes are concerned. We know of the occurrence and importance of root-knot nematodes in different horticultural crops, and some results on the control of these nematodes will be given in another paper. However, which species of Meloidogyne are involved in this root-knot complex is still insufficiently known. Two other damaging nematodes of importance in Ethiopia are the burrowing nematode (Randopholus similis) in bananas and the ear-cockle (Anguina tritici) in wheat. The former is the most important banana disease in Ethiopia where Dwarf Cavendish varieties are grown. The latter is important in farmers' fields in the north of the country when proper cleaning of the wheat seed is neglected. No information is available on the occurrence and importance of the so-called "free-living plant parasitic nematodes". Over the last few decades in other countries, these organisms have been connected with such obscure disease syndromes as die-back in trees, general stunting or chlorosis of plants, or soil exhaustion. These nematodes migrate through the soil and cause damage to the plant roots either as superficial necrotic lesions or as a deformation, stunting or reduction of the root system. They are involved in root rot complexes and can also act as vectors in the transmission of some virus diseases. Fortunately, we are expecting a FAO

Consultant on plant nematology who is due to arrive shortly. Hopefully, we will have more information on these problems after his survey and will know how to go ahead and to tackle the nematode problems.

The large group of non-parasitic plant injuries is caused by various factors such as: unfavourable soil structure, water-logging, drainage problems, over-irrigation, drought, too high or too low temperature, hail, sunburn, nutrient deficiencies, wind-breaks, phytotoxicity by pesticides or other chemicals. These injuries are found especially in drier or irrigated areas. They are extremely difficult to identify, because plant samples which are brought to the laboratory will not yield any pathogen in isolation. The history of the crop which is damaged by these factors has always to be checked in the field to find indications on what could have been wrong with the cultural practices such as: rotation, sowing date, irrigation patterns, fertilizer or pesticide use. In order to detect nutrient deficiencies various methods can be used preferably combined. Besides spray trials, visual identification according to the symptoms, sowing of indicator crops and leaf or soil analyses can be used. However these analyses require a chemical laboratory which is specialized in the methods to be used and in the evaluation of the results. It can be predicted that injuries by phytotoxicity will become more important in the future as more pesticides, especially herbicides, are applied in the country.

Among other factors which cause crop damage, only the parasitic higher plants should be mentioned. Striga, for example, is the most important sorghum problem in many areas. For some horticultural crops, Orobanche (broomrape) can cause trouble when rotation practices are neglected.

In summarizing the factors which cause plant diseases, it should be pointed out that most of these factors cause somewhat typical symptoms which will already give some indication of the direction in which the cause of a disease has to be sought. Also, each of these groups of diseases often has a similar way of transmission and, therefore, can be controlled by similar methods.

Each disease survey has limitations which have to be considered when we use its results. For example, if samples of diseased plants are only examined and identified in the laboratory without seeing the crop in the field, nothing can be said on the importance of the disease or from where it comes. Therefore, plant pathology in general, and a disease survey in particular, whenever possible has to start in the field.

If disease surveys are made only at Experimental Stations, the results would not help us to understand the conditions present in the farmers' fields, because the cultural practices followed - such as seed-bed preparation, the quality of the seed used, the rotation patterns, and the spectrum of crops or varieties grown - are very different when we compare these two types of location. (Examples are the difference in the occurrence of bunt of wheat or smut of sorghum, which are rare at Stations but frequent in farmer fields; and Fusarium in wheat, which is frequent at Stations but rare in farmer fields.)

A disease survey which is only based on one year's observations is not very representative. Each skilled agronomist knows that, depending upon the weather conditions and survival or build-up of disease potentials, some years can be "rust years", other years show no rust at all. In 1975 we had some new disease problems (e.g. Sclerotinia - white mould) in pulses and other crops in many parts of the country which had never been important in the past.

Finally, it has to be mentioned that crops which are newly introduced to a country or to an area are very often relatively free of diseases at first. It mostly takes some years until they catch their typical diseases (or until these are introduced accidentally).

In a developing country, a disease survey cannot be an "end in itself" (for example only to build-up a mycological collection or for taxonomic purposes); it has to serve the agricultural practices of the community at large in order:

1) to judge the importance of diseases and to decide on priorities for research (e.g. against which diseases breeding for resistance is needed; which routine control measures have to be introduced to prevent a build-up of diseases);
2) to understand the cycle of important diseases: that means from where they come and where they survive during the dry season;
3) to predict which disease problems could arise if we introduce a certain agricultural practice or bring a new crop to a certain area.

A discussion on the "Disease Situation in Ethiopia" has also to include a discussion on the means which we have to cut and to stop the disease cycle at a crucial point. For this, we have to know and to understand the life-cycle, especially the transmission and survival of the pathogen. Seed-borne diseases, for example, need different control measures from wind-spread diseases; soil-borne diseases others than those which are transmitted by vectors. The reservoir of alternative hosts on which diseases can survive has to be known before we can decide on rotation patterns.

The first question farmers or agricultural advisors ask, if they come to us with a disease problem, is very often; "Can you give us a chemical?" Such an approach is completely wrong. Chemical control in plant pathology, generally, has not to be the first but the last possibility which we have to consider.

Without doubt, using resistant varieties would be the most elegant way to control a plant disease. All efforts are concentrated at the early breeding phase, done by both breeders and plant pathologists; nothing will be left to the farmer; even often he will not be aware that such a disease, which could threaten his crop, exists. The general aspects of resistance have already been discussed by Dr. Goncharow in his paper. I only would like to make two, more or less personal remarks.

1) Breeding for resistance is a long-term programme: no short-term project or expert should undertake such an approach. Moreover, it needs a team of specialists working together, including a breeder and a plant pathologist.
2) The occurrence of new pathogenic races on the side of the pathogen has often caused a break-down of resistance. This has, in the last few years, largely discredited breeding for resistance when the so-called "vertical" resistance method had been used.

Consequently, new breeding methods were recommended, using the so-called "horizontal" resistance which cannot break down. To decide which approach has to be applied, we have to remember a few facts. On one side, the race problem causes difficulty only with some groups of diseases, for example the rusts, smuts, or mildews. Resistance to other disease groups, for example viruses or bacteria, remained stable over long periods without any break-down. Against these diseases, therefore, the classical breeding concepts can still be used without change. Even against the cereal rusts, smuts and mildews, as Dr. Goncharow has pointed out techniques are proposed or known to overcome the race problem. The concept of horizontal resistance, on the other side, still needs more detailed studies on many points before it can be said where and how it would work. In this situation, in a developing country, we still have to continue with the classical methods but, at the same time, we have to watch each development carefully in order to see what will be achieved in new techniques in horizontal resistance and in its understanding.

Agricultural practices, such as using certain sowing dates (e.g. in tomato or chickpea), rotation patterns or soil burning, are methods which - unconsciously - have been applied by the farmers for centuries to limit damage by plant diseases. If we propose to change these traditional farming practices - for example to replace soil burning by fertilizer application or to produce tomatoes for industrial production in repeated plantings throughout the year - we have to make sure that these new techniques do not create new disease problems which could only be overcome at great expense. More emphasis should be given in the future to the development of rotation programmes. The Experimental Stations should work out experimentally how the different crops have to follow each other, thus producing a package, instead of only recommending single varieties or crops and leaving it to the farmers to decide how to use them. Other cultural practices will also have to be considered - for example drainage (land levelling), irrigation patterns, soil preparation techniques, regulation of sowing depth, fertilizer application - before we have to think of chemical control as an alternative.

The chemical control of plant diseases is more difficult than that of insect pests. To control leaf diseases of plants, a permanent spray cover on the leaves is required. During the rainy season, where it is easily washed off, this is very difficult to achieve and would need continuous spraying at very short intervals. It would make the control very expensive and therefore would only be justified in valuable and high-yielding crops. For farmers also it would be difficult to apply the right dosage of the fungicide, which is effective but not yet phytotoxic. Therefore, generally, chemical control of plant diseases by spraying should not yet be recommended to small holders.

Nevertheless, in research, we have to continue with some trials on spraying against diseases. Firstly, in many countries, new products which are based on systemic fungicides are now being developed. They are taken up by the treated plants and thus would allow longer spray intervals. Probably, in the future, there will be crops and diseases where these products also could be used in Ethiopia by small holders in their fields, orchards or gardens. We have to follow the development. Secondly, if a seed production scheme is started in Ethiopia, we will have to use all possible control measures - including chemical control - to produce healthy seed.

In seed production, it is not only the quantity of seed - how many tons - that we have to consider; of more importance is the quality. This includes: purity, viability and health of the seed. Seed health means that the seed has to be free from seed-borne diseases. The way in which we have to start and to approach healthy seed production has to be: to produce healthy seed, and not only to reject (by a certification scheme) the seed lots which are bad. Inorder to do this plant pathologists will have to co-operate at the base; that is in the production fields, with the seed agronomists, helping them to produce high quality seed. Seed treatment, field inspection for diseases, and spraying against a further spread of diseases within the field are the means which we have to use. If we are able to give healthy seed to the farmers, this would be the easiest way for them to avoid seed-borne diseases such as bunt and smuts of cereals, Fusarium in wheat, anthracnose and viruses in beans.

Potentially, most crops can be attacked by a large number of diseases. In Ethiiopia, however, many of these diseases have not yet been found. We have to preserve this relatively healthy situation and try - by quarantine restrictions - to prevent the introduction of new diseases. Unfortunately, everywhere in the world, new plant diseases are mostly introduced accidentally by agricultural research institutes

or development projects; in the baggage of scientists or in diplomatic pouches with their samples of seeds or other planting material thus by-passing the official channels of importation. If we want to start an efficient quarantine service, we should first try to control these un-official channels before numerous quarantine inspectors are stationed at all border points, harbours and airports of the country. However, we have to be realistic: technically it would not be possible to detect each disease which is introduced with infected seeds; we have to restrict our efforts to the most important diseases which we want to a avoid by any means. Often after importation, new planting material will have to be grown at first in an isolated place and there, in the field, to be inspected by a plant pathologist for freedom from important diseases. Too strict handling of quarantine procedures could also delay the importation of all breeding material for months and thus obstruct development.

The whole discussion on the plant disease situation and on our means for improvement would be somewhat academic if we were not aware of what, in reality, are our possibilities and resources. Here in Ethiopia we are largely handicaped by the lack of trained staff in plant pathology. Following are some figures from the "World Directory of Plant Pathologiests" which was published in 1973. It listed for:

Egypt	131 Plant Pathologists
Ghana	25 " "
Kenya	33 " "
Iran	63 " "
Germany	317 " "
U S A	one to two thousand
Ethiopia	3 Plant Pathologists (now in 1975 it has increased to 9, half of them expatriates)

The consequences are clear: few plant pathologists in Ethiopia have to do everything; just touching the problems. Generally, it is not possible to go into details or to be specialized. Purely "theoretical research" can not be justified. As much as possible, we have to evaluate the literature and use results which are already available from other countries. Duplication of work - that means that two plant pathologists work on the same problem - should be avoided.

If new plant pathologists arrive, coming out from the College of returning from fellowship training, we have to check very carefully where to place them and how to use them in the most efficient way. Different responsibilities and subjects have to be covered. We need:

Crop Specialists: Grouped around a crop and approaching it from different angles. For example, including a breeder, an agronomist, a plant pathologist.

Specialists on the different Groups of Pathogens:

- Virologist
- Bacteriologist
- Mycologist
- Plant Physiologist
- Nematologist

Regional Advisors: For Extension Agencies, Agricultural Offices etc.

For Teaching and Training: At the College and E.P.I.D.

Central Staff at the Ministry of Agriculture:

For Quarantine, Seed health testing, Pest Control Certification and Legislation of Fungicides etc.

DISCUSSION

The Chairman thanked Dr. Niemann for his paper and for his comprehensive and constructive approach to solving some of the problems.

It was commented that agronomists need to introduce seed and in doing this, because there are so few pathologists in Ethiopia, they have to rely heavily on the centers which are sending them seeds and they have to trust that they are not sending diseased seed. At Awassa they have taken the risk and this has enabled them to develop new and promising varieties of maize. If all introductions were stoppdd then development will be also stopped. It was suggested there could be two situations: one for research stations and the other for introduction of commercial seeds. From the experience at Awassa it appeared very difficult to say wether a disease was introduced or not. To quote an example, that of Sclerotinia, it had been suggested that this disease was a new introduction, however, this same disease had also been found by workers in 1970. It is possible that this disease is already being carried by other crops such as sunflower, tomatoes, etc? But when a new variety which is highly susceptible to this disease is introduced then this disease appears very strongly; this had been the case with pea bean variety that had been introduced to Awassa. At Awassa it appears that we have a new disease each year, e.g. in haricot beans the 1973 crop was destroyed by rust, in 1974 it was destroyed by Anthracnose and in 1975 by Sclerotinia.

Dr. Niemann replied that he had brought up the problem of quaranteen not to stop development but in order to help the agronomists. If the agronomists come to the plant pathologist with their problems then they can be advised on how to cope with them. At Holetta the Plant Pathology Section check the literature to find what diseases are important which we wish to avoid and which have so far not been introduced to Ethiopia. When new material arrives, they check its country of origin and the disease situation of that country.

It is unfortunately often true that the phytosanitary certificates that accompany a seed batch are often not worth the paper they are written on. This is because the people sending the certificate do not check the material. Thus we have to consider the factors before making restrictions or recommendations which are advisable for introducing new material to Ethiopia. Regarding the Sclerotinia at first we thought it was a new introduction at Awassa but now it has been found in many other places and it is therefore a well established plant pathogen in this country. However, there are other problems such as virus diseases where we are sure that they were introduced with seed. In sugar cane there is a smut that has most likely been introduced with planting material.

An Entomologist asked Dr. Niemann, if they have a list of diseases that exist in Ethiopia. He replied that such a list had been compiled and was being continuously up-dated as new information became available. He also commented that inspecting material for entomologists and pathologists was perhaps somewhat different. In order to detect pathogens the material has either to be grown or subjected to some time consuming techniques. At the moment staff are very limited, therefore it is not possible to make exhaustive tests on all material and therefore we still do run a risk because even one seed out of a batch of several thousand can be sufficient to introduce a new disease.

The Chairman concluded this section be saying that this question of quaranteen was very valid as had been indicated in the case of Coffee Berry Disease. The pathogen had been present in Ethiopia for a very long time but not as a significant destroyer of coffee. It was the introduction of the virulent strain that has caused the devastation in coffee. Thus eventhough a disease is present in the country, we still have to guard against the introduction of new strains in these diseases.

PRELIMINARY RESULTS OF A STUDY ON WILT & ROOT-ROT COMPLEX OF CHICKPEAS

by

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(IAR HOLETTA)

INTRODUCTION

The total land area under chickpea cultivation in Ethiopia was estimated as 294.2 thousand hectares; the average yield was 6.3 q/ha and the total production was 185.3 thousand tons for the year 1969-70 (Statistical Abstracts 1970). During the general survey of chickpea fields in 1974-75 it was observed that 25% of the crop, on average, was destroyed by wilt and root-rot. Certain fields in the Debre Zeit area had about 50% of the crop destroyed by wilt.

The project was started in October 1974. By then it was too late to start any trials in the field. The field trials were started in August 1975. From the available data and the field observations it was felt that the problem was a complex which involved different fungi and soil factors. The main aim was to split the complex and approach it from different angles so as to arrive at effective control measures. The general approach followed has been to collect data on the disease situation in chickpea growing areas of the country; to have information on the biology of the pathogens (optimal infection age; humidity; soil type etc.) to arrive at effective control measures for the disease complex. This paper mainly deals with the preliminary green-house trials. The chickpea variety used was DZ-10-4.

I. General Survey

In 1974-75 the following areas were surveyed:

- i) Holetta .. .. Ambo
- ii) Addis Ababa .. .. Ghion
- iii) Addis Ababa .. .. Nazareth
- iv) Debre Zeit Experimental Station

Two trips were made to each area - the first one in November 1974 and the second in January 1975.

The pathogens isolated were:

- a. Fusarium oxysporum
- b. Macrophomina phaseoli
- c. Sclerotium rolfsii
- d. Rhizoctonia solani
- e. Others (Penicillium sp; Aspergillus sp; bacteria, etc)
- f. No isolation

The combined results of the two trips are shown in the Table I. The total number of infected plants collected was 524 during the first trip and 1004 during the second trip.

TABLE I

GENERAL SURVEY RESULTS FROM DIFFERENT PARTS OF ETHIOPIA 1974-75

Pathogen isolated	Holetta - Ambo 1st	2nd	Addis - Ghion 1st	2nd	Addis-- Nazereth 1st	2nd	D.Zeit Expt. Sta 1st	2nd	Average 1st	2nd
	---trip---		---trip---		---trip---		--- trip ---		--- trip ---	
Fusarium sp.	57%	31%	23%	28%	48%	31%	55%	11.6%	43.5%	29%
Macrophomina phaseoli	5%	6.3%	5%	4%	24%	10.3%	21.2%	5%	12.2%	6.4%
Sclerotium rolfsii	5%	0%	2%	0%	4.6%	0%	0%	5%	3%	0.3%
Rhizoctonia solani	6.2%	0.5%	2%	0%	2.3%	0%	15.3%	0%	5%	0.2%
Others	15%	22%	24%	29%	4.6%	26.4%	4%	21.6%	13.6%	25%
No isolation	12%	40%	45%	38%	17%	32.4%	5.5%	56.6%	22.7%	29.1%
Total number of plants collected	145	413	164	327	130	204	85	60	524	1004

2. Green House Trials

2.1 Symptoms: Considering the individual pathogens the following symptoms were commonly observed in the greenhouse: Rhizoctonia solani causes pre-emergence damping off if enough inoculum is present in the soil. In the case of older plants there is a rotting of the stem at the soil level and the plants fall prostrate.

Sclerotium rolfsii causes very little pre-emergence damping off. In the case of older plants a general wilting beginning with chlorosis of lower leaves might develop or the plants give Frost Struck wilting symptoms without any cholorosis. In heavily infected pots the roots are covered with thick white mycelium with or without sclerotia.

Fusarium oxysporum and Macrophomina phaseoli show the typical wilt symptoms beginning at the lower leaves and the plant dies completely in later stages.

In addition all these pathogens cause stunting of the plants under certain conditions.

2.2 Effect of Age on Percentage Infection by Wilt and Root-rot

A trial was carried out to find if there was a relationship between the age of the plant and its susceptibility to a pathogen and to determine the infection intensity of a pathogen.

The chickpeas were sown on different dates. The first sowing date was 22-10-74 and the last sowing date was 20-12-74. the inoculation was carried out on 23-12-74 when the eldest plants were 56 days old and the youngest plants were 3 days old.

The inoculum for the infection was grown on wheat. the culture was then blended and the solution was poured in holes bored on both sides of each plant. The total number of plants per pathogen/sowing date was 20.

The results are shown in Table II.

R. solani caused an average of 75% infection and at no age was the infection less than 50%.

S. rolfsii caused on an average 51% infection.

F. oxysporum and M. phaseoli mainly attacked older plants and proved to be weaker pathogens.

2.3 The Sowing Date/Sowing Depth Trial: The farmer usually broadcasts the seeds and then covers them by ploughing. This results in an unequal distribution of seeds in the field and planting at different depths. Also the farmers' views on a relationship between the diseases intensity and the sowing date vary in different regions.

Naturally infected soil from different chickpea fields was collected and sowing depth trials were made in the cold frames and greenhouse. The following results given in Table 3 were obtained:

TABLE 2. Effect of Age on Percentage Infection by Wilt and ORoot-rot

Pathogen	Age of Plants 56 days	42 days	28 days	14 days	9 days	3 days	Average Infection
Fusarium oxysporum	0%	30%	30%	25%	0%	0%	14%
Macrophomina phaseoli	0%	10%	0%	0%	0%	0%	2%
Rhizoctonia solani	70%	90%	50%	90%	75%	70%	75%
Sclerotium rolfsii	20%	35%	60%	40%	65%	85%	51%
Check	0%	0%	0%	0%	0%	0%	0%

Total number of plants infected / sowing date / pathogen were. 20.

TABLE 3. Sowing Depth Trial

Sowing Depth	% of pre-emergence dying	% of post-emergence dying	Pathogens isolated from post-emergence dead plants
2 cm	25%	8%	Fusarium sp.
9 cm	50%	8%	Fusarium sp. M. phaseoli S. rolfsii
16 cm	55%	10%	Fusarium sp. M. phaseoli S. rolfsii & R. solani

N.B. The total number of plants sown per sowing depth were 110.

2.4 Chemical Control: Different fungicides were tested in the greenhouse against specific fungi. The different treatments were:

a. Untreated
b. Benlate seed treatment (Methyl I-benzimidasol-2-ylcarbomate) — 2.5 g /kg
c. Vitavax kombi seed treatment (2.3 dihydro-6 methyl 5 phenyl carbomoyl-1,4 oxathin) — 5 g/kg
d. TMTD (Terametbyl thirum disulphide) seed treatment — 5 g/kg
e. Vitavax + TMTD seed treatment — 5 +5g /kg
f. Brassicol 75 W.P. seed treatment (pentachloro nitro benzine) — 5 g/kg
g. Brassicol 75 W.P. soil treatment — 5 g/m^2 of treated area

The infection was done by mixing the inoculum in to sterilized soil. The results are shown in table 4.

Vitavax + TMTD seed treatment proved to be the best, followed by Vitavax and Benlate seed treatments.

2.5 Host Range: Seven hosts including chickpeas were tested against *S. rolfsii* and *R. solani*, The hosts are:

a.	Cowpea	(*Vigna unguiculata*)	American Variety
b.	Haricot bean	(*Phaseolus vulgaris*)	Seafarer
c.	Soybean	(*Glycine max*)	Clark 63K
d.	Broad Bean	(*Vicia faba*)	Local Variety
e.	Lentil	(*Lens culinaris*)	local variety
f.	Pea	(*Pisum sativum*)	local shire
g.	Chickpea	(*Cicer arietinum*)	DZ-10-4

The results are given in Table 5.

a) All the hosts were found highly susceptible to *R. solani*

TABLE 4

THE RESULTS OF CHEMICAL CONTROL TRIAL IN THE GREENHOUSE FOR WILT AND ROOTROT

	Rhizoctonia solani			Sclerotium rolfsii			F. oxysporum & M. phaseoli			Check			Rank		a+b
	a	b	a+b	a	b	a+b	a	b	a+b	a	b	a+b	incl. check	excl. check	Overall Rank
Untreated	0%	<8	V <8	70%	<8	III 78	35%	17.7	VI 52.7	80%	11	IV 91	VI 18	V 14	VII 229.7
Benlate seed treatment	20%	13.3	II 33.3	30%	<8	I 88	40%	26.7	V 66.7	95%	<8	IV 103	III 10	III 8	III 291.0
Vitavax seed treatment	10%	15.4	III 25.4	80%	<8	I 88	70%	14.7	III 84.7	100%	< inf	I inf	II 8	II 7	II 306.1
TMTD seed treatment	5%	8.2	IV 13.2	45%	32.7	IV 77.7	25%	27.4	VII 52.4	90%	<8	III 98	VI 18	VI 15	VI 241.3
Vitavax + TMTD seed treatment	20%	17.6	I 37.6	75%	<8	II 83	70%	24.5	II 94.5	95%	<8	II 103	I 7	I 5	I 318.1
Brassicol seed treatment	0%	<8	V 8	75%	<8	II 83	65%	<8	IV 73	90%	<8	IV 98	IV 14	IV 11	IV 262.0
Brassicol soil treatment	0%	<8	V 8	45%	12.6	V 57.6	90%	<8	I 98	75%	11.4	V 86.4	V 16	IV 11	V 250.0

a is percentage of surviving plants

b is average time taken for dying

Roman numerals show the rank

< Infinity shows that all the plants reached maturity.

TABLE 5

RESULTS OF HOST RANGE TRIAL

Host	Rhizoctonia solani			Sclerotium rolfsii			Check		
	a	b	c	a	b	c	a	b	c
Cowpea	100%	-	100%	2.5%	0%	2.5%	2.5%	0%	2.5%
Haricot Bean	97.5	2.5%	100%	40%	7.5%	47.5%	2.5%	0%	2.5%
Soy Bean	100%	-	100%	40%	10%	50%	5%	0%	5%
Bread Bean	92.5%	5%	97.5%	5%	5%	10%	2.5%	0%	2.5%
Lentils	100%	-	100%	0%	7.5%	7.5%	0%	0%	0%
Pea	92.5%	5%	97.6%	2.5%	10%	12.5%	5%	0%	5%
Chickpea	100%	-	100%	10%	27.5%	37.5%	5%	0%	5%

a = shows percentage of pre-emergence dying.

b = shows percentage of post emergence dying.

c = shows the percentage of total susceptibility.

b) Bread bean, lentil and pea were less susceptible to S. rolfsii when compared to chickpea. Cowpea, on the otherhand, did not show any infections in these trials.

The effect of M. phaseoli and F. oxysporum on these hosts is still to be tested.

3. Field Trials:

Two sites, Debre Zeit Experimental Station and Ghinchi IAR site were selected to test the results from the greenhouse trials under field conditions.

The different trials at present being carried out at these sites are:

3.1 Sowing Date/Sowing Depth Trial: The sowing depths are 2 cm, 9 cm and 16 cm; and the sowing dates are at intervals of 15 days approximately. The second sowing date corresponds to the normal sowing date of the farmer in the area for 1975-76.

The germination results for the above trial from Ghinchi are:

Sowing Date	Number of plants germinated		
	Sowing depth		
	2 cm	9 cm	16 cm
1st sowing 9/9/75	268	68	12
2nd sowing 1/10/75	545	524	502
3rd sowing 14/10/75	339	451	474

Total number of seeds sown per sowing date/sowing depth was 600.

3.2 Chemical Control: The seven treatments tested in the greenhouse were tried at both sites. The treatments were

a. Untreated
b. Benlate seed treatment
c. Vitavax kombi seed treatment
d. TMTD seed treatment
e. Vitavax + TMTD seed treatment
f. Brassicol 75 W.P. seed treatment
g. Brassicol 75 W.P. soil treatment, and
h. Drenching with Benlate

The drenching was done with 0.05% solution of Benlate. The plants were about 15 days old at the time of drenching.

The results from trials at Debre Zeit (sowing date 26/8/75) showed that Vitavax + TMTD seed treatment is the best treatment followed by Benlate seed treatment and Vitavax seed treatment.

Brassicol soil treatment has shown very poor results at both sites; the germination of the plants being much less than in untreated plots.

3.3 Variety Testing for Resistance: Twenty-seven varieties of chickpeas and five varieties of rough peas provided by Dr. Schmidt were being tested for their resistance to the complex at Debre Zeit and Ghinchi. The selected varieties will then be tested against individual pathogens in the greenhouse.

DISCUSSION

Considering the greenhouse trials and general survey, the complex can be broadly split up into four different stages.

i) Pre-emergence damping off mainly by R. solani and S. rolfsii.

ii) Root-rot and wilt at seedling stages by R. solani, S. rolfsii, F. oxysporum and M. phaseoli.

iii) Wilting when plants are about six weeks old mainly due to F. oxysporum and M. phaseoli.

iv) The physiological pre-disposition and attack from weaker pathogens near maturity.

During the general survey all the areas visited provided the four pathogens even though their intensity varied.

The general survey results showed very low frequency of R. solani and S. rolfsii. Dr. Dagnachew reported 50% losses due to S. rolfsii in the Debre Zeit area. The greenhouse trials also point out that R. solani and S. rolfsii are capable of causing a high degree of infection. The isolations from Debre Zeit Experimental Station for 1975-76 trials yield the following results:

R. solani	60%
S. rolfsii	10%
F. oxysporum & M. phaseoli	11%
Others and no isolation	19%

Total number of isolations made are 140

A possible explanation for the low frequency of R. solani and S. rolfsii would be that the survey was started at a late date.

S. rolfsii is sometimes difficult to isolate and thus it is difficult to say how many of these no isolations from the fields might be infected with S. rolfsii.

Another fact to be noticed is the increase in number of plants yielding no isolations from about 23% during the first trip to about 39% during the second trip. The chickpeas experience a very long dry season and in later stages the black soil cracks, This puts the plants under a great stress as the roots are pulled between the cracks and are damaged. The weak pathogens then have ready access to the roots.

The sowing date/sowing depth relationship to the disease intensity is a complicated factor. The germination results at Ghinchi show that deeper sowing at a late sowing date increase the germination. BUT it also increases the time for and the length of the coleoptile being in contact with the soil and thus the fungi have better chances of infections. A shallow planting at a very early sowing date, on the other hand, has the disadvantage that the high moisture content of the soil favours fungal development and thus increases the amount of inoculum. The farmer has an unequal distribution of seeds. It is difficult to determine what percentage of the sown seeds reach maturity but it ensures some yield under all circumstances.

For successful chemical control the fungicide in this case has to have a long time effect as the plants are susceptible to one pathogen or another at all stages of their life. When the germination figures for Ghinchi and the results from Debre Zeit and the greenhouse trials are evaluated Vitavax + TMTD, Vitavax and Benlate seed treatments showed some promising results. These results will still have to be tested in other parts of the country. We might have to combine some of the treatments and work more on the dosage and methods of treatment. At present only one dosage for each fungicide has been tried.

R. solani and S. rolfsii seem to have a very wide host range. This helps the fungus in its survival even in the absence of particular host, of the seven hosts tested none was completely resistant to either of the two fungi.

DISCUSSIONS

The Chairman thanked the Speaker for her paper and said that this was a very important crop on the heavy black soil areas. It was encouraging to find some control methods already partially recommended and he wished her encouragement with the furtherance of her studies, which would hopefully come up with some very effective control measures.

A participant congratulated the speaker for working on a crop that was particularly important for the Ethiopian peasant farmers. However,if you come up with a recommendations to plant at a certain level, how is it going to be implemented in practice? Miss Bhasin replied that it was to early to make recommendations for a specific depth, however she felt that if this was part of a recommendation for controlling the disease complex then it should not be to difficult to implement this through EPID agents. She fully appreciated that a farmer could not use a planting stick to plant for a specific depth, however at the moment the ploughing for covering the seed was very shallow and if it was needed to make this ploughing deeper then farmers could accomodate this.

Ato Tekele Mariam from the Small Impelements Division of CADU pointed out that if it was seen that such a recommendation had very sound economic returns in it then an investment should be made in finding an implement to carry out this recommendation. At the present time he felt that it could be difficult for farmers to implement a certain ploughing depth for covering the seed. However in the future it was hoped that both an implement and the farmers' ability to purchase such implements would be possible.

Dr. Niemann commented that there appeared to be some misunderstanding of the situation, Wilt and root-rot was a disease complex which was conditioned by a number of factors including soil conditions and climate. Apart from studying the range of pathogens involved, the other factors will have to be studied separately. This will include identifying resistant varieties for the different pathogen ; cultural methods and chemical control. The results from all these studies will have to be examined and put together as a package recommendation for control measures.

PRELIMINARY RESULTS ON THE CONTROL OF ROOT-ROT NEMATODES

By

Dr. E. Niemann
(IAR - Holetta)

Root-knot nematodes (which belong to different Meloidogyne spp.) are world-wide in distribution. They are essentially hot-weather organisms and are most important in regions where summers are long and winters, if any, short and mild. In Ethiopia, they are injurious in farmer house-gardens, horticultural experimental fields with limited possibilities for crop rotation, and in some very susceptible crops such as tomato, tobacco (especially when these were pre-grown in infested seedbeds) and in melons. Many species of Meloidogyne are known from other countries. All of them have a different range of host plants which can be attacked. The species occurring in Ethiopia are not yet identified.

For the most part, root-knot nematodes are spread by human agencies such as (1) in the roots of infected transplants or seedlings; (2) in the refuse from storage houses; (3) in soil from infested fields on farm implements, the feet of men or of farm animals; (4) in irrigation water which can be an important means of spread.

Control measures which were proposed or have been used in other countries include:

1) The use of trap crops: These are highly susceptible, quick growing crops, which are sown to the land and allowed to grow a short time during which they will attract the nematodes. Then they are ploughed under or otherwise destroyed. This method is now considered as not being very effective.
2) Sowing *Crotalaria spectabilis*: Nematode larvae freely enter the roots of this "resistant" plant but fail to survive in them. Thus *Crotalaria* acts as an automatic trap that does not need to be ploughed under or destroyed.
3) If fields are flooded for a relatively long time, the nematode population will decrease. Four months flooding would be needed to kill the nematode larvae, but 12 months will be required to kill the nematode eggs.
4) Dry fallow, supplemented by periodic cultivation of the soil, will reduce the nematode population considerably.

5) In crop rotation schemes, susceptible crops are alternated with immune or highly resistant ones (e.g. different Gramineae such as oats, corn, millets). While these are growing, the nematode population decreases because nematode reproduction is less than natural mortality. At the end of one or more growing seasons, the nematode population will have decreased to a point where the su.ceptible crop can be grown again with little or no damage. After one growing season, a new cycle of resistant crops must again be started.

6) For some crops (e.g. tomato, lima beans, soybean, peach trees) varieties were found in other countries which are resistant against some species of root-knot nematode. None of them, so far, has been tested in Ethiopia.

7) Chemical control is based on products which are incorporated into the soil in form of a liquid, powder, granules or gas. Unfortunately, soil treatment with nematicides often remains effective only for one season after which the nematode population starts to increase again.

All the control measures mentioned have limitations, as can easily be seen; they are only partly effective and can only be used under certain conditions.

In the IAR, we had one field at Melkassa which - due to continuous intensive cultivation with horticultural crops, rainfed as well as under irrigation - was so heavily infested with root-knot nematodes that many crops could no longer be grown there. The questions were, which horticultural annual crop could still be grown and which control measures could be recommended to clean the field. For this purpose, two series of trials were conducted in 1974 and 1975 at Melkassa in collaboration with the IAR Horticultural Station at Nazareth:

1) A host range trial, including 20 annual horticultural crops which were of interest for that area; and

2) A number of soil fumigation trials with nematicides locally available in Ethiopia. For evaluation of both trials, the roots of the tested crops or of indicator crops (tomato, mungbean), which had been sown to the fumigated plots, were dug out after a certain time and scored for nematode galls, using a 0 to 10 scale: 0 = no infection; 10 = roots were completely destroyed and plants dead.

HOST RANGE OF ROOT-KNOT NEMATODES

Location:	Melkassa
Sowing Date:	1 - 3 July, 1974
1st scoring:	20 August
2nd scoring:	8 October
Replications:	RCB; 4 reps.
Plot size:	2 x 5 m
Scoring scale:	0 = no galls on the roots 10 = roots and plants completely destroyed.

CROP	VARIETIES	INFECTION (GALLS) ON THE ROOTS Date 20 Aug.	8 Oct.
Watermelon	Ananas yokneam	3.0	9.0
Lentil	Local	2.3	9.0
Chick Pea	Local	3.0	6.5
Grass Pea	Local	2.4	5.7
Mung Bean	M-109	1.9	6.1
Lima Bean	Early Thorogreen	1.3	6.2
Lettuce	White seeded	2.9	4.8
Adzuki Bean	ex Min. Agric.	1.7	5.3
Tomato	Rugers	1.1	4.8
Hyacinth Bean	A-51268	0.8	4.4
Carrot	Chantany	1.2	3.9
Eggplant	Round purple	0.5	3.9
Cabbage	Copenhagen market	0.4	2.9
Cowpea	Black eye ex Supermarket	0.1	2.9
Haricot Bean	Mexican 142	0.1	2.7
Potato	?	0.3	1.6
Pepper	Yolo Wonder	0.1	1.6
Onion	Bombay Red	0.1	0.9
Sweet Potato	White start	0.1	0.7
Pigeon Pea	Dr-4	0.1	0.2
	L.S.D. 5%	1.0	1.5
	1%	1.4	2.0

The results show clearly that, from the ten pulses and the ten other horticultural crops which were tested, watermelon, lentil, chick-pea, grass pea, mung bean and lima bean were the most susceptible. Watermelon and lentil had been completely wiped out at the second scoring date, 100 days after sowing. Pigeon pea, sweet potato, and onions were the least infected ones, only showing traces of gall development on the roots. Certainly, these results were found against the species of nematodes occurring at Melkassa. But there is a high probability that the spectrum of root-knot nematodes in other areas is not very different from that at Melkassa.

A preliminary soil treatment trial in 1974 with D-D and BASAMID had shown no efficiency of BASAMID and only a partial efficiency for D-D against nematode infection. Probably, re-contamination of the plots had occurred after the treatments, for the plots had been irrigated by furrow irrigation.

The trial was repeated in 1975 with 6 nematicides, using a sub-plot design in which the plots, one month after treatment, were sown in one half with mung bean, in the other half with tomato as an indicator crop. Only sprinkler irrigation was applied in order to avoid re-contamination.

The results show that only TERABOL and D-D proved to be sufficiently effective. NEMAPAZ was only partly effective. TERRACUR, NEMACUR and BASAMID were - in the dosages applied - not or not sufficiently effective. But, beside the efficiency, there are other aspects which have to be considered when such soil fumigation trials are evaluated:

1) The side effect against other diseases, soil insects and weeds: No other soil-borne diseases (e.g. damping-off, root rots) or soil insects were observed in the trials. However, there was a clear effect of METHYLBROMIDE, BASAMID and D-D on the development of weeds in the treated plots. Also, in TERRACUR and NEMACUR treated plots, virus infection in mung beans started later than in the other plots, probably due to a systemic effect against the virus-vectors affecting the plants.

2) Symptoms of phytotoxicity on the plants:
The germination and stand of the indicator crops had not been affected by any treatment. However, mung beans were slightly stunted on the plots which had been treated with METHYLBROMIDE, especially during the first month after sowing.

SOIL FUMIGATION AGAINST ROOT-KNOT NEMATODES

Location: Melkassa 1975
Soil treatment: 27.3
Sowing date: 28.4
Indicator crops: Mung bean and tomato
Split plot design, 4 - 7 (aver. 6) replications
Plot size : 1 x 10 m

1st scoring: 4.7
2nd scoring: 7.8 (mung bean)
25.8 (tomato)
Scoring scale: 0 to 10
0 = no galls on the roots,
10 = roots and plants completely destroyed

TREATMENT	ACTIVE INGREDIENT	FORMULATION (% act.ingr)	DOSAGE (formulated prod) m²	APPLICATION	TOXICITY (rats) Oral (mg/kg)	dermal (mg/kg)	respiration (ppm/air)	RESULTS ON Mung bean ROOT INFECTION ON DATE 4.7	Mung bean 7.8	Tomato 4.7	Tomato 25.8
UNTREATED	-	-	-	-	-	-	-	2.2	4.7	2.2	5.6
BASAMID	Daxomet	85% powder	60 gr	broadcasted and worked into the soil				2.4	4.3	1.9	4.8
TERRACUR	Fensulfothion	5% granular	30 gr	" "	2.2-10.5	3.5-30		1.6	4.0	1.0	4.7
NEMACUR	Phenamiphos	5% granular	24 gr	" "	15.3-19.4	500		0.9	3.3	1.1	4.9
NEMAPAZ	DBCP (1,2 dibromo-3-chloropropane)	75% liquid, E.C.	5 ml	by hand-injector	250-500	1420 (rabbits)		0.2	1.7	0.5	3.0
D-D-	1,3-dichloropropylene + 1,2 dichloropropane	liquid	67 ml	"	140	2100 (rabbits)		0.1	0.5	0.2	1.1
TERABOL	Methylbromide	liquid/gas	50 gr	fumigation under plastic sheets			514	0	0.1	0.1	0.5
					L.S.D. 5%			0.8	1.0	0.6	0.9
					1%			1.1	1.4	0.9	1.3

3) The human toxicity in TERRACUR, NEMACUR and METHYLBROMIDE is very high. BASAMID, NEMAPAZ and D-D are less toxic. However, to judge on their value, the formulation of the products has also to be considered, e.g. the percentage of active ingredient and whether the products have to be applied as powder, granules, liquid or gas.

4) A cost analysis of the treatments - comparing costs for the treatments with the increase in yield - has not yet been made. We hope to be able to go ahead with this in the coming season in collaboration with the Nazareth Horticultural Station, in order to get some information on which conditions a soil treatment would pay.

What conclusions can be drawn from the results and which recommendations can be given?

At present, it seems that under Ethiopian conditions in farmers' gardens and large production fields, from all methods discussed, only rotation patterns and dry fallow can be applied for control of root-knot nematodes, using the information on the nematode host range which was given in the paper. Other methods would still be too expensive or the education and knowledge of the farmers is not yet high enough to apply these methods properly and safely.

So far, only on lands or in crops of high value, with very intensive cultivation practices, can a soil treatment be recommended. For example in horticultural experimental fields or in seedbeds (tobacco tomato), and even here it can only be used by trained staff who are fully aware of the toxicity problem and the factors which affect the efficiency of the products.

DISCUSSION

The Chairman thanked Dr. Niemann for his paper and for the encouraging results that had been presented.

Dr. Niemann was asked whether he had used either hot water treatment of seeds or steam treatment of soil. He replied that hot water treatment was not effective because Root-knot Nematodes are soil born and therefore they come in with planting material or they are already present in the soil. However for burrowing nematodes which are very important in bananas, hot water treatment of planting material had been tried. Regarding steam treatment, he said that this required very specialized equipment and it was felt that this method was not practical under Ethiopian conditions and therefore the expense of importing equipment could not be justified.

Dr. Niemann was asked if the had tried Tagetes minuta or Tagetes erecta, these plants had been reported as being effective in other parts of the world. Tagetes minuta, which is a common weed in this country, had been studied as Debre Zeit and had been found very effective in reducing the Nematode populations in the soil. These studies were reported in the 1970 Annual Progress Report of the Plant Science Department. Dr. Niemann replied that neither these species nor Crotalaria had been used. The starting point for the study on Root-knot nematodes has been the tobacco seed bed at Melka Werer where soil fumigation was the most appropriate method.

PATHOGENIC PROPERTIES OF POTATO VIRUS Y ISOLATES (PVY) INFECTING ETHIOPIAN PEPPERS (a)

G. Selassie K. (1); G. Marchoux (2); J. B. Quiot(2)

Introduction

Peppers in Ethiopia are cultivated for local and industrial uses. However, in the South of Ethiopia potato virus Y type diseases cause serious losses in both hot and mild varieties. Symptoms consist of vein banding with severe leaf and fruit deformations. Except for one sample, which showed mixed infection with Tobacco Mosaic Virus, all the rest yielded the PVY type only. In the same region the same type of virus was isolated by one of us, for the first time (b).

(I) - Diagnostic Host's Reaction to Mechanical Innoculation.

Cucumis sativus L., Pisum sativum L., Phaseolus vulgaris L., Datura stramonium L., Vigna sinensis L., gave no reactions.
Lycopersicon esculentum Mill. latent reaction
Solanum demissum A-6 produced few local lesions and systemic reactions.
Capsicum annuum L., var. Yolo Wonder and Doux des hands. C. frutescens L. var. Tobacco, Nicotiana tabacum L., var. xanthi and N. glutinosa L., all showed systemic tabassco.

(II) - Electronic Microscope Observations

Leaf dips of negatively stained preparations for examination by electron microscope were prepared using 1% of neutralized phosphotungstic acid (PTA) and showed felexon particles of 700 - 750 mm.

(III)---Comparison with Other Viruses Affecting Peppers

The isolates have been further separated by diagnostic host's reactions and serological tests from other very closely related virus groups like Tobacco Etch Virus (TEV), Pepper Mottle Virus (PMV), and Pepper Veinal Mottle Virus (PVMV). The sisolate can neither infect Datura stramonium nor produce wilting on tobacco (TEV); it does not produced any local lessions (PMV), and it can not be also PVMV, because it infects tomato by mechanical inoculation easily, and infects tobacco systemically.

(1) Awassa Research Station - Ethiopia - (2) INRA - Montfavet - Avignon - FRANCE
(a) The paper was presented by Dr. Gebre Selassie Kidane of Awassa Research Station. It was an extract of the one presented at the Second International Conference on 'Progress and Problems in Vegetable Virus Research.

(IV) - Comparison with Other PVY Type Viruses

The Ethiopian isolate is different from French types like To - 72. (c) due to the fact that it does not provoke any necrosis on varieties like Doux des Lands or Bastidon. On the other hand its infectivity on Porto Rico Wonder, Yalo Y, Ikeda and Doux d'Alger makes it closer to the French type Pi. 72.

Conclusions:

In general we have found that the Ethiopian isolate was less agressive on susceptible varieties and Nicctiana tabacum var. xanthi than the French ones (d). Eventhough one can not rule out the existence of complex virus diseases in the peppers of Ethiopia, except for one sample, all our Isolates yielded PVY only. Moreover the Ethiopian isolates, inspite of its weak and non-necrotic behavior, on susceptible varieties showed broader infectivity on the so-called resistant pepper varieties.

DISCUSSION

The Chairman thanked the Speaker for his presentation and welcomed him as part of the team of Plant Pathologist now working in Ethiopia.

In 1974 there had been a survey on pepper initiated by the Ethiopian Spice Extraction Company. This survey had identifyed Tobacco Mosaic Virus as the most important one in peppers and recommendations for control measures using milk had been made. The questioner wanted to know if this method was effective and also if Tobacco Mosaic Virus was as widely spread as had been indicated in this report.

Dr. Gebre Selassie replied that treatment with milk could not be effective for Tobacco Mosaic Virus because this virus was transmitted by contact.

Secondly he was not surprised that tobacco mosaic virus was present in Ethiopia because solanaceous crops had been cultivated for a long time. As to the gravity of Tobacco Mosaic Virus, he could not say at this time because they were only working from observations and reports.

(b) MARCHOUX G., Rapport de Mission - IRAT - ETHIOPIA - 1970
(c) MARCHOUX G. POCHARD E. CHAMBONNET D. ROUGIER J. EUCARPIA., Budepest - 1974.
(d) POCHARD E, GEBRE S.K, MARCHOUX G., Communication au congres sur la Recherche pour les virus des cultures legumieres - 1975.

The Chairman commented that even if spraying with milk was ineffective perhaps it is worth while for the workers to wash their hands with milk before going from one field to the next. Dr. Gebre Selassie replied that he was still opposed to milk treatment. Tobacco Mosaic Virus had an inactivation point at 80°C and even at 100°C with heat treatment it is not fully destroyed. Therefore let alone milk control measures even heating to 100°C was not fully effective. The idea behind the recommedation to spray milk was that it provided a film on the leaf in order to prevent aphids from piercing and taking out the sap. However, this had been proved a failure in many countries as it had only been found effective at 10% or less.

The Speaker was asked if the Potato Mosaic Virus found on peppers is the same one that infected potatoes. He replied that it was the same virus and the reason it was called Potato Mosaic Virus was that in 1929, Smith had found two viruses which he had called X and Y. The one, Y, was first **isolated** from the potatoes and hence it's name. This virus is now wide spread in all Solanaceous crops.

It was questioned wether there was any hope for breeding for resistance to virus diseases. Dr. Gebre Selassie replied that he had presented this same paper at an International Symposium on Virus Research for Vegetable Crops. At that Symposium he had met plant breeders who had been working for 20 years in Florida and he had been promised to be given material for testing for resistance to the isolate found in Ethiopia. He was also hoping to receive material from South America.

Potato Virus Y has been shown to be transmitted by aphids, the questioner wanted to know if it was also transmitted by seed; if it was possible to control the insect then surely this should be a priority. Dr. Gebre Selassie replied that the virus is not seed transmitted. However for potatoes the problem is that the 'seed' is a tuber which has direct contact with the stem, therefore the tuber can conserve the virus. In peppers the virus is not transmitted through the seed. If the aphids are killed this is only done after they have pierced the plant, therefore the damage has already been done. Controlling the aphid is very expensive as it has to be done every time they appear. Also it is only possible to use systemic insecticides and this will only kill the present population and will not control the spread of the virus.

In replying to a question on what facilities were needed to continue the work on viruses. Dr. Gebre Selassie replied as follows: Plant quaranteen has been a topic for discussion for at least 10 years, rules and regulations had been made but not passed. As regards viruses in the world, we, in Ethiopia are in a very vulnerable situation because there is no source of resistance. Regarding facilities he would for the first time like to request the Institute for permission to build a small green house, it did not need to be a sophisticated type and to supply

him with an electron microscope to facilitate virus identification. For seorological work he could and was already cooperating with Debre-Zeit Experimental Station where the facilities for sereological work were available.

The Chairman found the lack of resistance to Ethiopian iolates very alarming. Peppers are an important part of the diet in Ethiopia, and he felt that there was a big diversity of types or even species in Ethiopia. He asked Dr. Gebre Selassie how many collections had been made and how many tests had been made on these Dr. Gebre Selassie replied that in Ethiopia we can not really talk of varieties, only populations or land races. Some of these had been collected from the market in the Upper Awash, Awassa and Buta Jira Region. So far no important differences have emerged from growing these populations at Awassa. He had only tried testing the Ethiopian isolate against internationally known varieties and the existing local varieties of Awassa.

It was commented from the floor that when the materials were send to Dr. Gebre Selassie in France the people at Awassa had selected only plants showing a high incidence of disease.

AN INTEGRADED APPROACH TO WEED CONTROL IN COTTON IN THE MIDDLE AWASH VALLEY ON CO-OPERATIVE OR STATE-OWNED PRODUCTION UNITS

By
Mr. J.E. Moore
(FAO Agronomist/Weed Control, IAR)

Introduction

While the importance of controlling weeds is well understood by research agronomists and other specialist workers, the actual problems of obtaining a high standard of weed control on a field scale are seldom fully appreciated. The research worker in Eastern Africa simply keeps his plots weed-free throughout his trial by handweeding and only when funds are scarce, or in the face of particular problem weeds, does he start to consider other means of control. In fact the stimulus for much of the weed control work in Eastern Africa was as a result of this.

Similarly the subject of weed control by smallholders, whether on a settlement project or on their inherent farms, is frequently dismissed as a minor one of manual weeding. The overriding importance of timely weed control (4) (5) (7) and problems of ensuring this may not be taken into account, nor the implications of failure on the potential benefits of quite simple research recommendations be fully appreciated. (e.g. fertilisation, date of sowing, improved varieties). Such factors as a continual rain, a heavy unworkable soil, weeds not susceptible to handweeding (Cyperus spp.; Digitaria scalarum, Launea cornuta, Portulaca quadrifida, and annual grasses in cereals) shortage of labour, or cash to hire labour, can easily result in failure in weed control, reduced yields, and a reduced cash return to the smallholder. Furthermore freedom from the drudgery of weeding can release the farmer for more rewarding work or increase the area he can handle. (8) (9).

It is therefore necessary to evolve improved methods of weed control, These include better use of existing machinery or development of new tools, extension emphasis on preventative measures such as use of cleaned seed and destruction of standing weeds before seeding, and the introduction of chemical control measures which offer striking possibilities of rapid advance. Manual weeding will not be superceded by reliance on sophisticated means alone and integration of all these methods into a system that is the agricultural, economic and social optimum should be the aim. This paper reviews the work done on weed control in cotton in the Middle Awash Valley and its application to meet that objective.

History

The difficulty of controlling weeds became apparent around 1966 as the commercial cotton farms along the Awash expanded their areas. Trial work was carried out from 1966 - 1969 which resulted in the introduction of pre-irrigation followed by cultivation and the use of the herbicides fluometuron and trifluralin on a field scale. In 1972 a programme to investigate the potential of herbicides was initiated at Melka Werer co-inciding with the introduction of better types of machinery on the bulk production fields. This work was planned when development policy in the Middle Awash was for the establishment of medium size (100 ha) commercial farms on the one hand and co-operatively worked plantations on the other. However the results obtained can with some modifications be used in the new farming systems being evolved following recent changes in land tenure whereby the private farms remain as state-owned commercial units while greater emphasis is being placed on individually owned smallholdings. In both cases the problem of weed control can be expected to increase.

The problem

The principal problems of weed control in the Middle Awash can be defined as:

1. Increasing populations of weeds that are hard to control by conventional means;
2. Wet weather and clay soil preventing use of machinery or manual labour for timely weed control;
3. Shortage of labour and a low output of work by the local tribesmen;
4. Ensuring timely weeding if high yields are to be obtained.

It can be predicted that Afar settlers with 1 ha cotton and 1 ha of other crops will find it difficult to keep ahead of the weeds. The mean number of man hours spent on the first and second weedings on five fields at Melka Werer was 94.44 and 127.34 man hours. These fields were over a range of sowing dates and were not treated with herbicides but received one or more cultivations (Tables 11 and 12). If it is accepted that an Afar settler can do 5 hours effective weeding a day this means that he must spend 44 days on the all-important first two weedings of his cotton alone. The growth of weeds and crop dictate that weeding should start about 3 weeks after irrigation while field experience has shown the second weeding is needed about 4 weeks later. On this basis over the 38 days between the 21st and 59th day of crop growth 44 man days have to be set aside for weeding. Fortunately the Afar Tribesmen have 2 or 3 wives! Reliance on hand weeding alone is obviously very dubius.

The Weeds Species

Knowledge of the weed species is important for any control programme and where use of chemicals is contemplated it is essential. Table 1 lists the weeds of the Awash Valley, the most important species being marked with an asterist(*). The dominant species vary with soil type and its water retaining capacity, fertility and how long a particular area has been under cultivation. Different weed floras call for different control measures and herbicides must be chosen with the weed flora in mind. Specific susceptibility to the main cotton herbicides is also indicated on Table 1.

The Experimental Programme

This started with Screening trials on a range of herbicides proven for use in cotton elsewhere, (4) (5) (6) principally East Africa and the Sudan. Trials were carried out in 1972 (Prog. Rep. 1972), 1973 (Prog. Rep. 1973) and in 1975. The results of these trials are summarised in Tables 2, 3 and 4 respectively. Appendix A outlines the scoring system used. The second stage of the work, assessment trials, commenced in 1974. The most promising herbicides were also used on bulk production fields from 1973 in order to gain experience of problems that would arise in field scale use as early as possible. This proved to be most important,

Screening Trials

In general our results follow the pattern found elsewhere in East Africa or the Sudan, with some particular variations. The aniline herbicides, trifluralin and nitralin, were very safe with the crop and controlled annual grasses exceptionally well and a limited number of broad-leaved species as well. Of serveral new similar chemicals tested fluchloralin and dinitramine appeared superior to CGA 10832 or AC92553. Prometryne generally gave the best overall control of both annual grasses and broad-leaved weeds, It also exhibited relatively greater selectivity under Melka Werer conditions of irrigated cotton than has been the case in the raingrown crop in East Africa. Fluometuron gave consistant weed control but also caused more pronounced damage as chlorotic mottling of the first leaves with some stand reduction. However the crop generally grew away from this very well. Diuron, a substitute urea used similarly to fluometuron was only tested in one trial and exhibited somewhat superior weed control. Surprisingly the indications were that it was slightly mcre selective.

Twelve other herbicides were included in the trials. Of these napropamide was of interest since it gave selective control of Cyperus, (probably rotundus) in the 1975 trials and this should be investigated further. Cyperquat also gave control of Cyperus but since it is specific and used post-emergence it could only be of value as a directed spray where

TABLE I

Weeds of the Awash Valley

Species and Family		Susceptability to herbicides: Triflu-ralin	Nitralin	Fluomet-uron	Promet-ryne
*Abutilon spp.	Malvaceae	0	0	0	0
*Amaranthus dubius	Amaranthaceae	x(x)	xx	xxx	xxx
*Amaranthus hypochondriacus	"	x(x)	xx	xxx	xxx
Amaranthus viridis	"	x(x)	xx	xxx	xxx
Argemone mexicana (upper Awash only	Papaveraceae	0	0	0	xx
Celosia argentia	Amaranthaceae	-	-	xx	xx
Cenchrus oiliaris	Gramineae	xxx	xxx	-	-
Chloris virgata	"	xxx	xxx	xx	xx
Commelina bengalensis	Commelinaceae	0	0	xx	xx
Commelina imberbis	"	0	0	xx	xx
Corchorus fascicularis	Tiliaceae	x	x	xxx	xxx
*Corchorus olitorius	Tiliaceae	x	x	xxx	xxx
*Cucumis dipsaceus	Cucurbitaceae	x	0	xxx	xxx
*Cucumis melo	"	x	0	xxx	xxx
Cynodon dactylon	Gramineae	0	0	0	0
*Cyperus bulbosus	Cyperaceae	0	0	0	0
*Cyperus rotundus	"	0	0	0	0
Digera muricata	Amaranthaceae	xx	x	xx	xx
*Echinochloa colonum	Gramineae	xxx	xxx	xx	xxx
Eragrostis tenella	"	xxx	xxx	xx	xx
Euphorbia geniculata	Euphorbiaceae	-	-	-	-
Euphorbia hypericifolia	"	-	-	-	-
Euphorbia hirta	"	-	-	-	-
*Flaveria trinervia	Compositae	0	0	xxx	xxx
Gynandropis gynandra	Capparidaceae	x	x	xx	x(x)
*Hibiscus dongalensis	Malvaceae	0	0	0	0
H. panduriformis	"	0	0	0	0
*Ipomoea plebia	Convolvulaceae	0	0	x	xx
*Launea cornuta	Compositae	0	0	0	0
*Portulaca foliosa	Portulacaceae	xx	xx	xxx	xxx
*Portulaca oleraceus	"	xx	xx	xxx	xxx
*Portulaca quadrifida	"	xx	xx	xxx	xxx
Rhynchosia minima	Leguminosae	(-)	(-)	(xx)	(xx)
Setaria acromelana	Gramineae	xxx	xxx	(x)	xx
Setaria verticillata	"	xxx	xxx	(x)	xx
Solanum dubium	Solanaceae	0	0	x	0
*Sorghum sudanensis	Gramineae	xxx	xxx	x	xxx
Tragus racemosus		xxx	xxx	-	-
*Tribulus terrestris	Zygophyllaceae	0	x	xxx	x
*Tribulus cistoides		0	x	xxx	x
Urochloa tricopus	Gramineae	xxx	xxx	-	-
Xanthium strumarium (Upper Awash only)	Compositae	-	-	-	-
*Zaleya pentandra	Aizoaceae	0	xx	x	xx

Key xxx Very susceptible
xx Susceptible
x Slightly susceptible
0 Resistant
- Not known

(...) Information uncertain

the weed is exceptionally severe. None of the others gave promise of giving better selective weed control than the standards.

Experiments on Mode and Timing of Application

1. The promising aniline herbicides are normally sprayed and incorporated immediately before planting. Under large scale farming conditions there are obvious advantages if this could be done several weeks before planting. Two trials were carried out to test this, the second on a field scale (Prog. Rep. 1974). In the first trial trifluralin was compared with EPTC, a carbamate giving good control of Cyperus species. Results are summarised in Tables 5 and 6. (Prog. Rep. 1973). The time elapsing from application to sowing did not make any difference to the performance of trifluralin, which gave highly effective control of E. colonum and other annual grasses. Overall control was poor however due to a high population of broad-leaved weeds and Cyperus sp. (probably rotundus). EPTC gave serious crop damage but very satisfactory control of Cyperus except where applied the day before sowing when incorporation was shallow using a rolling cultivator.

   The field scale application work in 1974 was upset by the postponement of planting on the farm for one month due to fears of pink bollworm infestation. This was not decided until after pre-irrigation and as further cultivation was then necessary on the untreated blocks the whole field was disc harrowed. As would be expected the extra cultivation reduced the weed population but later emergence was still sufficient to show clearly that application 6 weeks before planting does not reduce the effect of trifluralin at 1.0-1.3 kg a.i./ha and in the event of an enforced further postponment of planting such a delay should still not affect performance too adversely.

2. Under mechanised irrigated farming conditions pre-emergence herbicides have for practical reasons to be sprayed before irrigation onto a dry soil surface. Where irrigated first the weed seedlings usually germinate before it is possible for spraying to be done. Irrigation after spraying leaches the chemical downwards to a degree which should vary according to the amount of water and soil type. This can affect the weed control obtained and the crop damage that may result. Ideally application should be after irrigation while the soil surface is still quite moist. The two methods of application were compared using fluometuron and prometryne each at 3 levels (Prog. Rep. 1973). The trial results are summarized in Table 7.

   The post-irrigation treatments were superior to pre-irrigation in terms of mean yields (24.4 against 17.2 q/ha), weed control and crop damage as scored after 35 days. The mean plant height of pre-irrigation fluometuron at 62 cm was lower than post-irrigation at 69 cm but for prometryne it was not. Stand differences were not apparent.

Differences between the mean yields of the two herbicides (prometryne 21.1 q/ha, fluometuron 20.4 q/ha) plant heights, stands or crop damage scores did not appear of importance, but the rates of fluometuron used were relatively higher.

The highest rates of fluometuron, post-irrigation, gave a considerably greater increase in yield over the lowest rate (9.0 q/ha) than was the case with prometryne (3.6 q/ha). This was in spite of the damage caused (visual score 4.8) considered as unacceptable. Field experience has confirmed that rates over 1.6 kg a.i/ha fluometurnn under middle Awash conditions (pre-irrigation) are usually excessively damaging. That 3.3 kg post-irrigation gave such good results is very encouraging.

The superior performance from post-irrigation application of both herbicides confirmed theoretical expectations based on their known chemical properties and activity in soils. While this mode of application presents difficult practical problems on mechanised farms it should present little difficulty for small holders particularly if low volume application of flowable formulations becomes feasible.

Herbicide Assessment Trials

The varied weed flora and narrow margin of selectivity of the broad-spectrum cotton herbicides in the Awash Valley, which restricts the increase of application rates means that whatever herbicide is used there will always be a population of uncontrolled weeds which require handweeding. Thus the value of each herbicide should be assessed by the degree to which its use reduces the amount of supplementary weeding. This can best be evaluated as the extension in the period of time after planting before handweeding is required and as manhours of work done. The second criterion is however only valid for comparative purposes within the particular experiment since weeding trial plots always costs more and takes longer (and should be more efficient) than on a field scale. A series of trials was started in 1974 to assess these factors. The herbicides chosen were trifluralin, nitralin, fluometuron and prometryne. Results are summarised in Tables 8, 9, and 10.

TABLE 2. Cotton Herbicide Screening Trial - 1973
Weed Control and Crop Damage Assessment

Herbicide	Rate Kg a.i. per ha	Time of Application	Scores on EWRC 1-9 System Crop Damage Days 21	38	Weed Control after Sowing 21	38
Trifluralin	0.8	P.P. Incorp.	1	1	5	5.25
Trifluralin	1.6	" "	1	1	2.75	5.25
EPTC	2.4	" "	5.25	4.5	3.25	7
EPTC +	5.1	" "	6	8	2.3	7
Nitralin	1.15	" "	1	1	3.25	7
Nitralin	1.5	" "	1	1	3.25	5
Fluometuron	1.2	Pre-Emergence	2.5	1.7	4	4.7
Fluometuron	2.1	" "	3.5	3	3	2.75
Prometryne	0.8	" "	2	1.25	3	3.5
Prometryne	1.75	" "	3.75	3.5	2.25	2.5
A 4002	0.75	Post-Emergence		6.5		6.25
A 4002	1.5 *	" "		6		5.5
MSMA	1.8	" "		2.5		7.25
MSMA	2.5	" "		2.5		6.5
MSMA +	1.6	" "		3.75		5.25
Fluometuron	+ 0.9					
MSMA +	2.2	- "		5		2.5
Prometryne	+ 0.8					
Glyphosate	1.5	" "		6.5		2.75
Glyphosate	2.7	" "		7.25		1.25

+ Means of 3 Replicates only

* Rate calculated. Application faulty due to spray pump malfunction.

Variety: Albar 637
Sown: 22 August 1972
Plot size: 32 m^2
Soil type: Light alluvial silt

Weeds	% population
Cyperus sp.	25.2
Echinochloa colonum	23.1
Amaranthus angustifolius	12.0
A. dubius	
Cucumis melo	9.1
Tribulus terrestris	6.7
Zaleya pentandra	6.0
Ipomoea plebia	2.0
Sorghum sudanensis	5.0

TABLE 3. Cotton Herbicide Screening Trial 1974
Weed Control and Crop Damage Assessment

Herbicide	Rate Kg a.i. per ha	Time of Application	Scores on EWRC 1-9 system Crop Damage Days after sowing 37	Weed Control 37	93	Yield q/ha
Nitralin	1.05	P.P Incorp	1.0	3.25	5.4	19.5
Nitralin	1.5	(22-6-73)	1.5	2.25	3.75	27.7
Fluchloralin	1.0	"	1.0	3.5	5.4	26.0
Fluchloralin	1.6	"	1.4	2.5	3.5	26.1
R 25823	2.2	"	1.0	7.6	8.4	16.2
R 25823	4.35	"	1.5	6.25	8.25	16.4
CGA 10832	1.0	"	1.0	4.25	6.15	19.3
CGA 10832	1.5	"	1.0	4.0	5.0	24.7
Fluometuron	1.7	Pre-Emergence	3.25	2.5	4.15	27.3
Fluometuron	2.1	Pre-Irrig.	3.75	2.75	5.1	20.1
Prometryne	0.9	(23-6-73)	1.4	4.6	6.4	23.3
Prometryne	1.7	"	1.25	2.1	3.25	29.4
Methazole	1.6	"	1.0	5.4	6.4	25.6
Methazale	3.0	"	1.0	5.0	5.8	16.9
Fluoradifen	1.7	Pre-Emergence	1.0	5.4	7.75	16.0
Fluorodifen	2.8	Post-Irrig. (29.6.73)	1.0	4.25	6.25	22.7
Handweeding	x 1	37 days	1.0	9.0	4.85	27.3
Handweeding	x 2	37, 71 days	1.0	9.0	1.75	28.3
SE						±4.0**
LSD 0.05						8.0
CV%						33.0

Variety: AMS 1(70)
Sown: 23 June 1973
Plot Size: sprayed 16 m^2
harvested 12m^2
Soil type: Medium alluvial vertisol

Weeds	
Echinochloa colonum	25.0%
Tribulus terrestris	14.5%
Amaranthus angustifolius	14.3%
Zaleya pentandra	7.0%
Cyperus spp.	3.9%
Eragrostis tenella	7.7%
Gynandropsis gynandra	3.3%
Other Grasses	15.3%
Other Broad-leaved weeds	0.9%

TABLE 4. Cotton Herbicide Screening Trial 1975
Weed Control and Crop Damage Assessment

Herbicide	Rate Kg. a.i. per ha	Time of Application	Plant Height cms	Crop Damage Stand Count m^2	Crop Damage EWRC Score 23	Weed Control EWRC 23	Weed Control Score 57
Nitralin	1.0	P.P. Incorp.	35.0	11.9	1.0	6.9	8.7
Nitralin	1.5	(2.7.15)	36.5	11.7	1.3	5.4	8.3
Dinitramine	0.6	"	35.2	13.5	1.3	5.9	7.7
Dinitramine	1.0	"	32.6	13.9	2.3	4.1	6.0
AC 92553	1.0	"	30.9	13.7	1.3	5.3	6.2
AC 92553	1.5	"	32.2	12.2	1.0	5.0	6.2
Prometryne	1.0	Pre-Emergence	34.6	14.3	2.0	5.3	6.5
Prometryne	1.4	(4.7.75)	32.0	12.6	3.0	4.6	6.3
Diuron	1.0	"	31.8	12.6	2.7	4.1	5.3
Diuron	1.4	"	31.7	13.9	3.7	3.0	5.5
Fluomotaron	1.2	"	33.1	15.7	3.7	6.1	6.7
Fluometuron	1.5	"	28.2	12.0	4.3	3.7	6.0
Gs 16068	1.5	"	33.6	14.6	1.3	6.1	7.2
Gs 16068	2.1	"	31.1	11.9	3.0	4.6	5.8
Napropamide	1.1	"	36.4	12.1	1.4	6.1	8.2
Napropamide	2.1	"	31.1	12.6	3.0	4.0	5.5
A 4002	0.5	"	31.3	12.4	1.4	5.9	6.7
A 4002	1.1	"	29.5	11.6	3.7	4.1	6.5
Cyperquat	1.9	Post-Emerg	34.7	14.2	1.0	9	8.5
Cyperquat	3.7	(30.7.75)	30.8	14.6	1.0	9	8.1
Handweeded	-	-	38.6	13.3	1.0	9	1.0
SE			±2.1**	±1.2*			
LSD 0.05			4.2	2.4			
CV%			12.1	17.9			

Variety: AMS 1(74)
Sown: 3rd July, 1975
Plot size: 16 m^2
Soil type: Medium vertisol clay.

TABLE 5. Mode of Application in Cotton - 1974

Herbicide and No. of days before planting applied		Rate Kg a.i/ha	Crop Damage Score 25 days	Crop Damage Score 42	Weed Control Scores General 25 days	General 42 days	Cyperus sp. (rotundus?) 25 days	Cyperus sp. (rotundus?) 42 days	Echinochloa colonum 25 days
Trifluralin	31 (a)	0.94	1.0	1.0	4.3	7.3	9.0	9.0	1.5
	17 (a)	0.95	1.0	1.0	5.7	7.7	9.0	9.0	1.0
	2 (a)	0.9	1.0	1.0	7.0	7.3	9.0	9.0	1.0
	1 (b)	1.0	1.0	1.0	5.7	7.7	9.0	9.0	1.0
EPTC	31 (a)	3.7	7.0	7.3	5.3	9.0	3.3	5.5	4.5
	17 (a)	3.9	5.3	7.0	5.0	9.0	3.3	5.0	3.3
	2 (a)	3.8	6.3	7.3	5.7	9.0	3.3	6.5	4.5
	1 (b)	4.1	2.3	4.0	8.0	9.0	6.7	4.5	5.3
EPTC + Antidote									
	31 (a)	3.8	6.7	7.3	5.0	9.0	3.0	4.0	4.5
	17 (a)	3.9	6.3	7.3	5.0	8.3	2.3	6.3	2.7
	2 (a)	3.9	7.0	7.0	5.0	8.7	2.3	4.7	5.5
	1 (b)	4.1	2.0	4.3	7.3	9.0	7.3	7.0	4.0

Sown: 29 June, 1973 Plot sizes: 64 m^2 Variety: AMS 1(70)

Spray volumes 31 days 585 l/ha. Soil type: Medium vertisol
17 " 470 "
2 " 420 "
1 day 625 "

a) Application onto flat cultivated land. Incorporation by disc harrow.
b) Application onto ridged land. Incorporation by lilliston cultivator.

TABLE 6. Time and Method of Application of Trifluralin

Application time-days before planting	General Control S	General Control % Cover	Corchorus olitorius S	Corchorus olitorius No./m^2	Annual Grasses S	Annual Grasses No./m^2	Annual B-Leaf S	Annual B-Leaf No./m^2	Cucumis spp.* No./m	Abutilon spp.
73	3	13	9	22	1	0	1	9	3	0
60	2	9	-	19	1	0	1	16	7	1
43	1	2	-	5	1	0	1	21	0	0
10	2	2	-	11	1	0	1	18	0	3
Control	6	32	6	16	-	3	9	14	7	6

Sown 30.5.74 to 2.6.74

Soil type Heavy vertisol clay

Rate applied 1.0 - 1.3 kg a.i./ha

S = Score on EWRC 1-9 system on 15th June

No/m^2 = Number of weeds per square metre on 2nd July

*Weeds removed before sufficiently mature for identification

TABLE 7. Time and Rates of Application Trial

Herbicide Treatment	Rate Kg/a.i /ha	Crop Damage: Stand Count No./m of row 38	Crop Damage: Plant Ht. cms Days 52	Crop Damage: EWRC Scores From 35	Crop Damage: EWRC Scores Planting 89	Weed Control: General Control Scores 35	Weed Control: General Control Scores 89	Yield q/ha
Pre-Irrigation								
Prometryne	0.75	9.3	65.0	1.6	1.0	6.6	8.8	14.3
"	1.1	15.4	72.5	2.0	1.0	5.3	7.0	20.6
"	2.3	10.5	66.5	2.8	1.0	4.2	6.8	21.7
Fluometuron	1.1	12.7	60.0	2.2	1.0	7.0	9.0	11.7
"	1.6	13.8	68.5	3.2	1.0	6.5	8.0	17.4
"	3.0	13.2	57.5	5.2	1.0	4.6	6.5	17.2
Post-Irrigation								
Prometryne	0.8	13.1	73.0	1.2	1.0	4.3	6.8	22.2
"	1.2	11.6	70.0	1.6	1.0	3.0	6.2	21.8
"	2.5	12.5	64.0	3.3	1.0	2.2	3.7	25.8
Fluometuron	1.2	10.7	74.0	1.2	1.0	3.8	6.2	21.6
"	1.6	12.4	70.5	2.5	1.2	4.5	5.8	24.1
"	3.3	12.2	64.0	4.8	1.3	1.8	3.7	30.6
SE		±1.9^{ns}	±4.5**					±4.6*
LSD 0.05			9.0					9.1
CV%		26.5	11.7					38.1

Variety: AMS 1(70)

Soil Type: Light alluvial

Sown: 30 June, 1973

Date Sprayed - pre-Irrig. 30 June 1973
- post-Irrig. 4 July 1973

Plot size - Sprayed 16 m^2
- Harvested 12 m^2

Weed Population %	
Echinochloa colonum	10%
Eragrostis tenella	2%
Amaranthus angustifolius	24%
Gynandropsis gynandra	2%
Other grasses (mainly *Sorghum sudanensis*)	31%

TABLE 8. Herbicide Assessment Trial 1974

Herbicide	Rate Kg ai/ha	Crop Damage Score 18	General Weed Control Score 26	General Weed Control Score 39	Herbi-cide Cost $/ha	Days to first weeding	Weeding times and costs: 40 days Time Man-days /ha	40 days Cost (incl. herb.) $/ha	55 days Time man-days /ha	55 days Cost (incl herb.) $/ha	Total to harvest Time man-day /ha	Total to harvest Cost (incl. herb.) $/ha	Yield q/ha	Cash return compared to weeding
Nitralin 1)	1.1	1.0	5.5	4.0	38.70	31	36.9	103.30	49.6	125.50	60.4	144.40	31.8	+ $112.00
Nitralin	1.5	1.0	3.5	525	52.60	34	27.8	101.30	39.7	122.15	39.7	122.10	29.8	- $ 28.00
Trifluralin	1.0	1.0	3.5	7.75	43.20	40	25.0	86.90	25.0	86.90	32.9	100.90	32.2	+ $140.00
Trifluralin	1.6	1.0	3.5	5.75	64.40	37	24.5	107.30	24.5	107.30	42.8	139.60	30.0	- $ 14.00
Prometryne 2)	1.2	1.0	4.75	4.0	34.00	31	33.0	91.75	38.0	100.45	59.0	137.20	30.8	+ $ 42.00
Prometryne	1.8	3.0	3.75	4.75	52.00	37	24.3	94.50	31.2	106.65	37.9	118.30	31.4	+ $ 84.00
Fluometuron	1.25	2.5	5.25	5.0	38.90	34	37.9	105.20	51.5	129.08	73.3	167.30	32.9	+ $189.00
Fluometuron	1.7	2.5	4.75	5.25	52.50	34	32.0	108.46	32.0	108.46	49.6	140.00	35.3	+ $357
Handweed	x 2	1.0	1.75	4.0	-	21	28.0	49.10	52.1	91.20	52.1	91.20	30.2	-
Handweed	x 3	1.0	1.5	4.25	-	21	31.7	55.50	60.6	106.10	87.6	153.30	30.2	-
SE													$\pm 4.3^{NS}$	
CV%														

Sown : 13 June 1974
Variety: Albar 635
Soil type medium alluvial silt
Plot size sprayed 48 m^2
harvest 32 m^2

1) Preplant incorporation 12 June 1974
2) Pre-emergence 14 June 1974
Handweeding x 1 At 21 days
x 2 At 55 days
x 3 At 81 "

TABLE 9. Herbicide Assessment Trial 1975

Herbicide	Rate kg/a.i /ha	Crop Damage Score 23	General Weed Control Score 23	Days to first weeding	Weeding Times and Costs: 41 days Time man-days /ha	41 days Cost (incl. herb.) $/ha	55 days Time man-day /ha	55 days Cost (incl. herb.) $/ha	Total to harvest Time man-days /ha	Total to harvest Cost (incl. herb.) $/ha	Yield kg/ha
Nitralin 1)	1.0	1.0	6.6	32	49.8	120.70	84.3	181.10	84.3	181.10	2538
Nitralin	1.4	1.0	5.2	33.8	56.6	148.50	71.3	174.30	75.6	181.80	2472
Trifluralin	1.0	1.6	4.8	37.4	50.0	128.80	62.7	151.00	80.9	182.90	2531
Trifluralin	1.5	1.4	4.8	35.6	60.7	168.10	76.6	195.95	97.3	232.20	2528
Prometryne 2)	1.1	1.0	5.6	35.6	60.9	137.20	77.3	165.90	98.4	202.80	2100
Prometryne	1.6	1.4	6.4	35.6	59.3	148.80	86.1	195.70	95.0	211.25	2441
Fluometuren	1.2	3.0	6.8	33.8	46.0	118.90	69.2	159.50	88.6	193.45	2447
Fluometuren	1.5	3.0	7.4	33.8	54.6	143.25	76.1	180.80	88.4	202.40	2306
Handweed	x 1	1.0	9.0	24	53.8	94.15	53.8	94.15	53.8	94.15	1553
Handweed	x 2	1.0	9.0	24	47.2	82.60	77.8	136.15	77.8	136.15	2497
Handweed	x 3	1.0	9.0	24	64.2	112.35	93.3	163.30	111.9	195.80	2503
No Weeding	-		9.0								453

Sown: 10 June 1975
Variety: AMS 1(74)
Soil type medium - light alluvial silt
Plot Size - sprayed 48 m^2
- harvest 32 m^2

1) Preplant incorporation 9 June 1975
2) Pre-emergence 11 June 1975
Handweeding x 1 At 24 days
x 2 At 55 "
x 3 At 116 "

Weed population %	
Cyperus rotundus	33.7
Gynandropsis gynandra	18.0
Tribulus terrestris	5.2
Echinochloa eolonum	13.4
Zaleya pentandra	9.2
Corchorus olitorius	6.8
Amaranthus angustifolius	3.9

The time elapsing before supplementary weeding was needed was constant over all treatments for both seasons. The second handweeding was also needed at the same time. However the manhours of labour required was far higher in 1975 which reflected a greater population of resistant weeds, notably Cyperus and Gynandropsis and it was possible that weeding could have been beneficial a few days earlier.

The most important data is that for 55 days after which period cotton gives little response to additional handweeding in terms of yield (although costs of harvesting and grade of seed cotton may be affected) Table 10 gives the means of this data over the two years.

TABLE 10. Weeding Costs up to 55 days 1974 and 1975

Herbicide	Rate Kg. a.i. per ha	Mondays Per ha.	$ per ha. (including herbicide)
Nitralin	1.0	66.4	153.30
Nitralin	1.5	55.5	148.20
Trifluralin	1.0	43.8	118.90
Trifluralin	1.5	50.5	115.60
Prometryne	1.2	57.6	133.17
Prometryne	1.7	58.6	151.17
Fluometuron	1.2	60.3	144.30
Fluometuron	1.6	54.0	144.60
Handweed	x 1*	53.8	94.15
Handweed	x 2	64.9	113.70
Handweed	x 3	76.9	134.70
		(70.9)	(124.20)

Figures in brackets give mean of times and costs for two weedings done by 55 days for the x 2 and x 3 handweeding treatments.

* = Data for 1975 only available.

In terms of both extension of time until weeding and reduction of supplementary weeding the best performance over two years was from trifluralin, with the lower rate appearing superior to the higher rate, thought due to differential distribution of the resistant weeds. The lower rate was also the only treatment to approach the cost of two handweedings and below the mean for all plots being weeded twice only. Nitralin was disappointing over both years but the unavoidable delay in incorporation due to it being sprayed a short time before the trifluralin might have been deleterious.

In 1974 the high levels of both fluometuron and prometryne also substantially reduced the amount of supplementary handweeding but in 1975 results were poorer and there was no benefit. This is only partially explained in terms of resistant weeds but certainly the high population of Cyperus meant that the second supplementary weedings took longer than the previous year.

No pre-irrigation was given to these trials due partly to the practical problem of irrigation before spraying and mechanical incorporation of the aniline herbicides and partly because pre-irrigation is seldom practised by farmers. In the bulk fields performance has generally been superior and the practise of pre-irrigation appears to be beneficial since it reduces the amount of water applied at planting and thus the leaching of the chemicals.

Yield differences were not significant in 1974 indicating that supplementary weeding had been satisfactory. The planned single weeding treatment was unfortunately weeded twice so that no comparison of yields from weeding once only with two weeding or with herbicides was possible which could have been valuable for assessing the economic benefits. The yield from the higher level of fluometuron was greater than would be expected from its level of weed control but yields from bulk fields treated with fluometuron have also been consistently good.

Use in bulk production fields

Detailed costings are made on all bulk production fields at Melka Werer and data relevant to weed control operations have been extracted and are given in Table 11 for some of the fields for 1974 and 1975. Table 12 give the results of field scale evaluations of benefits from herbicides in comparison with conventional weed control methods at three sowing dates in 1973 and 1975. This is carried out as a field scale trial every year. These tables illustrate a number of points.

1. The use of well-chosen herbicide substantially reduces the amount of handweeding, and while the overall cost of weed control per hectare is higher the increase is not high in relation to the crop return.

2. Where resistant weeds are dominant (as was the case in June sown blocks, Table 12, where infestations of Cyperus rotundus was very severe) no benefit will accrue from use of a herbicide.

3. The weed problem is less serious on the heavy soils than the light ones. However the light soil fields have been cultivated several years longer than the heavy soils and introduced weed species such as Launea cornuta, Gynandropsis gynandra, Portulaca oleraceus have not yet colonised them to such an extent.

4. Weed control costs are consistently high in later planted cotton coinciding with the July rains. Not only is a vigorous flush of weeds germinating and competing with the crop but use of machinery is often impossible and handweeding is less effective. Use of herbicides is most valuable at this time.

5. May planting on very weedy fields can mean high weeding costs Two flushes of weeds can occur, the first induced by irrigation, the second by the July rain, Table 12 shows the benefit from herbicides which saves two handweedings at $80-90 per ha with yields unaffected. Conversely on relatively clean fields use of a herbicide with May planting gave no benefit (Table 12).

6. On alluvial soil fields cotton treated with fluometuron has consistently given higher yields than from untreated fields. (Table 11 fields A1 and A3. Also in 1973 treated fields gave 43.9 and 37.5 q/ha. untreated gave 29.8 q/ha ref. (Prog. Rep. 1973 - 1974 P 214))

Although not apparent from these tables fluometuron has also consistently caused syptoms of crop damage as leaf chlorosis, and patchily distributed stand reduction. In 1974 in field A3 (Table 11) the stand reduction was serious on 0.5% of the total area. This results in increased cost of gapping up.

Recommendations

These must be considered preliminary as much further work needs to be done, particularly on the relationship between sowing dates, weed floras and their competition.

The approach should be based on a concept of integrated control involving cultural, mechanical, manual and chemical measures.

1. Residues from the previous cotton (or other) crop should be destroyed as soon as possible after harvesting and the land ploughed deeply with a mouldboard plough to promote dessication of Cyperus bulbils and tubers for as long a period as possible. Where serious infestions of Cyperus are known to occur the land should also be chisel ploughed to 30-40 cm depth. Soil surfaces should be left rough and cloddy to reduce wind erosion. Early ploughing will also prevent the establishment of perennial grasses e.g. Cynodon dactylon.

2. Weeds regenerating in the dry season or after the light March/April rains should be destroyed. The main weed appearing at that time is often Launea cornuta, populations of which tend to increase with disc harrowing. Slashing before seeding is a better practise. Treatment with glyphosate at 2.0 kg a.i/ha repeated after 45 days should give good control. Hormone weed killers such as 2.4-D or MCPA must NOT be used since soil residues will damage cotton planted afterwards.

3. Pre-irrigation, carried out mainly to build up water reserves, can also assist in weed control. It should be made 2-3 weeks in advance of sowing and cultivation to destroy germinating weed seedlings done just prior to sowing. It is essential to destroy all weeds germinating from pre-irrigation since otherwise they become established ahead of the crop and are more seriously competitive. The method of pre-irrigation will depend on soil type. On light alluvial silts the field must be ponded since ridges cannot be made. Weed seedlings are then destroyed during the ridging operation, or by disc harrowing when weed growth is exeessive. On other soils the pre-irrigation is down the furrow and cultivation made with a rolling cultivator set to give maximum penetration and a fine seed bed.

4. Early sowing, as well as giving intrinsically higher yields, is advantageous for weed control. Cotton established well ahead of the July rains is better able to withstand competition from "late" weeds germinating with them and control of the "early" weeds is not interrupted by rain-induced problems.

5. Inter-row cultivations with a rolling cultivator, or deeper cultivation with a furrower, should be timed to control weed seedlings between two and five weeks from sowing, making one or more cultivations as necessary. If a pre-emergence herbicide has been used the cultivation should not be deep.

6. Hand weeding should be done early and the crop kept weed free for at least six weeks until crop canopy closure between the rows. Further weeding after eight weeks is unlikely to greatly affect yields since a well developed crop will effectively suppress further weed growth. However early May sown cotton may benefit from an extra weeding in mid-July.

7. The value of herbicides where labour is cheap is in ensuring that the crop is grown without weed competition during the important first weeks of growth, and in reducing weed populations to a level manageable with the time and efficiency of labour available. Use of herbicides is likely to be of maximum value in Middle Awash conditions in May or July planted cotton. Yields from late sown cotton are already irreversibly diminished and herbicides should not then be used. Chemicals currently recommended, with certain reservations, are:-

Trifluralin

Trade names TREFLAN. TRIFLUREX. Supplied as a 48% emulsifiable concentrate. Application is pre-planting with immediate incorporation onto weed free soil. It may be safely used up to six weeks before sowing. Rates of application are 1.0 - 1.25 kg a.i/ha (2.1 - 2.6 litre product). There is little hazard from overdosing to 2.0 kg a.i. Trifluralin is recommended where annual grasses are the principle weeds but certain broad-leaves are also controlled (Table 1.)

Nitralin

Trade name PLANAVIN. Supplied as a 75% wettable powder. Application as for trifluralin but early (6 weeks) pre-planting application has not specifically been tested. Rates are 1.0 - 1.25 kg a.i/ha (1.3 - 1.7 kg product) again there is no hazard in overdosing to 2.0 kg a.i. Nitralin controls a similar spectrum of weeds to trifluralin but appears more active against some broad-leaved weeds (Zaleya pentendra, Tribulus spp. Amaranthus spp.)

Fluometuron

Trade Name COTORAN. Supplied as an 80% wettable powder and 50% liquid. Application pre-emergence after planting, with irrigation as soon as possible and certainly within 3 days. Post-irrigation application is preferable where this is practical but application must be before crop or weed emergence. Where tractor sprayers are used this is seldom possible. Rates of applicationare 1.2 - 1.4 kg a.i./ha (1.5 - 1.75 kg of 80% product) at these rates a varying degree of chlorosis will occur in the first leaves with possible stand reduction unevenly distributed in the field. At rates above 1.4 kg a.i. damage becomes increasingly severe and care is essential to prevent overdosing.

Prometryne

Trade Name GESAGARD. Supplied as an 80% wettable powder and 50% liquid. Applications as for fluometuron. Rates from 1.2 - 1.6 kg a.i/ha (1.5 & 2.0 kg 80% product). At rates over 1.6 kg damage may result shown as scorch and shrivelling of seedling leaves but the safety margin is wider under Awash conditions than with fluometuron.

TABLE 11. Bulk Fields Weeding Times and Costs Per ha 1974 and 1975

Operation	Field and Sowing Date							
	D1 1.6.75		D2 15.6.74		A3 9.6.74		A1 6.6.74	
	Time	Cost	Time	Cost	Time	Cost	Time	Cost
Spraying	0.86	6.02	-		0.80	5.60	-	-
Incorporation	1.68	11.76	-	-	-	-	-	-
Cultivation	1.20	8.40	0.49	3.43	0.44	3.08	0.19	1.33
Furrowing	-	-	0.78	5.46	0.70	4.90	-	-
TOTAL		26.18		8.89		13.58		1.33
Herbicide	(Trifluralin)	35.90	-	-	(Fluometuron)	43.30	-	-
Handweeding x1	19.2		49.1	-	50.9	-	91.07	-
" x2	29.9		114.0		63.3		119.60	-
" x3	111.9		21.0		86.7		21.24	-
x4	-		56.2		-		41.89	68.45
TOTAL	161.0	40.30	240.3	60.08	200.9	50.22	273.80	69.78
TOTAL COST		102.38		68.97		107.10	32.8	2296.00
Yield /ha	28.8	2016.00	32.1	2247.00	39.9	2793.00	N.A.	N.A.

	Field and Sowing Date							
	D1 15.5.75		D2 24.5.75		C1 30.4.75		C2 26.5.75	
	Time		Time	Cost	Time	Cost	Time	Cost
Spraying	1.08	7.56	1.08	7.56	1.12	7.84	0.74	5.18
Incorporation	1.08	7.56	1.08	7.56	-	-	-	-
Cultivation	0.27	1.89	0.37	2.59	0.93	6.51	-	-
Furrowing	-	-	-	-	0.74	5.18	-	-
TOTAL		17.01		17.71		19.53		5.18
Herbicide	(Trifluralin)	37.40	(Trifluralin)	38.00	(Prometryne)	21.65	(Fluometuron)	29.70
Handweeding x1	30.8		12.3		83.1		17.8	
" x2	32.3		55.2		132.6		77.0	
" x3	43.8		57.9		87.2		127.2	
x4	-		-		29.1		60.2	
TOTAL	106.9	26.70	125.4	31.35	332.0	83.00	282.2	70.55
TOTAL COST	N.A.	N.A.	N.A.		30.6	N.A.	N.A.	N.A.

Soil Type - A.I. A 3.C1.C2 Alluvial silt - light and powdery.
D1. D2 Vertisol clays - heavy and cracking.

Rainfall	May	June	July	August
1974	44.4	53.8	151.1	28.8
1975	29.6	57.0	186.0	169.0

TABLE 12. Costs/ha of Weed Control Economics Trial 1973

Operation	May Nitralin Time	May Nitralin Cost	May Control Time	May Control Cost	June Nitralin Time	June Nitralin Cost	June Control Time	June Control Cost	July Nitralin Time	July Nitralin Cost	July Control Time	July Control Cost
Spraying	0.2				0.3				0.5			
Cultivation	1.1		1.0		2.2		2.3		1.7		1.4	
Furrowing	0.7		1.5		0.7		0.6		-		-	
TOTAL	2.0	14.00	2.5	17.50	3.2	22.40	2.9	20.30	2.2	15.40	1.4	9.80
Weeding*	101.9	25.50	97.2	24.30	128.7	32.18	139.8	34.95	235.3	58.82	313.5	78.38
Herbicide (Nitralin)	1.25 kg	27.10	-		1.5 kg	32.50		1.5 kg	1.5 kg	32.50	-	-
TOTAL		66.60		40.80		87.88		55.25		106.72		88.16
Yield q/ha	36.0		36.4		24.4		27.8		26.6		27.1	

Herbicide rates kg product/ha

* Work was allocated on a contract basis but costed on a daily basis, the exact time to complete contracts not being recorded. This was biased against the herbicide treatment

Tractors hrs $7.00/hr
Man hours $0.25/hr
Blocksize 2 hectares
Soil type Vertisol Clay - heavy and cracking

Rainfall May 28.5 mm
June 13.7 mm
July 139.4 mm
Aug. 149.0 mm

TABLE 13. Costs/ha of Weed Control Economics Trial 1975

Operation	MAY Prometryne Time	$	Fluometuron Time	$	Control Time	$
Pre-plant cultivation	1.82		1.82		1.82	
Spraying	0.45		0.37		-	
Cultuvation	0.82		0.90		1.42	
Furrowing	0.92		0.92		0.92	
TOTAL	4.01	28.07	4.01	28.07	4.16	29.12
Herbicide	1.0kg	23.40	1.46	36.65	-	-
Weeding x 1	-	-	-		55.85	13.96
" x 2	-	-		-	109.75	48.01
" x 3	139.84	34.96	110.73	27.68	43.62	10.90
" x 4	34.50	8.62	37.52	9.38	31.52	47.88
TOTAL		43.58		37.06		80.75
TOTAL COSTS		95.05		101.78		109.87
Yields kg	29.6		27.8		28.6	

Operation	JUNE Prometryne Time	$	Fluometuron Time	$	Control Time	$
	2.77		2.77		2.77	
	0.27		0.27		-	
	-		-		-	
	-		-		-	
	3.04	21.28	3.04	21.28	2.77	19.39
	0.91kg	20.50	1.27kg	31.90	-	-
	268.83	67.21	254.09	63.52	131.54	32.63
	164.85	41.21	115.80	28.95	93.36	23.34
	-	-	-	-	-	-
		-		-		-
		108.42		92.47		55.97
		150.20		145.65		75.36
Yields (kg)	20.3		21.7		19.2	

TABLE 13. (Continued)

Operation	JULY Prometryne Time	$	Fluometuron Time	$	Control Time	$
Pre-plant cultivation	-(a)		-(a)		-(a)	
Spraying	0.37		0.45		-	
Cultivation	0.45(b)		0.37(b)		-	
Furrowing	-		-		-	
TOTAL	0.82	5.74	0.82	5.74	0.0	-
Herbicide	0.9kg	19.35	1.1kg	27.61	-	-
Weeding x 1	121.63	30.40	88.89	22.22	144.65	36.16
Weeding x 2	101.71	25.43	71.63	17.91	200.00	50.00
Weeding x 3	185.80	46.45	77.32	19.33	245.17	61.29
Weeding x 4	-	-	-	-	-	-
TOTAL		102.28		59.46		147.45
TOTAL COSTS		127.37		92.81		147.45
Yields Kg	13.3		13.8		10.5	

Discussion

Technically the application of the recommended measures should present no problems on large-scale,state-owned farms using machinery. The extent to which herbicides are integrated with the more conventional measures should primarily depend on the availability and efficiency of labour.

On smallholdings owned and worked by individual families it will not be so easy to implement them. Build up of Cyperus rotundus, other sedges and perennial grasses must be expected in the absence of deep ploughing, in addition to the problem of Launea cornuta, none of these being susceptible to control regimes based on hand-weeding. A partial solution may however be in the oxdrawn mouldboard plough now being tested.

The problem of timely weeding has already been stated. Herbicides appear to be the answer. One of the major problems in use of herbicides by smallholders has been the difficulty of precise application. Elsewhere the use of granular formulations has been proposed but the recent development of very low volume application of concentrated liquid herbicides through an adaption of the Micron ULVA seems to offer a better solution. It has not yet been possible to sufficiently test the machine in cotton but it appears to solve problems of damage due to excessive dosage, of distribution of the chemical and of water shortage. Total volume of application is only 10 litres/ha. It also permits post-irrigation application which, as already mentioned, should increase effective weed control while reducing crop damage.

The system that can perhaps best be termed "Co-operative share-farming" in which the participants (shareowners) are allocated a particular area of cotton which they are supposed to irrigate, thin, weed and harvest, but which is otherwise handled on a commercial farm basis has several advantages from the point of view of weed control. It permits the economic use of machinery for land preparation and thus the control of perennial weeds and, in theory, should allow the share-owner time to weed satisfactorally, since other time consuming operations, such as land preparation, planting and insecticide spraying are done for him.

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ANNEX I

Outline of the 1-9 Scoring System of Assessing Trials

A scheme for estimating damage to Crop and Weeds, and the Effectiveness of Herbicides, modified from the scheme for Pesticide Trial Assessments developed by the European Weed Research Council.

Score	Herbicidal Effectiveness (on weeds)	Approximate % Kill of Weeds	Damage by Herbicide to Crop	Approximate % Cover by Remaining Weeds	Degree of Weed Infestation After Treatment
1	Excellent	100	None;Control	0	None
2	Excellent	99	Very Slight	1	Trace
3	Good	98	Slight	2	Very Slight
4	Satisfactory	95	Slight - Moderate	5	Slight
5	Just Adequate	90	Moderate	10	Moderate
6	Inadequate	75	Severe	25	Severe
7	Poor	50	Very Severe	50	Very Severe
8	Very Poor	25	Extremely Severe	75	Extremely severe
9	Useless * = Control	0	Killed	100 = Control	Complete Cover

*Score of 9 is allocated to the Control.

The degrees of Effectiveness and Weed Infestation will have to be defined more precisely according to the requirements of any particular trial, the crop and number of days since application or planting to date of assessment. Score 4 is taken as "Satisfactory to a farmer".

N.B. Category 0 = No observation to record.

DISCUSSION

The Chairman thanked Mr. Moore for his brief and comprehensive presentation.

The question was raised from the floor about the use of implements especially for small farmer. Mr. Moore replied that this was extremely important not only in the Middle Awash where the figure that had been quoted, 44 man-days, was the amount of time needed for hand weeding on large scale fields and the fields had already received one or two cultivations. If an ox drawn harrow or inter row cultivator could be developed, this would be a great advantage. He felt that in Ethiopia the use of small tools by both completely unsophisticated low landers and also the highlanders required a lot of further investigation. For example, at Holetta in trials on the optimum time of weeding and supplementary weeding the labour had said they could not weed until after 45 days from planting because of the condition of the soil. Prior to that date the weeds are also to small to be pulled by hand. Mr. Moore felt that late weeding was not a deliberate practice of Ethiopian farmers but they were just unable to do it earlier because they do not have the correct tools.

The Speaker was asked what percentage weeding and different weeding regimes contribute toward increasing yield. He replied that in all herbicide trials, they always include a no-weeding control. In a herbicide trial in cotton in 1974, the zero weeding treatment had given 2 q/ha of seed cotton compared to the best treatment which had given between 31 and 35 q/ha. The two hand weeding and three-hand weeding treatments had given yields of 30.2 q/ha. The first and second hand w weeding were made at the 21st and 25th day after emergence and the third at 81 days. Until now in Ethiopia, there has not been a trial which compared the effect of with-holding weeding until certain stages in the crop growth versus weeding. However there were results from many other places in Africa particularly the Sudan and Zimbabwe. These trials had indicated that the most important time in the crops' growth for being free from weed was between 21 and 42 days. Weeding prior to 21 days did not have a very significant effect on yield, if it did this effect was small and similarly weeding after 55 days had never made a material difference to the yield. However, late weeding could have an effect on the quality of the crop and the problems of harvesting.

A participant questioned the value of using herbicide particularly if recommendations were to be made to small farmers. He considered that it was more important to concentrate on cultural methods for weed control. Mr. Moore replied that this question had been asked in many places throughout the tropics. However, weed control had been tackled in an integrated fashion as was indicated in the title of the paper. Herbicides were only an adjunct to the main approach. Where labour

is available and cheap then it should be relied upon for weeding. The cost for weeding at Melka Werer by hand and with herbicide were $60/ha for hand weeding and when combined with chemicals they rose to about $120/ha. Even though these costs were high the use of herbicide could materially reduce the amount of supplementary weeding required if the herbicide was correctly selected.

Another participant wanted Mr. Moore to expand on benefit of herbicide for the farmer. He replied by referring to Ato Mulugeta's paper in which he had indicated that one way to increase the surplus of the country was to siphon off from agricultural production for industrial use. In order to have such a surplus one has to make sure that the small holder can cultivate much more land than he had done before. One of the limiting factors in increasing production, Mr. Moore felt, was weed control. This is partly due to the availability of labour and partly due to lack of tools and partly to the climatic condition for production. However, it is apparent that timely weeding of many crops is not carried out. If herbicides can be shown to be safe and they can be applied with a relatively high degree of accuracy then they do have a place. He felt that the dignity of human life should be looked at in a long term perspective. Surely, it was not correct for someone to spend at least 30% of their life digging fields when for a relatively low cost they can be freed for better and more useful occupations. For example Atrazine can be used in maize at a cost of around $10/ha. This herbicide could well replace 70% of the hand weeding necessary in maize.

INSECTICIDES & LOCUST CONTROL

by

R. D. MacCuaig
(FAO/SIDA Locust Project at DLCO-EA Headquarters)

Locust swarms are large; each adult desert locust (Schistocerca gregaria) weighs around 2 g and a swarm will contain about 50 m locusts/ km^2 weighing about 100 tons. The largest swarm ever measured covered some 1000 km^2 in area and occurred in Ethiopia 17 years ago. This swarm crossed the Jijiga plain and it was estimated that it destroyed between 50 and 150 thousand tons of cereal. Individually the adults can fly strongly at a speed of 5-8 km/h for hours on end and whole swarms can move 100 km/day.

However, the individuals in a swarm do not fly in any particular direction - indeed it is best to regard the insects as just flying so as to keep together and thus they are literally carried by the winds. Ultimately the winds carry the swarms to areas where rainfall is likely to occur. This is important because moist soil is necessary for the development of the eggs which actually double their weight by absorbtion of water whilst in the ground.

The adult locusts become sexually mature when they are 1 - 3 months old, and after copulation the females lay two or three egg pods each containing 50 - 100 eggs. The eggs are laid in the soil and remain there generally for 2 - 6 weeks according to the temperature before hatching. The young stages, the nymphs, or hoppers as they are often called, require about 6 weeks to complete their development when, after the 5th moult, they become adults.

The desert locust can live and breed in an area stretching from West Africa to India, northwards into South Russia and southwards into Tanzania. Because the weather has a fairly regular annual cycle, so do the locusts' movements. Across Ethiopia and Somalia it is the Inter Tropical Convergence Zone which is of interest with a smaller less well defined CZ in the summer months around Dire Dawa and Hargeisa which tends to trap the swarms in this area. Later in September the Inter Tropical Convergence Zone moves south and the swarms will be carried southwards into the Ogaden where breeding occurs. The next generation, still experiencing the same winds from the north will move into Kenya and later Tanzania. When the front moves northwards again the swarms reverse their direction and may lay eggs in Kenya in February and March.

For the small scale farmer locusts are a particular menace because they are so completely beyond his capability to get rid of. They are also virtually beyond the capability of a National Government

to control. The best protection for the farmer lies, we believe, in international cooperation to seek out and destroy this pest whenever and wherever groups are found. In Africa there are four International Organizations, the Desert Locust Control Organization for Eastern Africa (DLCO-EA), the Organization Commune de Lutte Antiacridienne et de Lutte Antiaviare (OCLALAV) dealing with the desert locust in East and West Africa, the International Africa Migratory Locust Control Organization (OICMA) and the International Red Locust Control Organization for Central and Southern Africa (IRLCO-CSA).

DLCO-EA has its Headquarters in Addis Ababa with operational bases in Khartoum, Asmara, Dire Dawa, Hargeisa, Mogadiscio and Nairobi whilst temporary sub-bases can be set up in an emergency as required. Each base is fully equipped with all the supplies necessary - vehicles, spray gear, insecticides and camping kit.

The fairly complete picture we have of locusts' behaviour has been associated with the use of aircraft. Only air-craft have a mobility which is more than that of the swarms, so enabling them to keep in day to day contact. All the Locust Control Organizations use aircraft both for survey and control. A variety of control techniques have been tried but the most effective ones are associated with the use of ultra-low volume(ULV) spraying with volume median diameters of 50-150 μm.

For a number of years a 15% oil solution of γ-BHC was the most used formulation against swarms but others such as aldrain, malathion and fenitrothion are also used. Now technical fenitrothion is the insecticide of choice generally. Against nymphs dieldrin is the most used and effective insecticide but others have also been used. On a small scale the individual farmer can protect his crops from the young stages and a variety of methods are available from spreading bait amongst them, dusting or even spraying. The ULVA sprayer, of which there are several hundred in Ethiopia is a promising applicator for ULV formulations.

Locust plagues are fortunately intermittant but even during non-plague periods the amounts used may be quite large on a world scale. Thus for the year ending October 1974 reports of insecticides used during the previous year sent to FAO totalled:

BHC dusts, mostly 1-5%	308,000 kg
Malathion ulv	9,000 l
BHC oil solution 10-20%	7,900 l
Dieldrin 10-20%	142,000 l
Others	6,000 l

This total probably comprises some 40 tons of active ingredients of which about 75% were BHC and dieldrin. During a plague period the amounts of insecticide used are large, e.g. 150,000 l of concentrates in a single compaign in Eastern Africa.

In the 1960s world wide concern started to be felt about the use of the persistent organochlorine insecticides and measures to restrict or ban the use of these materials have been taken in many countries. This concern was also shared by the countries involved in FAO's locust work and eventually the FAO/SIDA Locust Project was established to study the implications of using non-persistent insecticides in locust control. The author was appointed to run this project and by mid-1972 the DLCO-EA had established its new Headquarters in Addis Ababa with excellently equipped laboratories which are still improving their potential. A vigorous culture of locusts is maintained including both the Desert Locust and the Migratory Locust. Several laboratory rooms are available for different activities, a general laboratory, a radioisotopes room which is mostly used for cholinesterase measurements, a chromatography room housing the two gas-liquid chromatographs, etc.

In deciding our programme of work it was necessary to have a clear idea of how BHC and dieldrin are used in practice. BHC is used because it is effective and cheap. It is not used because of its persistence. Dieldrin however, is most effectively used sprayed over vegetation at the extraordinarily low dosages of 8-20 g/ha. In this method of application which must be by using a suitable non-volatile formulation, dieldrin acts largely asastomach poison. Tests have shown that dieldrin is fully cumulative within the insect's body over a few days. In addition when exposed to sunlight dieldrin is converted into a photoisomerization product, termed photodieldrin, which is much more toxic to locusts than the original product. Studies in African grasslands have shown that 6 days after large scale spraying the total dieldrin residues had fallen to about 2/3 of the initial level but most of the residues were photodieldrin. Even 2 months after spraying there was still 25% of the original quantity of insecticide remaining on the vegetation. This method of use is certainly the cheapest and most effective way of killing the young stages and is only possible because of the combination of the persistence and high toxicity to locusts shown by dieldrin.

Two main lines of work have been followed: The first being to determine the toxicity of insecticides to locusts. This is done in a number of ways:

1. Simple experiments in which a known quantity of insecticide is applied directly to the body of the locust. For this a special microapplicator is used, able to dispense a fraction of a microliter with reasonable accuracy.

2. Spraying experiments using a specially constructed spray tower. With this equipment field formulations can be sprayed so that the conditions imitate those obtained in practice as nearly as possible. In these experiments locusts are anaesthetised before treatment. Vegetation can also be sprayed with this equipment. Wheat seedlings are mostly used for these tests, the treated seedlings being fed to locust nymphs after varying periods of time in the sunlight.

3. In other experiments the insecticide is mixed with bran and fed to the locusts as soon as it is prepared and after varying periods of storage.

These types of experiments have shown that there are a number of new insecticides of high toxicity to locusts e.g. chlorpyrifos (Dursban), cyanophos and bendiocarb (Ficam).

The other main line of work undertaken has been on the safety of pesticides when applied on a large scale. In much of the area where locust control operations are carried out, flocks of sheep, goats and camels belonging to the local people wander amongst the vegetation feeding more or less continuously throughout much of the day. Locust swarms may be sprayed in flight or when settled and the actual area to be sprayed is not known until the pilot arrives over the target. Under these conditions of application situations inevitably arise where domestic animals (although avoided where seen) are exposed to insecticides by direct contact or by eating sprayed vegetation. The same criteria generally apply to the control of nymphs. It is necessary to establish some method by which the safety of using insecticides under these conditions may be evaluated.

The first series of experiments were carried out in order to determine the maximum quantities of insecticides likely to be absorbed by domestic animals through direct contact and by ingesting sprayed vegetation. A number of sheep were tethered in a suitable area facing across wind and sprayed in the same manner as that in which locust control operations are carried out. Measurements were made of the deposits on the sheep, the ground and two levels of vegetation. From these experiments it was clear that absorbtion of insecticide by contact was of much less importance than ingestion of insecticide. Because of the distribution of insecticide on the vegetation, it appeared likely that goats which often eat <u>Acacia</u> leaves would be the most exposed to poisoning by ingestion. These experiments enabled a relation between quantity of insecticide applied and maximum likely amount ingested to be calculated.

All the insecticides so far tested on domestic animals have been cholinesterase inhibitors. Cholinesterase is an enzyme which occurs in the blood and its inhibition is often the first sign of incipient poisoning to occur. A method defining relative safety then became apparent: it was that an insecticide was considered safe to use if domestic animals could feed indefinitely in an area sprayed with ten times the amount of that insecticide necessary for killing locusts and suffer no drop in cholinesterase activity. Both laboratory and field experiments have been carried out. In the laboratory experiments sheep and goats have been force-fed known amounts of insecticides and their blood cholinesterase levels measured. In the field experiments <u>Acacia</u> bushes were sprayed with an estimated ten times the amount of insecticide they were likely to receive during control operations and goats tethered to the bushes so that they had to feed in the sprayed areas. These tests seem generally satisfactory. Fenitrothion has been used and recommended for a number of years because of its low toxicity to mammals: it caused no significant drop in cholinesterase activity whereas furadan, a carbamate extensively used against grasshoppers in the USA and Canada, under vigorously controlled application conditions, caused a large drop in cholinesterase activity.

The work carried out so far has indicated that there are a number of new alternatives to BHC for use against adults. Against nymphs however, no compound has been found combining anywhere near the toxicity and persistence of dieldrin so that any alternative compound would have to be applied at least ten times the dosage used for dieldrin and possibly more than once with a proportionately large increase in costs.

DISCUSSION

The chairman thanked the speaker for his paper which had been so interestingly illustrated.

The speaker was asked what possibilities existed, if any, for eradicating locusts. Mr. MacCuaig replied that locusts occur over such vast areas that at present there is no chance of eradicating these insects. WHO had hoped that it might be possible to eradicate mosquitoes but this hope had now been abandoned.

In reply to a question on the possibilities for other means of control other than insecticides, Mr. MacCuaig said that biological control was an important factor in natural control. The eggs were particularly vulnerable which can easily be destroyed by parasites. In other parts of the world fungal diseases are an important factor affecting populations. However the problem with biological control was the enormous scale of the problem during a plague and the difficulty of finding locusts during non-plague periods.

A participant asked if remote sensing techniques had been used in trying to detect locusts. The speaker replied that trials had been carried out using satelites to detect areas of rainfall in potential breeding grounds. However the area then has to be checked on the ground to see if there are any locusts present. New trials, by FAO, were being undertaken in the current year, 1975. Another useful device for detecting swams is radar but political constraints have prevented the use of radar on a wide scale.

The final question related to the possible danger of using dieldrin in crops. Mr. MacCuaig said that the DLCO were aware that is use was undesirable. However if spraying took place at about six weeks or earlier before harvesting, the residues on the edible parts would generally be very low. Even though, there is some hazard in the use of dieldrin it was better to spray and give the farmer the chance of harvesting a crop than leaving it unsprayed with the certainty that it would be completely destroyed by locusts.

CROPS AND SOILS

THE DOOR IS OPEN FOR GREEN REVOLUTION IN TEFF

by

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(Debre-Zeit Agricultural Experiment Station)

Summary

After almost two decades of unsuccessful attempts to crossbreed teff through conventional breeding techniques, the first successful crosses were made towards the end of 1974. Since then over 100 crosses have been made combining 14 selected varieties in single, double, and top crosses. These crosses are being grown for selection in subsequent generations and for making further multiple crosses.

It is an undeniable fact that the standard emasculation and pollination techniques used in breeding field crops were the key factors of the so called "Green Revolution". Through the use of these techniques, yields of corn, wheat, rice, sorghum, etc. were raised from less than one ton to ranges of 5 to 10 metric tons per hectare. With the new tool in hand and the already existing high variability in teff, the prospects for increasing yields of the crop are very high. On the other hand, the chances for teff to be substituted by wheat, corn, sorghum or triticale are very low. At least the challenge is now much tougher.

Currently, teff breeding objectives include (1) the creation of short and stiff-strawed varieties that could be grown under mechanized conditions with high fertilization, and high rainfall or irrigation with minimum lodging and (2) the creatinn of early and high yielding varieties that can be grown (a) in areas with short and limited rainfall (Tigrai, Eritrea, Harar) and (b) that can fit in a double cropping pattern, i.e. varieties that can be planted in late June or early July to be immediately followed by Chickpea or Guaya (Lathyrus) in September.

This paper will discuss teff breeding procedures currently in use at the Debre-Zeit Agricultural Experiment Station.

Materials and Methods

Seeds of selected varieties are grown in the greenhouse in 15 cm x 14 cm plastic pots. About five plants per pot is considered as a reasonable population. At the beginning of heading observation is made for the first signs of mature florets. This can be done either by observing them at 6:00 to 8:00 a.m. at which time mature florets will be wide open or at other times of the day by observing the whole panicle under a bioscope (25-30 x magnification) to see if the basal florets of spikelets have been already pollinated. In teff, maturity on a spikelet basis is acropetal, i.e. basal florets mature first, whereas, on a panicle basis maturity is basipetal, i.e., spikelets at the apex of the panicle mature first. Therefore, one can emasculate only a limited group of florets of a panicle on a particular day. Once the position for emasculation is determined, all spikelets whose basal florets have already been pollinated are removed. Next, all young spikelets with immature anthers and stigmas are removed leaving only those spikelets that are within 5-8 cms. below those whose first florets have already been pollinated. Most of the basal florets of spikelets within the 5-8 cms. would open the next morning and therefore can be emasculated 16 to 20 hours earlier. With experience one can easily identify between mature and immature florets by the size and bright colour of anthers and fluffiness of the stigmas.

The emasculation process is carried out under a bioscope by opening the florets and removing the three anthers with the aid of superfine tweezers and fine, edge-bent, safety-pins with a handle. Since the first, second or third florets of each spikelet do not mature on the same day, only the basal floret is emasculated. The following morning after emasculation (6:30 - 8:30 a.m.) emasculated florets are again brought under a bioscope. Open florets from a pollinator plant are detached with tweezers and brought to the microscope field near the florets to be pollinated. Pollination is carried out by putting one or more anthers to each floret and applying a slight pressure to the tweezers in order to burst open the anthers. After pollination, the unemasculated florets of each spikelet are removed. Earlier removal of florets causes difficulty in opening the basal florets for either emasculation or pollination.

After maturity seeds are harvested and put in small bottles or vials. The first generation (F_1) seeds are then first germinated in petri-dishes in a germinator and then space transplanted either onto plastic pots or wooden flats. The second generation (F_2) and subsequent generations are planted in the field.

Unless one wants to make several crosses in a day, it is also possible to make crosses without emasculation. Anthers do not dehisce for ten to fifteen minutes after the florets start to open. It has

been demonstrated that pollination at this time can yield as much as 60% hybrid seeds.

The following characteristics are being used as markers to identify hybrids in the F1 generation (1) white versus red seed color, (2) compact versus loose panicle type, and (3) various glume colors (red, purple, white, grey, variagated).

DISCUSSION

From previous investigations (Melak 1964, Tareke 1969, Tadessa 1974), the difficulty in teff breeding was attributed to the small size and delicated nature of teff florets which renders them highly sensitive to mechanical manipulation. However, later investigations (Tareke 1974) suggested that plant growth regulators which are produced in the anthers may control embryo-sac development and fertilization and recommended that pollination be tried by avoiding or minimizing emasculation. This recommendation resulted in the discovery of the early and short pollination period of teff which lies approximately between 6:30 to 8:30 a.m.

Now crosses can be made easily by emasculating 16-20 hours earlier and pollinating at 6:30 - 8:30 a.m. This procedure yields 80-90% seed set and 95-100% cross-fertilized seeds. At this point, it must be noted that several days of practice are necessary before one can master opening and closing teff florets under a bioscope. The very early pollination period of the crop also poses a slight problem to the teff breeder. However, this may be solved by photoperiod studies that could make the crop flower at later hours in the day.

Studies to-date indicate that red seed-color is dominant over white seed-color and that loose panicle type is dominant over compact panicle type. There is interaction among glume colors. Studies are in progress to determine the segregation ratios for the above mentioned characters.

Without prior knowledge of teff's physiology and yield components, it is hard to determine for what types of plants to breed and select. However, the author is now trying to breed and select for short, stiff-strawed, and compact head types. It is anticipated that such a type of plant will lodge less, can made more efficient use of fertilizer and irrigation water, and can accommodate itself to mechanization. In view of this the initial crossing block consisted of 14 selected types. They were selected for one or more of the following characterstics: (1) short height (2) thick culm (3) compact head (4) high yield and (5) white seed. On these selected types, 24 single and 66 double and top crosses have already been made. These are being grown for selection and further multiple crosses.

There is no doubt that the possibility of making crosses has opened the door to a "Green Revolution in Teff." Already, an observation of F_2 and F_3 progenies from the first successful crosses of DZ-01-186 x DZ-01-44 indicate that desirable recombinants can be obtained easily. There is every sign to believe that the crop can be improved.

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DISCUSSION

The Chairman on behalf of the seminar participants congratulated Ato Tareke on his excellent presentation and for the hard work he had done in bringing about this break through in teff breeding.

Ato Tareke was asked what his breeding procedures were for the F_2 and F_3 generations. He replied that the work was just starting and that they were willing to accept any recommendations for selection procedures. At the present time they were using straight-forward progeny selections.

One participant suggested that teff is found to grow very well in some of the wetter parts of the country but the yields are still low. He suggested that perhaps the F_2 generation could be pushed out to areas such as Jimma and Bako where the crop grows well but does not give much yield. If the F_2's were pushed out into these areas, this could help to focus down on the selection pressures needed to meet the need of these areas. Ato Tareke replied that this was a good suggestion. At the

moment they were using a green house in order to continue work during the dry months and to advance the selection work. However, if some of the early crosses could be in such areas this would help in selecting material and also material could be grown in traditional teff growing areas during the rainy season to further advance selection work.

A participant asked if it was possible to help advance work in teff not only by making crosses but to increase the selection work from the local population because teff has a tremendous diversity in this country. Ato Tareke replied that they had over five hundred populations collected by EPID, in 1974; 80 populations had been selected for desirable characteristic. This number was now down to 23. These 23 selected varieties had been sent out to 20 locations for national yield trial. In fact, until the conventional breeding programme came up with some superior characteristics selection work will continue. The selection work on local populations will also help in identifying characters which should be used in the breeding programme.

Ato Tareke was asked to comment on limitations for his breeding work. He replied that in 1972 people from the International Atomic Agency, the Agricultural Department, had visited Ethiopia and seen the problem in teff breeding. The major problem appeared to be lodging and as there was no successful breeding programme they had suggested that since mutation breeding had helped in many crops in producing short and stiff straw varieties mutation breeding should be started for teff. This work had already been started and they are indications that it may be possible to get short and stiff strawed varieties through mutation breeding. Mutation breeding was also helpful because it could be combined with conventional breeding. As useful characteristics from mutations are identified, they can be combined with other characteristics in the conventional breeding programme. Thus the two complement each other.

In a follow-up question on the possibilities of this work for the farmer Ato Tareke replied that this work just cannot be done by one man. Fortunately there is a plant pathologist at Debre Zeit Experimental Station who is already working with the programme. There are also plans to employ a plant physiologist. Plant physiologists outside Ethiopia have also been involved and seeds had been sent to the US for determination of their characteristics. At London University in UK there are now 2 genetic students studying Eragrostis species in an endeavor to find which species might be the progenitors for teff. In fact, Ato Tareke remarked this is the time for Ethiopian students to be very much encouraged to become involved in the teff work so that research on all aspects of teff can be undertaken and recommendations could then come for forwarding to farmers.

It was commented that the bigest problem was the production of food per unit area. Thus did Ato Tareke think that the breading programme will give you the same kind of results as has been found from other breeding programme? He replied that this was difficult to answer at this stage. However, as a plant breeder his impression was that the possibilities and the potential for teff is very very high. If one looked back at the history for other cereal crops, the yield before conventional plant breeding work was undertaken were about 10 quintals/ha in the range 5 to 27 quintals. It is now possible to produce 78 to 80 q/ha of wheat under irrigation, 100 quintals of maize and similar results were possible for sorghum. If this has been done for other crops, then he did not think that it was impossible for teff. These results had been achieved by changing the architecture or the form of the plant so that it was able to stand erect with plenty of water and plenty of fertilizer. If this can be done for teff than he thought it was extremely possible that yields could be doubled or tripled.

It was commented that there were two aspects to improving food supply. The first was improving quantity i.e. yield and second was improving quality i.e. the nutritional content of the food. Both of these were equally important and he asked Ato Tareke to what extent will teff contribute to the nutritional quality of the Ethiopian diet. Ato Tareke replied that they already had quite a lot of data on the nutritional quality of teff. Studies had been undertaken on its protein content, mineral content and carbo-hydrate content. These studies had shown that teff is one of the most nutritious cereals that we have. In the breeding programme it will not be our aim just increase yield per unit area, it will also be to improve both the protein and mineral yield per unit area. One cannot diverce nutritional quality from yield. Studies will be undertaken to identify as many genes as possibles in the progenies produced. The work will ensure that the nutritional quality of each combination is incorporated into the breeding programme.

EFFECTS OF FERTILIZATION ON DEVELOPMENT, DRY MATTER PRODUCTION AND NUTRIENT UPTAKE OF TEFF

By

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(Giessen University)

Introduction:

Selection at the Experimental Station in Debre Zeit has improved teff yields in that area. But the results of the National Yield Trials from other locations has, in many cases, shown a superior yield performance for the local varieties, because teff is grown under very varying environmental conditions in Ethiopia and the Debre Zeit varieties are not adapted to them. The possibilities to improve teff yields by selection are limited and conventional breeding methods (artificial crosses) had until recently failed with teff. However even in a breeding programme, selection will be one of the main steps in developing higher yielding teff varieties. For the necessary selection and testing work fertilizer tolerance and response has to be one of the criteria, otherwise teff yields will remain on a very low level in comparison with other cereals.

From fertilizer trials it is known that teff in many cases does not respond to fertilizer, or fertilizer response is low, because loding with high grain losses is favoured by fertilization. It is known that the response to fertilization of the teff varieties grown at present in Ethiopia are limited by the properties of the teff plant especially the thin straw. But there is little basic information about the reactions of teff to fertilization. Therefore in 1971 and 1972 a series of fertilizer trials was carried out at Debre Zeit Experimental Station to study the development, dry matter production and nutrient uptake of teff at different levels of fertilizer.

Material and Methods:

The following 11 field experiments were accomplished:

a). Four Variety-Fertilizer-Trials /NPK-Trials
(1971 and 1972 on black and light soil)
3 varieties: DZ-99, DZ-354, DZ-196
3 Fertilizer levels: unfertilized
: 40kg/ha of N,40kg/ha of P_2O_5,40kg/ha of K_2O
: 80kg/ha of N,80kg/ha of P_2O_5,80kg/ha of K_2O

b) 2N-Fertilizer Trials (1971 and 1972) on black soil
5 levels of N: 0, 20, 40, 60 and 80 kg/ha
2 varieties: DZ-99 and DZ-196
basic fert. appl.: 40 kg/ha of P_2O_5 and 40 kg/ha of K_2O

c) 2P-Fertilizer Trials (1971 and 1972) on black soil
5 levels of P: 0, 20, 40, 60 and 80 kg/ha of P_2O_5
2 varieties: DZ-99 and DZ-196
basic fert. appl.: 40 kg/ha of N and 40 kg/ha of K_2O

d) 3K-Fertilizer Trials (1971 on black soil, 1972 on black and light soil)
5 levels of K: 0, 20, 40, 60 and 80 kg/ha of K_2O
2 varieties: DZ-99 and DZ-196
basic fert. appl.: 40 kg/ha of N and 40 kg/ha of P_2O_5

Fertilizers used: Urea (46% N)
Triple Superphosphate (46% P_2O_5
Potassium Sulfate (50% K_2O)

Seed rate: 25 kg/ha

In the four variety-fertilizer trials (NPK - trials) 5 to 6 cuttings of 1 m^2 per plot were made during the vegetation period to estimate the dry matter production and nutrient uptake. The chemical analysis were made at Giessen University and the results of the experiments were evaluated by Hesselbach (1975) in his doctrate-thesis.

Results

In this paper only selected results are shown and the main findings are discussed.

On the soils of the Experimental Station at Debre Zeit P and K showed very little effect on teff. The applied nutrients were either not used at all or only a small amount of them was taken up and used for additional vegetative mass production with no effect on the grain yields. Only N influenced significantly the growth, development, uptake of nutrients and teff yields. The reason for the inefficiency of P and K are the high amounts of available P and K found by analysis of the soils. The "Freedom From Hunger Campaign" - trials in the surroundings of Debre Zeit (1967-1971) also show no K-effects but rather highly significant P-effects on the grain yield of teff. Residual effects caused by the regular annual P-fertilization at the Experimental Station are most likely responsible for the high amounts of available P and the low P-fertilizer effect at Debre Zeit Experimental Station. For these reasons the observed fertilizer effects in the NPK-fertilizer trials have to be regarded as effects of N mainly. Therefore results from the NPK- trials as well as from the N-fertilizer trials are

are discussed together to demonstrate the effects of N-fertilization on teff.

For the three investigated teff varieties the average time from sowning to heading was found to be 50 days and the time from heading to maturity was 73 days. This ratio between vegetative and reproductive period is quite favourable in comparison with other cereals. Only in the case of new high yielding wheat and rice varieties is the grain formation period found to be longer than the vegetative period. The upper diagrams of figure 1 show that the time between sowing and heading is even shortened by increasing doses of nitrogen especially on the black soil. On the light soil this period anyway is shorter and the effect of fertilization is therefore lower. On the average the highest nitrogen dose of 80 kg/ha shortened the vegetative period by 10 days.

The reproductive period between heading and maturity was prolonged by the application of nitrogen by an average of 7 days. This can be seen from the diagrams in the middle of figure 1. The graphs at the bottom of the figure show the effect of fertilization on the whole growing period of teff. It can be observed from them that the differences between fertilizer levels are an average of 3 days only. From these results it can be summarized that the length of the growing period of teff is only shortened a little by N-application, but the ratio between vegetative and reproductive period is widened from 1/1.4 to 1/1.6 which should be favourable for the grain formation of teff.

The next points investigated were the plant length, straw length and panicle length. It was found that the plants from the plots fertilized with 80 kg/ha of N were an average of 54% longer, at the time of heading. But at the end, at maturity, the difference in plant length was only 20%. Figure 2 shows the influence of N-dressing on the stem and panicle length at maturity. The graph shows that not only the straw length but also the panicle length was greater if nitrogen was applied. In case of the variety DZ-99 there was an increase of panicle length with each step up in fertilizer application up to 80 kg/ha of N in both years, but the panicle length of DZ-196 did not increase in such a regular way.

The average of all N- and NPK- trials showed that the panicle length was increased by 12% with 80 kg/ha of N but the stem length was increased by 23%. That means the ratio between stem length and panicle length became more unfavourable if nitrogen was applied. The correlation coefficients for the relations between dose of fertilizer and stem length and for the relation dose of fertilizer and panicle length were highly significant. For the varieties DZ-99 and DZ-354 significant correlations between panicle length and grain yield were also found. This relation may be important for future breeding work. Lodging of teff was found to be an average of 53% in the control plots and was increased to 93% by the application of 80 kg/ha of N.

FIGURE 1. Fertilizer Effect on Development of Teff, 1971

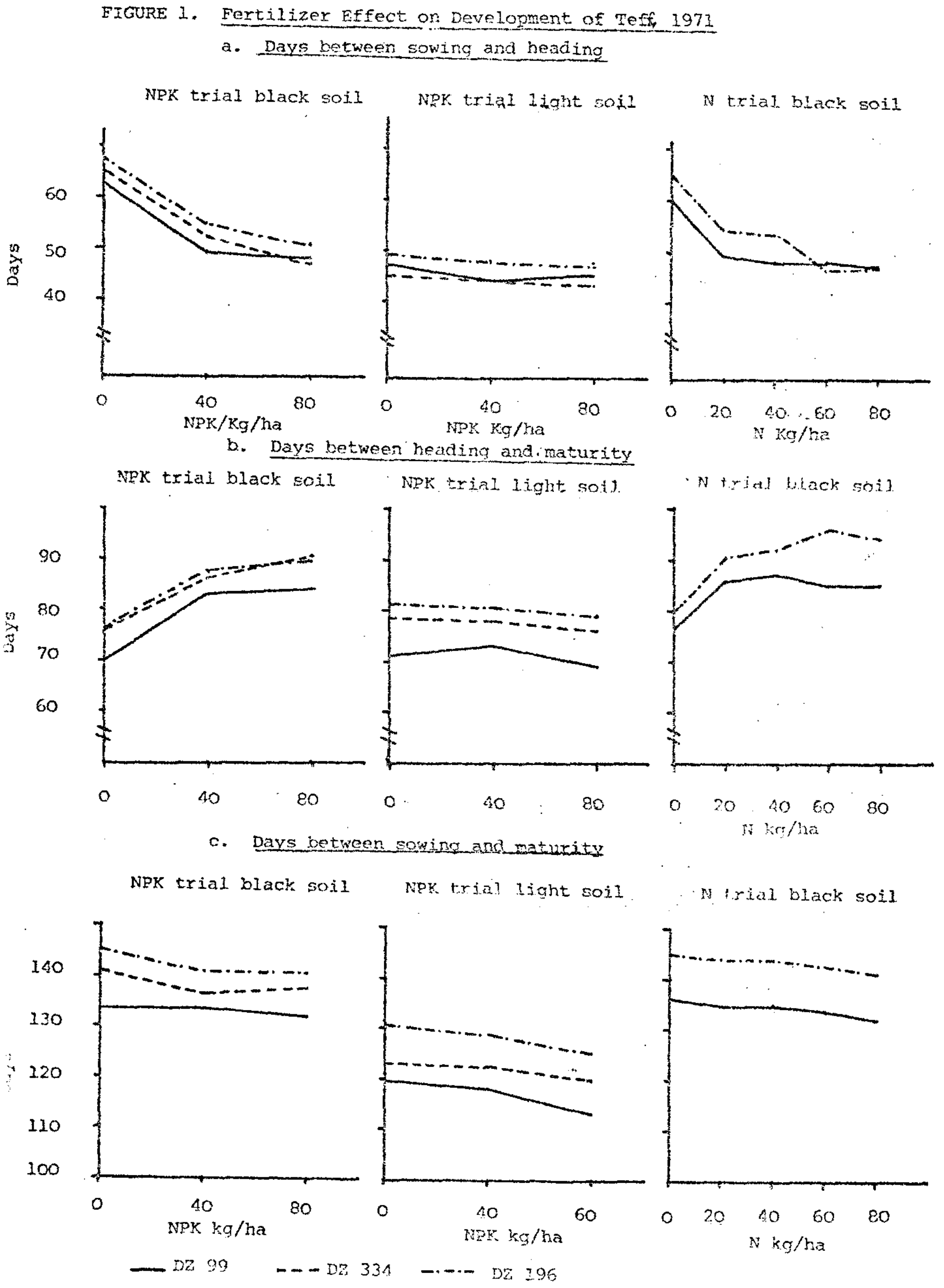
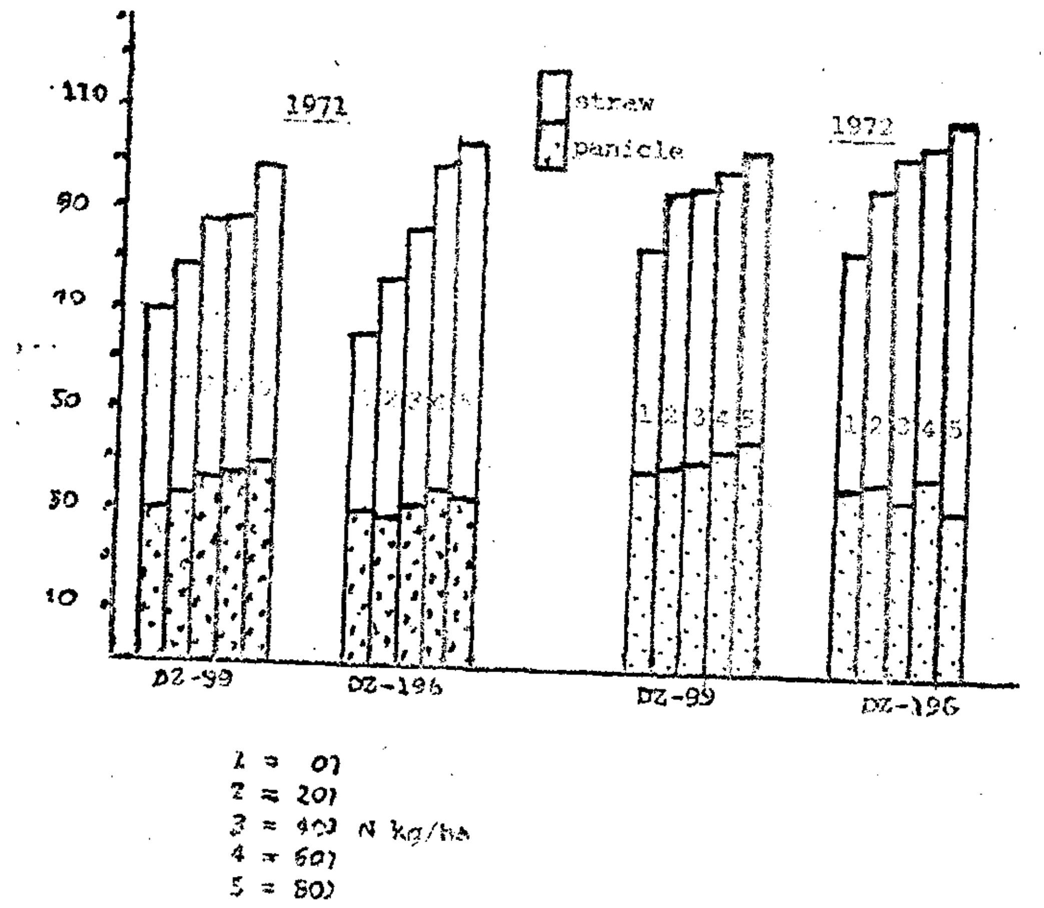


FIGURE 2. Effect of N on Panicle Length and Straw Length of Teff



As an example Figure 3 shows the effect of fertilization on the dry matter production of the variety DZ-196 on black and light soil in 1971. On the black soil only about 30 q/ha of dry matter were produced while on the light soil 70 q/ha were produced by the unfertilized treatment. The dry matter production was also much faster on the light soil. But the effect of fertilizer application on the dry matter production was much higher on the black soil. From the curves one also can see that the maximum dry matter yield was reached at an earlier time, by the highly fertilized treatments. The differences in dry matter between the three fertilizer levels were found to be significant at any time of cutting (I to V). The quite high increase of dry matter after heading is caused not only by the grain formation but to a great extent by the growth of tillers. Up to nine tillers/plant were counted in the experiments. At the second cutting time, 70 days after sowing, teff already showed a high dry matter production which, in the case of fertilized treatments, comprised up to 80% of the total yield at harvest. This can be compared with the mass production of Mexican wheat varieties which during the same period in West-Germany produced up to 92% of the total yield at harvest time. At the time of harvest the dry matter of teff straw + grain reached more than 90 q/ha in 1971 and more than 110 q/ha in 1972 on the highly fertilized plots. These high amounts of dry matter production are comparable with those of high yielding wheat varieties. But as we see from the graphs in figure 4 the grain yield represents only a small portion of the total dry matter produced. The primitive teff plant with its very small seeds is only able to transform a small part of the dry matter produced into grain yield. On average the grain yield of the 3 teff varieties was increased from 12.0 to 16.5 q/ha by the application of 80 kg/ha of N, that is an increase of about 40%. The straw yields were raised by the highest fertilizer dose from 45 q/ha to 69 q/ha (average) that means more than 50% straw yield increase. The graph shows, that the fertilizer effect on grain and straw yields was higher on the black soil. The variety DZ-354 gave the highest yield increases with fertilization.

As a result of the fertilizer application the very wide grain: straw ratio, 1:3.8, was widened still more to 1:4.2. That means the straw yields were raised to a greater extend than the grain yields. This is a typical reaction of unbred primitive varieties which has also been found with other cereals.

In figure 5 the nutrient uptake of two treatments from the NPK trial 1972 is shown. The uptake of nutrients was greatly increased by the application of fertilizers on the black soil. On the light soil the nutrient uptake was raised to only a small extend. When fertilizer was applied the highest points in the uptake curves as well as in the dry matter curve were reached at an earlier time. Already at about 6 weeks after sowing 50 to 80% of the total nutrient uptake had been taken up by the teff plants. At that time only about 30% of the total dry matter had been

FIGURE 3. Fertilizer Effect on Dry Matter Production of Teff, 1971

Variety: DZ-196

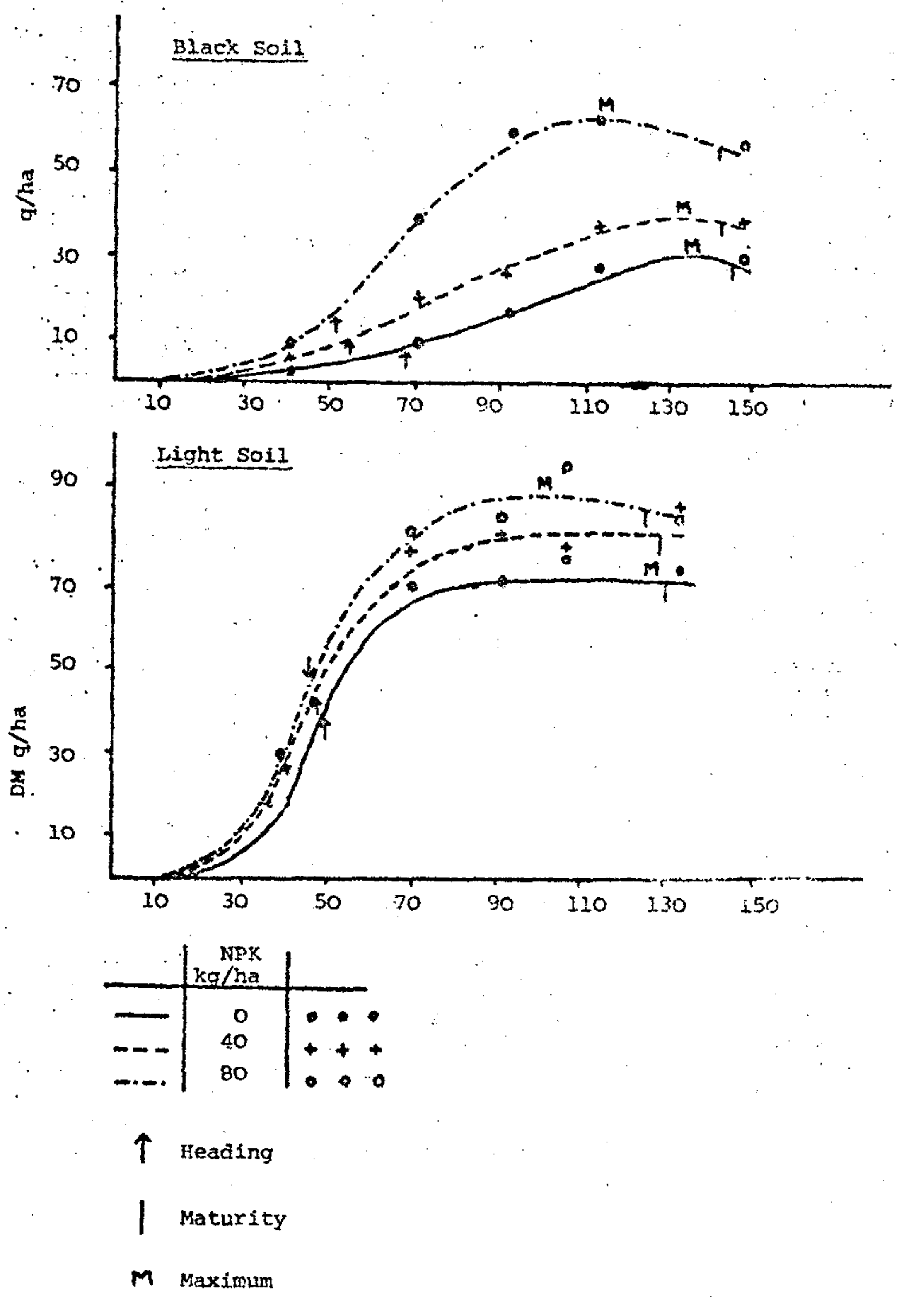
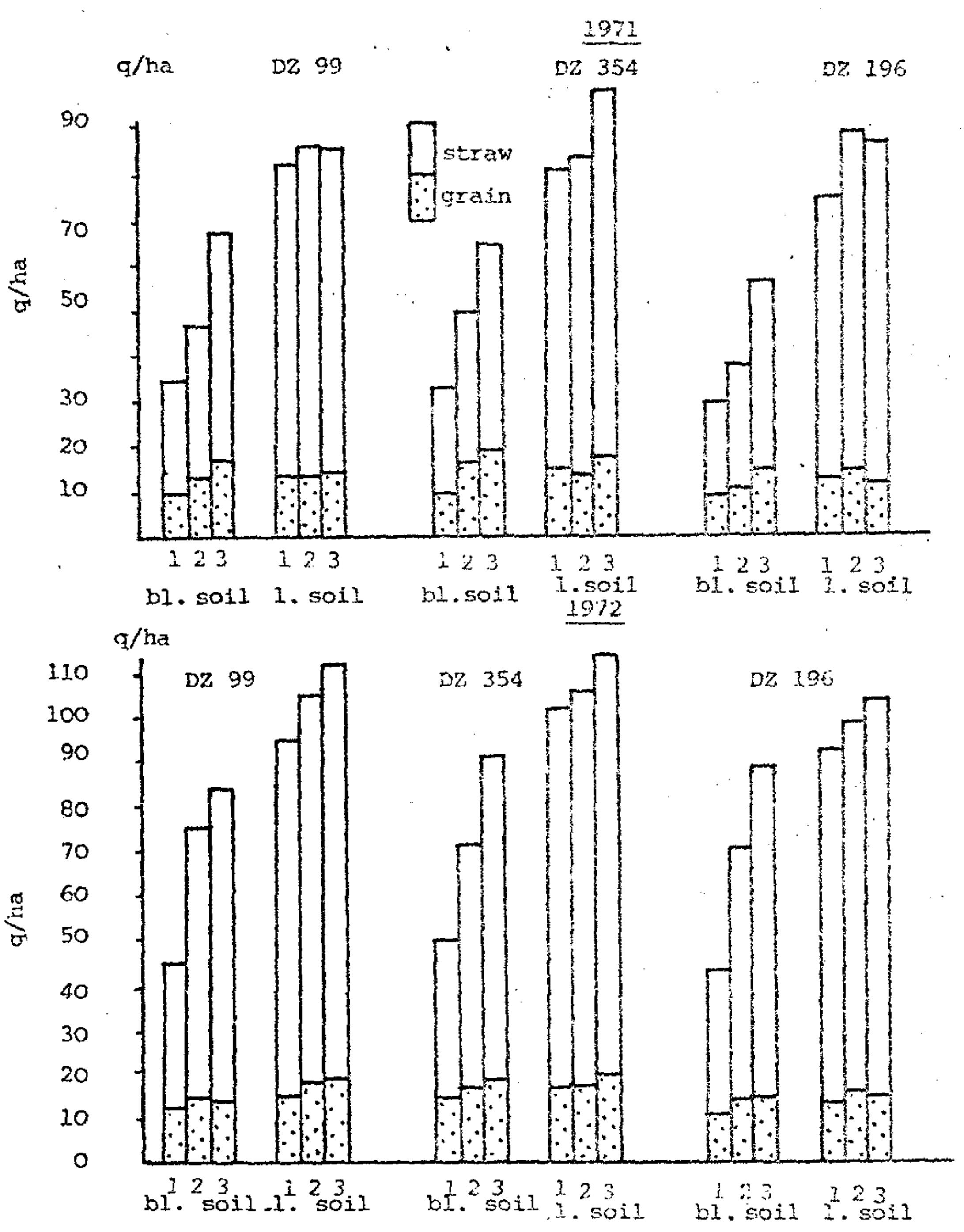
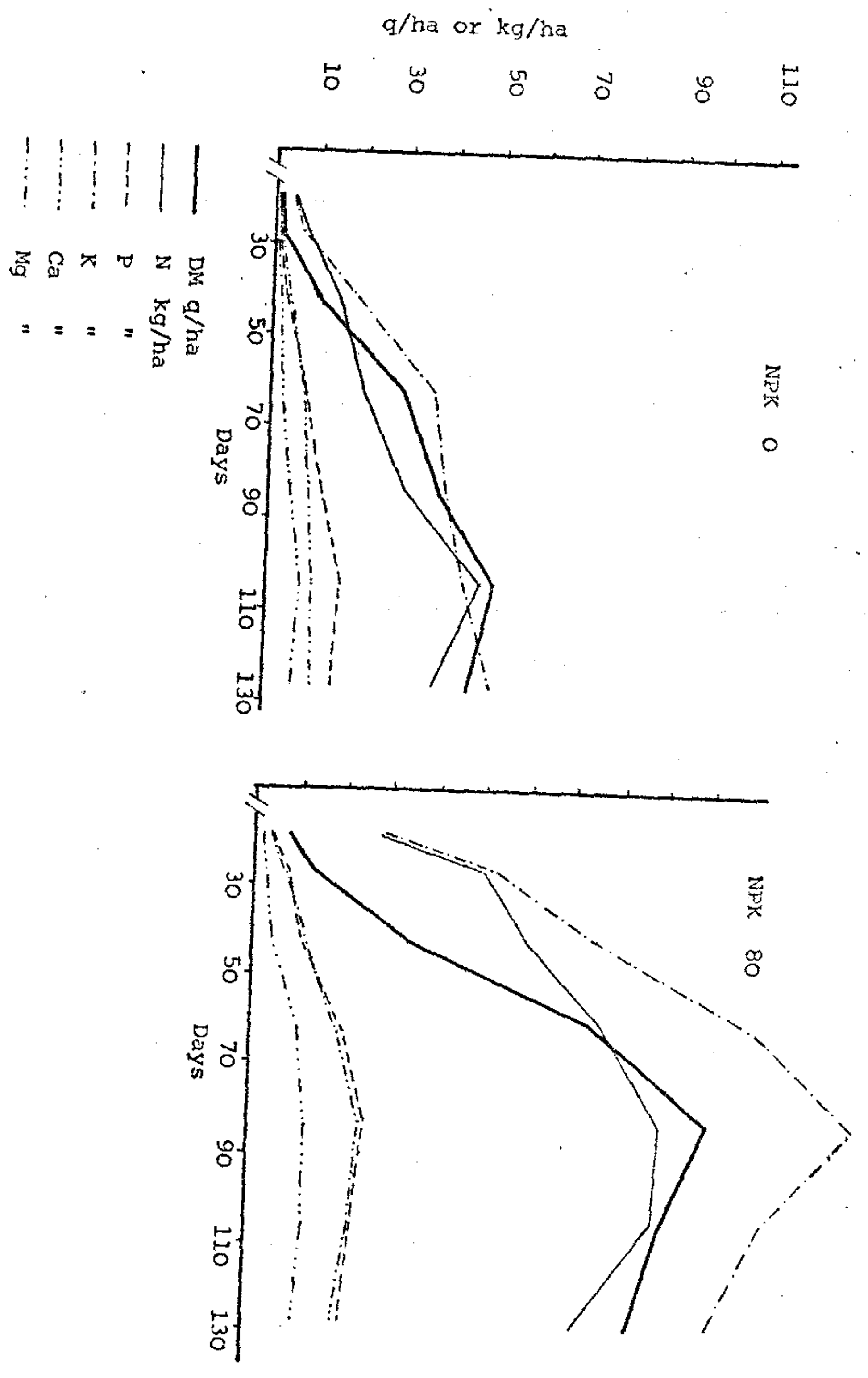


FIGURE 4. Fertilizer Effect on Yields of Teff



1 = 0)
2 = 40) NPK kg/ha
3 = 80)

FIGURE 5. Nutrient uptake by Teff on black soil - NPK Trial, 1972
Variety: DZ-99



produced. That means the concentration of nutrients in the teff plant during the first half of the growing period was quite high, in case of N and K between 2 and 4.5% of dry matter. The removal of nutrients at harvest time was greatly increased by the fertilizer application. The average figures from the NPK and N-trials are:

		Unfertilized	80 kg N/ha
Removal by	(kg N/ha	55.6	113.6
Grain + Straw	(" P/ha	15.1	20.4
	(" K/ha	65.6	105.4

The nutrient removals through straw were much higher than those through grain and this tendency was enhanced further by N fertilization.

		Unfertilized	80 kg/ha of N
Removal of nutrients	N	62%	76%
by straw in % of	P	66%	65%
total removal	K	88%	91%

In the unfertilized treatments about two thirds of N and P and nearly 90% of K is found in the teff straw. In the highly fertilized treatments even three quarters of the nitrogen are removed by the teff straw. These figures show again the primitive character of teff, if this plant is regarded as a cereal crop only. But because teff straw has high nutrient contents, up to 1.4% N or 8.8% crude protein and because it is normally used for fodder purposes, teff should not only be regarded as a cereal but a fodder crop, too. Among the three teff varieties used in the experiments the medium maturing variety DZ-354 seems to be best suited for intensive cultivation. It has the most favourable ratio between vegetative and generative growth, an earlier heading date and a longer reproductive period than the other two varieties. But this variety is most succeptible to lodging. This is probably due to the earlier heading date, to the longer panicles and the higher grain production. The variety DZ-354 is significantly superior to the other varieties in grain yield, especially on the higher levels of fertilization. A selection for short straw from the variety DZ-354 would most likely reduce the susceptability to lodging, increase the utilization of nutrients through grain and therefore additionally increase the yield. The positive correlation between grain yield and panicle length found with this variety confirms that plants with longer panicles should be selected. The variety DZ-354 also shows the highest reponse to fertilization.

Summary:

Summarizing the results, of which only selected tables and graphs were shown in this paper, the following main findings may be helpful for future research and breeding work in teff:

1. The ratio between vegetative and reproductive period is rather favourable for grain production and is still improved by N - fertilization.

2. The stem length and the straw yield is more increased by N-application than the panicle length and the grain yield. This is a typical reaction of primitive cereals with low grain yield and little fertilizer tolerance, and leads to higher percentage of lodging.

3. Significant correlations between panicle length and grain yield were found for the varieties DZ-354 and DZ-99. Therefore the panicle length may be one of the criteria in selection work.

4. If teff is fertilized with N nutrient uptake and the dry matter production is very fast in the first half of the growing period, but the teff plant is not able to use the quite high amounts of nutrients taken up and the dry matter produced for grain production. Instead of that a great number of tillers with little grain yield and high straw yields with high nutrient contents are produced. Only by breeding plants with stronger, shorter straw, with lower numbers of tillers and with bigger grains can the relation between straw and grain yield be improved. Otherwise the fertilization can only raise grain yields of teff to a small extent.

5. The straw of fertilized teff contains a rather high percentage of crude protein and therefore should be used in any case for fodder purposes during the dry season.

DISCUSSION

Dr. Westphal explained the background for the relationship between Giessen University and the IAR. "Some of the Germans working at Bako Experimental Station over the last 10 years came from the university of Tropical Agriculture at Giessen. Dr. Alkamper and myself returned also to that Institute when we left Ethiopia some years ago. Since we both have to teach and to train students in tropical agriculture and the possibilities for research in this field are very limited in Germany we have to have good relationships with national and international research institutes in tropical countries. We try to assist their research programmes by sending post graduate students for special investigations in the research institute themselves and by taking plant and oil samples to Germany for analysis which cannot be done in the country concerned or which are not planned to be done at the time. A lot of plant samples from trials which are laid out for yield estimations can be taken for other types of basic research. For example, to study the infuence of environmental conditions on the quality of agricultural products. The paper on teff was the result of an agreement between the Dean of the College of Agriculture and Giessen University in which a post graduate student was sent to study the effect of fertilizer up-take on various parametres in teff. The co-author of this paper Mr. Hesselbach was the student sent to work in 1971 and 1972. It is hoped that the results from this basic research will be of assistance in the cross breeding programme for teff. As Mr. Hesselbach is now working in Somalia, it is appropriate for me to make these main findings available to you here in Ethiopia".

A participant commented that the normal situatinn for black soils is that crops respond less to nitrogen than they do to phosphate. He asked Dr. Westphal if he thought that the amount of phosphate applied had been sufficient. Dr. Westphal replied that he did not think the phosphate fertilizer level was too low. Soil analysis had shown a high level of phosphate in soils of Debre Zeit Experimental Station. This may not be true for surrounding areas or other areas with black soils. However, at Debre Zeit phosphate fertilizers are applied regularly each year and thus the amount of phosphate may have been built up in the soil.

An economist from Debre Zeit commented that he had been working on fertilizer trials in teff for the past three years. These trials had been conducted in several areas around Debre Zeit. Although he was not a soils man it has been found consistently that there was a low response to phosphate and a high response to nitrogen in all the soils of these other areas. They had applied very large quantities of phosphate and still had very little response from the crop. He invited any one who wanted to come and look at this problem in the Debre Zeit area.

INFLUENCE OF THE LOCATION ON THE PROTEIN QUALITY OF WHEAT VARIETIES GROWN IN ETHIOPIA

by

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Introduction

Wheat is grown in Ethiopia at altitudes between 1700 and 3400 m as a basic food crop. The cultivation of wheat is limited by low temperature at higher altitudes and by diseases like Puccinia gramminis tritici and Septoria tritici at lower altitudes. Analyses of cereal samples from Ethiopia show that the crude protein contents of wheat and barley decrease with increasing altitude (Alkamper 1974). Investigations on the influence of environmental conditions on the protein composition of wheat have led to differing results. Gunzel (1962) observed an influence of the location on the portions of prolamin and glutenin fractions, but Prugar and Sasek (1969) as well as Schipper (1973) stated, that the characteristic protein composition of varieties is not changed even under very differing environmental conditions. Lein (1974) found that the lysine content of adapted varieties, at least in middle Europe, is only little affected by climatical factors. To study the influence of the location, especially the altitude, on the protein quality of wheat, samples from the National Yield Trials carried out in Ethiopia 1972 were collected. Selected results of the protein quality analyses done are presented in this paper.

Material and Methods

Samples of three mexican wheat varieties from 8 locations with altitudes between 1650 and 2400 m were analysed in addition to samples of 10 varieties grown at 2 locations of extremely differing altitudes. Crude protein was estimated using the Kjeldahl method; protein fractions using the method described by Maes (1962 a, b; 1963). For the column chromatographic determination of lysine the Beckmann-Multichrom apparatus was used.

Results :

1. Protein fractions:

The results of protein fractions in Tables 1 to 3 show that the influence of the altitude of the location on the protein fractions is not clear. The differences between the three selected varieties are greater than the differences between locations.

Correlation Coefficients for Inia 66, Penjamo 62 and Sonora 63 (Table 1 - 3) grown at 8 locations in Ethiopia

Relation	r	Required r (5%)
Altitude of location / Protein Fractions:		
Altitude / Albumin	-0,314	0,406
Altitude / Globulin	+0,277	"
Altitude / Prolamin	-0,313	"
Altitude / Glutenin	+0,302	"

The correlation coefficients calculated for the three varieties together (n = 24) show a tendency of decreasing albumin and prolamin and increasing portions of globulin and glutenin with increasing altitude. But this tendency is non-significant. That means, there is no direct effect of the altitude on the protein fractions in wheat grain. But if we look at the relation between crude protein content and protein fractions we find some significant corellations, which are shown in figure 1. The proportions of the constitutent proteins albumin and globulin decrease with increasing crude protein content. In case of globulin the correlation is highly significant. On the other hand a significant increase of the reserve protein prolamin was found with increasing protein content. That means, higher protein contents in wheat grains are related with higher proportions of reserve protein, which are lower in quality, because the lysine content is low in the reserve proteins.

2. Lysine contents:

To characterize the three investigated Mexican wheat varieties the mean yields, protein contents and lysine contents are shown in Table 4. The variety Penjamo 62 with the highest average yield contains more lysine in % of crude protein than the other two varieties, but the lysine yield in kg/ha was the same in case of Inia 66 and Penjamo 62, because Inia 66 had a higher protein content in average for the eight locations. The maximum differences between the three varieties (at the bottom of Table 4) are very low in comparison with the differences between locations shown in Table 5. From this Table we can see, that the yields were higher at higher altitudes but the protein contents decreased with increasing altitudes. The lysine content in % of crude protein increased with increasing altitude as well as the lysine yield in kg/ha. This relationship which is shown in figure 2 is significant or highly significant. In additional to the correlations between altitude and quality properties of wheat the correlation coefficients between grain yield and quality properties were calculated with the following results.

Correlation Coefficients for Relations between Grain Yield and Wheat Quality (Inia 66, Penjamo 62 and Sonora 63 grown at 8 locations in Ethiopia).

Relation	r	required r(5%)
Yield/Crude Protein Content	-0,657	0,434
Yield/Lysine Content	+0,381	0,434
Yield/Lysine Yield	+0,959	0,434
Crude Protein Content/Lysine C.	-0,714	0,406

The correlation coefficients, r, show a highly significant negative correlation between yield and crude protein content, but a highly significant positive correlation between grain yield and lysine yield. The positive correlation between grain yield and lysine content was non-significant, but the negative correlation between crude protein content and lysine content was highly significant. In Table 6 the three varieties Inia 66, Penjamo 62 and Sonora 63 are compared at 3 selected locations of low medium and high altitude (Awassa, WADU and Holetta). This Table again shows increasing yields and decreasing crude protein content with increasing altitude. But a decreasing crude protein content was not connected in all cases with increasing altitude. At Holetta the crude protein content was higher in comparison with WADU in spite of the higher yields at Holetta. At the two higher locations, Holetta and WADU, the variety Inia 66 showed relatively higher lysine contents as well as relatively high protein contents and yields. The connection between lysine yield and grain yield is also evident: in spite of high lysine contents the lysine yield at Awassa was very low because of the low grain yield. In addition to the analyses of the three mexican wheat varieties grown at 8 locations another series of analyses including 10 varieties from Holetta (2400 m) and Awassa (1700 m) was made. The results are shown in Table 7. In general the results are in accordance with those from the three mexican varieties. But special attention should be paid to the fact that the differences in crude protein content and lysine content were greater between the locations than between the 10 varieties. The protein of the variety Romany contained the highest lysine content at both locations.

Conclusions:

From the results presented it is clear that there is a connection between grain yield, crude protein content and lysine content of wheat: the higher the grain yield, the lower the crude protein content and the higher the lysine content in percentage of crude protein. Because there is a significant positive correlation between grain yield and altitude

it can also be said: the higher the altitude, the lower the crude protein content and the higher the protein quality. The results of the analyses have also shown that the changes in yield, protein quantity and quality of wheat caused by the environmental conditions of the locations were greater than the differences between varieties.
To improve the quantity and quality of wheat protein at the higher altitudes varieties have to be selected, or bred, which are able to combine high yield with high protein content and high lysine content. That means, it is necessary to break the connection high yield - low protein content - high lysine content of the protein. Among the 13 varieties analysed Romany and Salmayo seem to be best suited in this respect.

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TABLE 1. The influence of locations (altitude) on the parts of protein fractions of total protein of wheat from Ethiopia (mg/10 g grain dry matter and percentage of total soluble nitrogen). National Yield Trial "Early" 1972 Ethiopia - cultivar Inia 66

Location - Altitude (m)		Albumine mg	Albumine %	Globuline mg	Globuline %	Prolamine mg	Prolamine %	Glutenine mg	Glutenine %	Soluble N mg	Total N mg	Prol. Glut.
Bako	1650	47.1	21.6	22.8	10.4	75.2	34.5	73.1	33.5	218.2	275	1.03
Awassa	1700	45.1	16.6	26.5	9.9	92.9	34.6	103.7	38.7	[illegible]	275	0.90
Debre Zeit l.s.*	1860	42.3	19.7	24.1	11.2	71.9	33.5	76.6	35.6	214.9	260	0.94
Debre Zeit bl.s*	1860	35.2	18.3	20.9	10.8	63.7	[illegible]	[illegible]	37.9	192.9	234	[illegible]
Debre Zeit Ø		38.8	19.0	22.5	11.0	67.8	33.3	74.9	36.8	203.9	247	0.91
Alemaya	2075	36.8	18.6	22.8	11.5	70.0	35.3	68.5	34.6	193.1	257	1.02
WADU	2100	29.0	16.9	19.2	11.2	56.3	32.9	66.8	39.0	171.3	210	0.84
CADU	2150	34.7	16.7	21.0	10.1	71.3	34.3	80.7	38.9	207.7	244	0.88
Asmara	2300	39.5	17.1	23.7	10.2	82.7	35.7	85.8	37.0	231.7	282	0.95
Holetta	2400	35.6	18.1	20.9	10.5	69.6	35.5	70.2	35.8	196.3	242	0.99
Mean		38.4	18.2	22.6	10.6	72.6	34.4	77.6	36.8	211.0	257	0.94

TABLE 2. Cultivar Penjamo 62

Bako	1650	40.7	22.2	21.9	12.0	66.1	36.1	54.4	29.7	183.1	233	1.22
Awassa	1700	45.5	18.7	26.0	10.7	95.1	39.1	76.7	31.5	243.3	283	1.24
Debre Zeit l.s.*	1860	38.9	20.4	23.2	12.1	70.9	37.1	58.1	30.4	191.1	231	1.22
Debre Zeit bl.s.*	1860	37.5	19.3	22.5	11.6	72.8	37.4	61.9	31.8	194.7	230	1.18
Debre Zeit Ø		38.2	19.9	22.9	11.9	71.9	37.3	60.0	31.1	192.9	231	1.20
Alemaya	2075	40.3	20.0	23.8	11.8	76.6	38.0	60.8	30.2	201.5	253	1.26
WADU	2100	25.6	19.2	16.3	12.2	41.6	31.2	49.7	37.3	133.2	160	0.84
CADU	2150	33.2	19.3	22.0	12.8	59.7	34.6	57.4	33.3	172.3	204	1.04
Asmara	2300	32.0	19.2	21.3	12.8	54.2	32.5	59.2	35.5	166.7	196	0.92
Holetta	2400	36.0	20.3	20.5	12.2	61.5	36.6	51.8	30.9	167.8	197	1.19
Mean		36.4	19.8	21.9	11.9	66.5	36.2	58.9	32.1	183.7	221	1.12

TABLE 3. The influence of locations (altitude)on the parts of protein fractions of total protein of wheat from Ethiopia (mg/10 g grain dry matter and percentage of total soluble nitrogen). National Yield Trial "Early" 1972 in Ethiopia—cultivar Sonora 63

Location - Altitude(m)		Albumin mg	Albumin %	Globuline mg	Globuline %	Prolamine mg	Prolamine %	Glutenine mg	Glutenine %	Soluble N mg	Total N mg	Prol. Glut.
Bako	1650	39.9	21.1	21.7	11.5	67.7	35.9	59.4	31.5	188.7	238	1.14
Awassa	1700	44.6	18.1	24.4	9.9	100.0	40.7	76.9	31.3	245.9	283	1.30
Debre Zeit l.s.*	1860	37.8	22.7	21.8	13.1	63.0	37.8	43.9	26.4	166.5	208	1.44
Debre Zeit bl. s*	1860	34.7	18.0	22.3	11.6	72.1	37.5	63.2	32.9	192.3	223	1.14
Debre Zeit ∅		36.3	20.4	22.1	12.4	67.6	37.7	53.6	29.7	179.4	216	1.29
Alemaya	2075	32.7	21.3	19.1	12.5	56.3	36.8	45.1	29.4	153.2	194	1.25
WADU	2100	29.0	20.1	19.7	13.6	41.3	28.6	54.6	37.7	144.6	169	0.76
CADU	2150	32.0	18.6	22.0	12.8	60.1	34.8	58.4	33.8	172.5	210	1.03
Asmara	2300	32.8	19.5	17.7	10.5	56.9	33.9	60.6	36.1	168.0	197	0.94
Holetta	2400	30.3	18.9	19.3	12.1	58.0	36.3	52.4	32.7	160.0	190	1.11
Mean		34.9	19.7	20.9	11.8	63.9	36.1	57.2	32.3	176.9	212	1.12

TABLE 4. Protein quality and grain yield of 3 mexican wheat varieties in Ethiopia (average of 8 locations with different altitude).

Variety	Yield q/ha	Crude Protein %	Lysine Content g/100g	Lysine % of Crude Protein	Lysine Yield kg/ha
Inia 66	27.8	14.7	0.434	2.97	13.9
Penjamo 62	29.0	12.6	0.410	3.28	13.9
Sonora 63	25.8	12.1	0.387	3.22	11.9
Max. Difference	3.2	2.6	0.047	0.31	2.0

TABLE 5. Lysine content and lysine yield of wheat in Ethiopia as affected by the altitude of the location (average of 3 varieties)

Location	Altitude	Yield q/ha	Crude Protein %	Lysine Content g/100 g	Lysine % of Crude Protein	Lysine Yield Kg/ha
Bako	1650 m	13.3	14.2	0.464	3.29	6.2
Awassa	1700 m	9.1	16.7	0.457	2.75	4.2
Debre Zeit	1860 m	33.8	13.2	0.401	3.05	13.5
Alemaya	2075 m	28.1	13.4	0.409	3.07	11.7
WADU	2100 m	34.4	10.2	0.353	3.41	12.3
CADU	2150 m	30.3	12.5	0.381	3.08	11.6
Asmara	2300 m	-	12.8	0.414	3.27	-
Holetta	2400 m	37.3	12.0	0.414	3.45	15.1
Max. Difference		28.2	6.5	0.111	0.70	10.9

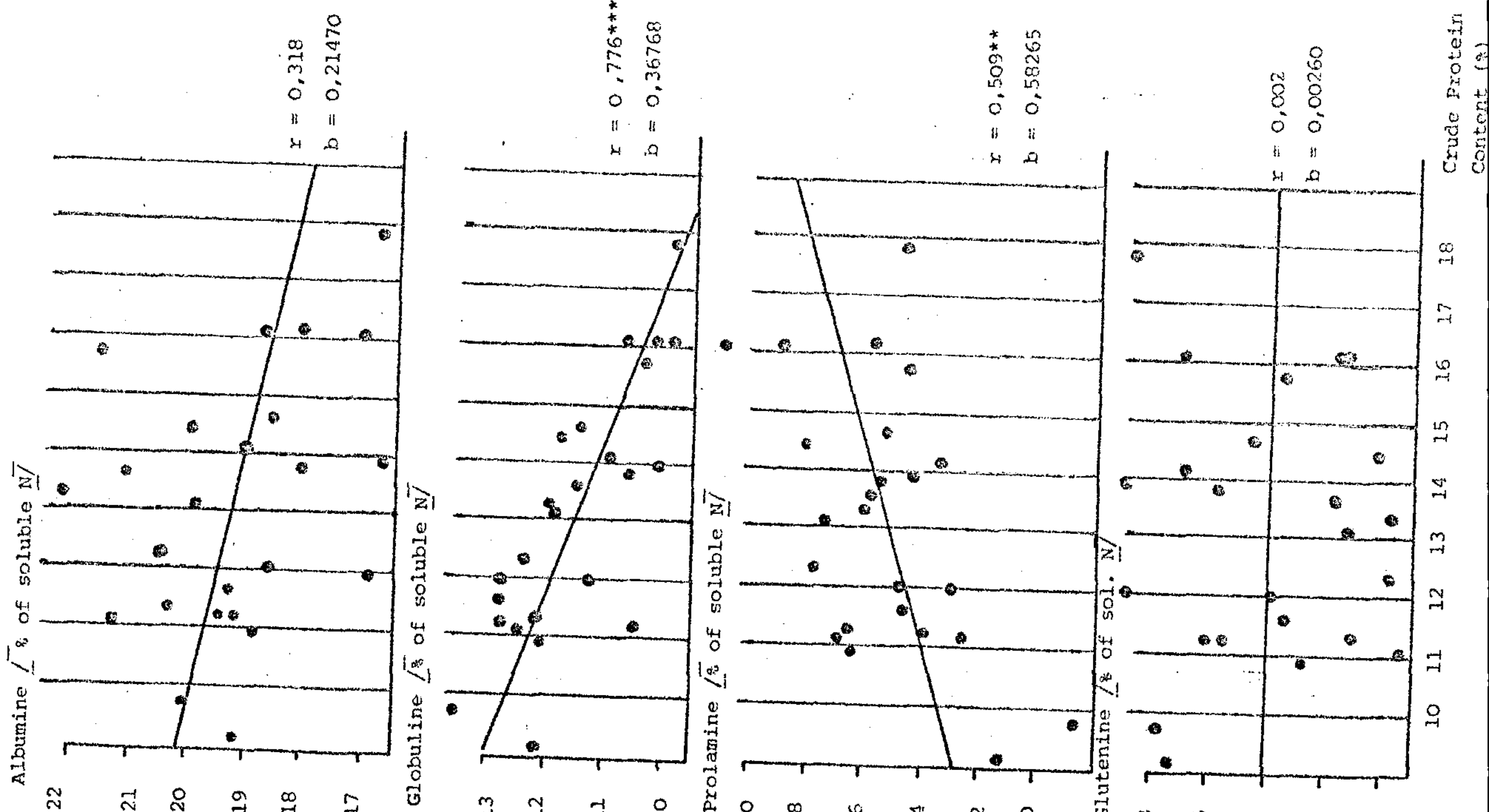
TABLE 6. The influence of the altitude on the protein quality and the grain yield of wheat in Ethiopia

Location Altitude	Variety	Yield q/ha	Crude Protein %	Lysine Content g/100 g	Lysine % of Crude Protein	Lysine Yield kg/ha
Awassa 1700 m	Inia 66	10.1	17.8	0.451	2.54	4.6
	Penjamo 62	10.5	16.1	0.464	2.88	4.8
	Sonora 63	6.9	16.1	0.456	2.83	3.1
WADU 2100 m	Inia 66	38.9	12.0	0.422	3.43	16.4
	Penjamo 62	35.8	9.1	0.302	3.32	10.8
	Sonora 63	28.6	9.7	0.336	3.48	9.6
Holetta 2400 m	Inia 66	28.4	13.8	0.482	3.49	13.7
	Penjamo 62	38.8	11.3	0.387	3.44	15.0
	Sonora 63	44.6	10.9	0.372	3.42	16.6

TABLE 7. Lysine content of wheat cultivars in Ethiopia as affected by the altitude of the location

Variety	Awassa 1700 m					Holetta 2400 m				
	Yield q/ha	Crude Protein Content %	Lysine Content g/100g	Lysine % of Crude Protein	Lysine Yield kg/ha	Yield q/ha	Crude Protein Content %	Lysine Content g/100 g	Lysine % of Crude Protein	Lysine Yield kg/ha
8156 (W) Laketch	9.8	16.5	0.339	2.06	3.3	29.8	11.9	0.309	2.61	9.2
Supr. Ken. x Yaqui 48	3.6	19.1	0.395	2.01	1.4	29.4	13.3	0.325	2.45	9.5
C. I. 8154 - Fr2	10.3	18.3	0.410	2.26	4.2	29.1	14.0	0.337	2.41	9.8
12 A - 4	18.1	17.1	0.390	2.29	7.1	26.3	13.4	0.325	2.43	8.5
Choti Lerma	9.7	16.6	0.352	2.12	3.4	17.4	13.4	0.322	2.41	5.6
Salmayo	14.1	15.8	0.354	2.25	5.0	42.6	11.4	0.304	2.68	12.9
Romany	10.4	16.8	0.417	2.49	4.3	43.0	12.2	0.328	2.69	14.1
K 4328 D1 A2	8.3	18.5	0.420	2.28	3.5	39.3	12.3	0.314	2.56	12.3
K 4958 A2 H1 B1 Sel	7.7	18.7	0.417	2.23	3.2	36.4	12.9	0.297	2.30	10.8
K 4471 E8 E2 C	8.0	16.9	0.341	2.01	2.7	33.0	13.1	0.288	2.19	9.5
Mean	10.0	17.4	0.383	2.20	3.8	32.6	12.8	0.315	2.47	10.2

FIGURE 1. Relations between Crude Protein Content and Portions of Protein Fractions of Wheat (Inia 66, Penjamo 62 and Sonora 63 grown at 8 locations in Ethiopia)

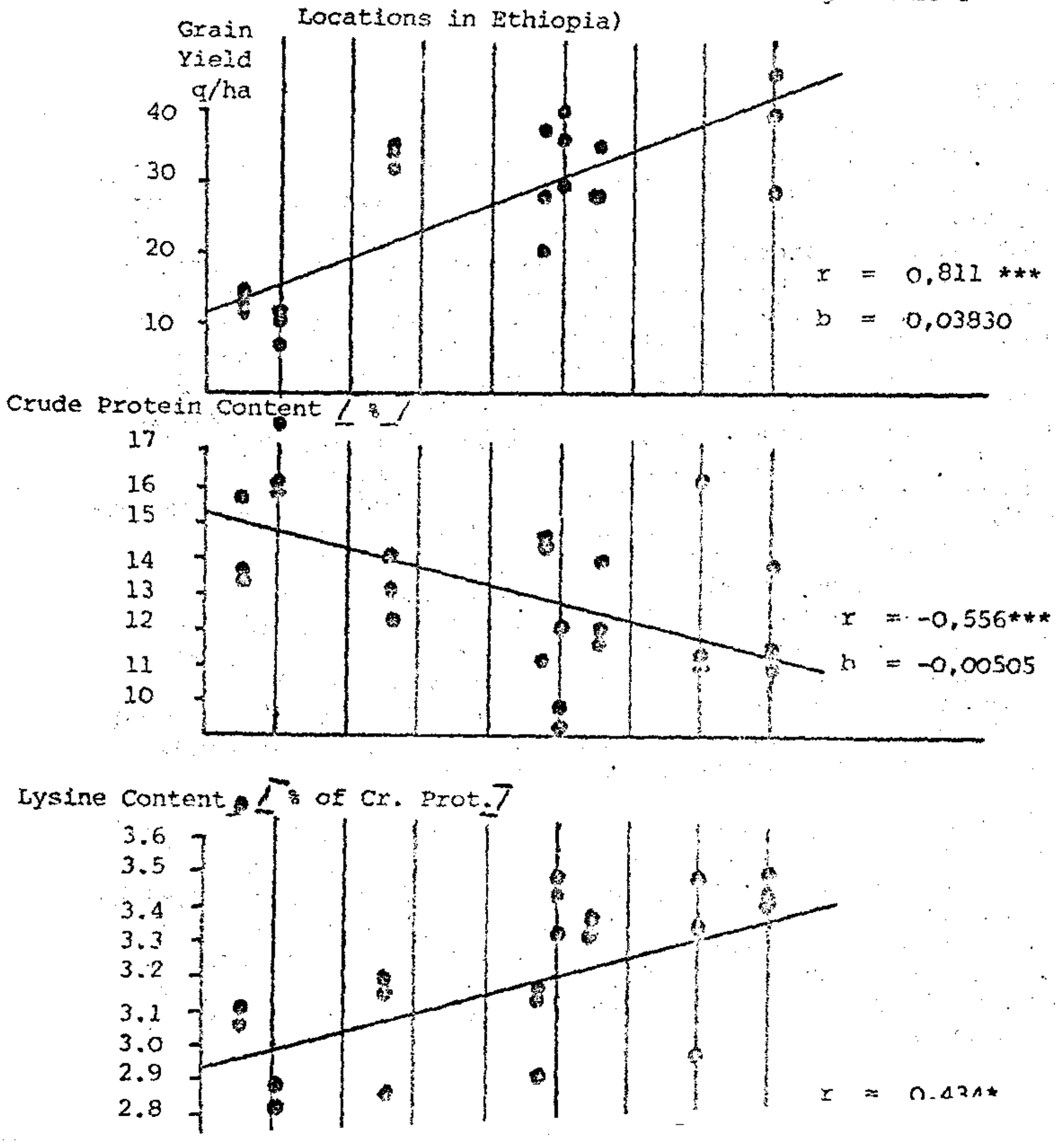


DISCUSSIONS

A participant commented that the results had shown that yields were higher at higher altitudes but the protein content decreased with increasing altitude. However, the lysine content in percentage of crude protein increased with increasing altitude. The participant wanted to know how this could be accounted for because the lysine content was generally thought to be fixed by genetic factors; could it possibly be an influence of nitrogen availability? Dr. Westphal replied that the trials had not included fertilized and unfertilized plots and therefore the effect of nutrients had not been included. It should be possible to avoid a decrease in protein content at higher altitudes by applying nitrogen particularly if the fertilizer was applied later on in the growing season. He acknowledged that it was well known that lysine content was fixed genetically and that environmental factors would only have a small effect on the content. However, these studies had been carried out in Europe and America where the variation in environmental factors is not very great. In Ethiopia environmental conditions vary very greatly and thus these could be having a larger effect than the genetic potential of the plant. However, it was too early to make any final conclusion. The results presented had been from one lot of samples from the 1972 National Yield Trial. There was another set of samples at Giessen University which were awaiting analysis.

A participant questioned how altitude per se could affect yield. Dr. Westphal replied that altitude was just a measure taken because they did not have data on the climatic parametres for all locations. Altitude was only an indicator of location. It would have probably been more meaningful if parametres analysed could have been measured against such data as temperature means or rainfall. One factor that could have influenced wheat yield favourably was that the diseases decrease with increasing altitudes.

FIGURE 2. Influence of Location (Altitude) on Yield and Quality of Wheat (Inia 66, Penjamo 62 and Sonora 63 grown at 8 Locations in Ethiopia)



TRITICALE: ITS POTENTIALS AND PROBLEMS IN ETHIOPIA

by

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Ever since A. Stephen Wilson of Aberdeen, Scotland, made the first recorded attempt to cross wheat and rye in 1873 (Wilson, 1876), scientists have been trying to find ways of exploiting the possibility of combining these two genera to produce a crop which was more productive and superior than either of its parents. During the 1930's two important developments that greatly affected the development of triticale as a crop species occured. These were the discovery of Colchicine which can be used to induce chromosome doubling to produce amphidiploids (Kostoff, 1938) and the improvement of embryo culturing methods to enable hybrids to be obtained from normally incompatible parental combinations. These developments paved the way for the production of hexaploid triticales.

The first hexaploid triticale from hybrids of tetraploid wheat (2n = 28) and Secale montanum (2n=14) was reported by Derzhavin (1938). Later O'Mara (1948) reported the production of hexaploid triticale from crossing durum wheat and cultivated rye, Secale cereale. However, even before these deveöopments had taken place, Arne Muntzing of the University of Lund, Sweden, began work on triticales in 1931. His work has contributed substantially to triticale research, in particular to the development of octoploid triticale. Since the discovery of colchicine triticale breeding and research work has also been carried out in Russia, Hungary, Spain and Germany. Nevertheless, triticale research took a new direction after a breeding and cytogenetics research programme started in Manitoba, Canada, in 1954 and when a triticale breeding programme was initiated by Dr. N. Borlaug in CIMMYT, Mexico, in 1964.

Now, under the leadership of CIMMYT as Coordinator of the International programmes, the triticale work has become very extensive. In this short paper the Ethiopian triticale programme is examined and the potential of the species as a food crop is assessed. In addition the problems that will be faced if the crop is advanced to large scale production is evaluated.

Materials and Methods

The information for this paper was obtained from the triticale materials in the project at Holetta Research Station, National Trials and Observations, various trials and nurseries at IAR out-stations and IAR/EPID research sites. Most of our material came from CIMMYT although we also received material from Canada, Hungary and the USA.

In most cases trials were laid out in randomised complete block designs in 2 to 4 replications and standard fertilizer and seed rates were employed, depending on the location. A standard plot size of 3.0m^2 was used in all observations and trials unless yield was based on bigger increase or demonstration plots. Yield comparisons were calculated based on the five best triticale / wheat test locations; Alemaya, Awassa, Kulumsa, Debre Zeit, and Holetta. Agronomic and grain data such as test weight were based on standard procedures. Total protein analyses (N x 5.76) were carried out according to the Kjeldahl method.

Utilization tests were evaluated by sets of procedures developed by the project at Holetta. Acceptability trials of triticale food products were carried out using a facial imagery voting method of a permanent panel at Holetta and questionnaires in selected farming communities.

Potentials

The triticale work in Ethiopia started with a few lines from CIMMYT in 1970. Since 1972 the programme has grown in scope because of financial support from International Development Research Center (IDRC), Canada, The objective of the programme is to develop triticale varieties well adapted to a wide variety of climatic conditions and which will complement other cereal grains in an effort to increase and improve the quality of the diet in the low income group of people. The potential of the crop has been found to be very encouraging.

Triticale has been found to be widely adapted and vigorous under different conditions in the country. It is best adapted to cool growing conditions at intermediate to high elevations. It performs well at altitudes from about 1700 to 2500 m. In addition the crop has also indicated its potential adaptation to marginal small-cereal growing areas such as the lowlands (1500 m) and highlands with very cool temperatures, e.g. Chencha (2880 m).

Fertility in triticale has improved substantially and many of the promising lines available at present in our programme are highly fertile. This was the result of spontaneous outcrossing of an F_1 hybrid of triticale with a Mexican bread wheat progenitor having a NORIN 10 dwarfing gene (Zillinsky and Borlaug, 1971). This fortunate out-crossing also introduced into triticale other desirable characters such as stiff straw, short stature and day length insensitivity. Therefore under our conditions triticale has been found very vigorous and resistant to lodging even under high rates of fertilizer. Thus compared to barley and non-Mexican wheats, triticale has a definite advantaged in lodging resistance.

Triticale is also better in disease resistance than barley and wheat. Among the three rusts, leaf rust may concern us more than the other two. Even here we have a number of strains which are resistant to leaf rust although most lines in the national trials were found to be susceptible at intermediate and lower altitudes. Stripe rust (Puccinia striiformis West) is a problem only at very high altitudes (e.g. Sheno, 2800). At Sheno most strains were found to be susceptible when some early groups of triticale and the late complex crosses from the USA were resistant under field conditons.

Stem rust (Puccinia graminis) resistant varieties are available in the programme. Even at lower altitudes (e.g. Awassa, 1650 m) a number of triticale lines have been found to be resistant/tolerant to strains of stem rust found in the country. Many European workers have also reported that triticale is generally more resistant to disease than wheat (Shulyndin, 1972; Kiss, 1973). At higher altitudes and under cooler temperatures such as at Holetta, Septoria leaf spot is one of the most important foliar diseases on wheat. Triticale is found to be generally more resistant to the strains of Septoria pathogen prevalent in Ethiopia and many lines are available which have appreciable resistance. Diseases such as powdery mildew, smuts, ergot and downy mildew have not appeared as serious problems in our programme so far.gave only 13% more than the best bread wheat, Mamba.

The introduction of fertile strains of triticale with high tillering capacity, better spike length and plant structure in the programme has resulted in triticale yields equal or superior to those of the best wheats in a number of national trials. In 1972 the best triticale gave a mean yield of 4031 kg/ha which was 29% higher grain yield than the best bread wheat check. In 1973 the best triticale (Holetta 14) yielded 4253 kg/ha, 31% higher than the best bread wheat. In the 1974 season the top triticale (H6) with a mean yield of 4410 kg/ha, gave only 13% more than the best bread wheat, Mamba.

Recently developed triticales are better in kernel development and yield. However, there is still a lot to do to solve the problem of abnormal endosperm formation which results in seed shrivelling, low test weight and low germination rate. The test weights under our conditions range from 61 to 79 kg/hl, while the best bread wheats have test weights in excess of 81 kg/hl. Many workers have reported cytogenetic research findings on the possible cause of seed shrivelling in triticale but so far its cause is not definitely known. We are attempting, nevertheless, in our breeding programme to improve the grain quality. Although progress is slow, improvement in kernel plumpness has been achieved by breeding (Zillinsky, 1974).

Protein content of triticale varies with the level of nitrogen fertilization, location, moisture stress, genotype and kernel development (Gebremariam and Larter). Protein percentages, calculated as N x 5.76, as low as 8.7 and as high as 19.5 were obtained from some strains at certain locations. When protein values were converted into protein yield per hectare some varieties gave as high as 717 kg/ha. More important than total protein in triticale is the lysine content of the protein. Triticale has a higher lysine content than wheat (Kies and Fox, 1970; Gebremariam and Larter).

The main objective of the Triticale Project in Ethiopia is to introduce this new crop for the purpose of human food. Various local food products, injera, dabo, kita, genfo, ambasha, dabokolo, chechebesa, kemuse and kinche, have been successfully produced from triticale flour. Acceptability trials and cooking demonstrations in the research station and selected farming communities have indicated that the triticale 'injera' and the other food products were acceptable. In addition supplementation of triticale flour with other protein and calorie sources has been very encouraging. Very attractive and nutritive 'injera' was obtained by mixing 10% of field peas, chickpeas, horsebean, or soybean flour to trtiticale flour. A 25% mixture of triticale flour to 'kocho' (enset product) gave highly acceptable and better flat bread locally called 'kemuse' than the whole 'kocho' bread. Having in mind the higher lysine content of triticale this has been given an immediate priority in the project at the Indibir enset growing area, where cereals are not common and malnutrition high.

The triticale flour absorbs more water than teff, 540-590 ml. vs 460-500 ml/200 g standard sample; requires more mixing time, lower 'absit' temperature (42°C vs. 62°C) and less fermentation period, 18-24 hrs vs. 40-46 hrs. for teff. It has recently been found that the fermentation period depends on room temperature, and 'absit' temperature also can vary depending on what type of 'injera' is required.

Problems

Disease of immediate importance in triticale production in Ethiopia are leaf rust, stripe rust, and Septoria in the intermediate and higher altitudes. Although triticale appears to possess greater resistance to Septoria spp. than wheat, all three species cause some damage under Holetta conditions. Septoria avenae f. sp. triticea has been found to be the most abundant while Septoria nodorum is the least common. Septoria tritici is also common at Holetta (Walter, Pers. Comm). Other diseases such as bacterial stripe (Xanthomonas translucens), eye spot (Pseudocercosporella herpotrichoides) take all (Ophiobolus graminis) and Fusarium spp. may be of considerable importance in triticale production. Some varieties were found to be susceptible to bacterial stripe at Holetta, Awassa and Alemaya. High infection by head blight causing crown rot, probably due to Fusarium graminearum, occurs on triticale in many locations. Another serious pest is the stem borer at lower altitudes. At Awassa, up to 50% of the stand in this season's plots were stunted and damaged by stem borer, probably Sesamia spp.

Agronomic problems such as late-tillering and the tendency to pregerminate are also observed. Abnormal endosperm development is the most important unsolved problem in triticale. Bennet (1973) suggested that differences in the duration of the meiotic cycle might influence endosperm development, i.e., to slow chromatin formation in the rye genome chromosomes resulting in disturbances in cell replication in endosperm tissue. This is due to the presence of segments of late-replicating heterochromatin at the telomeres of the rye chromosomes. Kaltsikes (1973) also suggested that differences in rates of meiotic development could result in meiotic abnormalities, since rye chromosomes are larger and carry 1.5 times the amount of DNA compared to wheat chromosomes. Nevertheless, it has been possible to improve grain quality through breeding and selection. The poor grain colour which is due to its rye parent may also be possible to improve by breeding.

After the discovery of the Armadillo lines infertility has been of less importance. However, considering the high potential of triticale spikes, high fertility has been an important area of research for maximum productivity. Merker (1971; 1973) and Larter and Hsam (1973) have reported that fertility and meiotic instability are independent. In Ethiopia low fertility rates have been observed only at very high altitudes (e.g. Chencha and Bedi). It is not clear whether this is due to some environmental factors or an interaction between the genotype and the environment.

A basic question when one thinks of introducing triticale as a commercial food crop in Ethiopia is utilization and marketability of the product. Extensive utilization studies and acceptability tests are required by increasing and refining the present utilization work, demonstrations and acceptability trials and these must be followed up by marketability studies. For this the best varieties have been distributed to farmers on a limited scale in certain areas and the harvested produce utilized by the farming family in the preparation of various local foods.

Further, in cooperation with the extension services it is intended to undertake an extensive distribution of seed and fertilizer in successful demonstration areas and to carefully monitor how the farming families use the harvested grain and straw.

Conclusinn

Here is the first radical man-made species in the hands of conservative and conventional workers. Whether this result of man's effort to explore and exploit nature can be fuitful or futile will depend on the far sightedness and hard work of triticale cytogeneticists and breeders during the next quarter of the century. At this juncture it would be appropriate to quote the brilliant speculation of Dean Shebeski during the 1973 Triticale Symposium in Mexico. "In my opinion, over the next 15 years, yields of triticale will improve much more rapidly than those of wheat and should plateau, at a level approximately 50% higher than those of wheat". Then we will stop comparing triticale with wheat and talk of this species as a crop with its own standards and management requirements.

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DISCUSSION

The Chairman thanked Ato Hailu for his comprehensive coverage and opened the floor for questions and comments.

The first comment came from a participant who was raising once again a topic that concerned him greatly. This was the whole question of the relevance of research on triticale particularly with respect to the present stage of Ethiopia's development. Ethiopia has many crops and for most of these there is not a single plant breeder in the country. Coffee is the major foreign exchange earner but in 1974 Ethiopia lost about Eth.$81 million from crop destruction due to Coffee Berry Disease; this year, 1975, we face the possibility of loosing over Eth.$150 million. There are other important crops such as teff where we only have one or two breeders. Now we are facing a new deal for the national and in this can Ethiopia afford research on triticale. One of the main reasons for triticale research is that it is financed from outside the country. However a lot of money is also being spent by the Ethiopian Government, i.e. the Ethiopian people and this money and the time spent listening to such reports should be devoted to the problems of Ethiopia's farmers. He therefore challenged the IAR General Manager on whether we can afford triticale research and to give a justification for allowing this research to continue. He also challenged the speaker; did he not feel guilty carrying out this research, denying the people who taught him the service that they need.

Ato Hailu replied that this was a legitimate challenge. However, he was prepared to compare triticale with any other food crop. He also felt that equal, not less, priority should be given to food crops in comparison to coffee; in fact research needed to concentrate mainly on food production. The validity and justification of triticale research should be seen in the results. If this crop is promising for this part of the world and if, in a few years, it can be shown to be useful, then he will stand for it. He believed that triticale has a potential and will add to the food production of Ethiopia. For example, if in the coming year it is confirmed that triticale is a useful crop for the farmers at Endibir then he would be more satisfied than in working on CBD. But the question of priority obviously stands and is a very delicated issue; i.e. should we go to teff or wheat breeding instead of triticale. He felt that the whole question centred on the problem of producing more calories per unit area of land and not per unit manpower or any other capital input. Which crop will do this is a comparitive question and depends on what is productive given the limited resources available at this time. Personally he did not feel guilty working on triticale. Although this is a very new species, especially when compared with wheat, he felt that this part of the world will benefit from it.

The General Manager of IAR, Dr. Samu-Negus, commented as follows: He felt that this question was very relevant. It had been raised many times and his predecessors had also questioned this point. It has been pointed out in meetings and discussions that unless triticale has unique qualities to anwer some of the problems in this country which can not be solved by wheat or barley or other cereals then it has no place as the yields of wheat and triticale are about the same at this time. Ethiopia has many crop species and if these can be improved by breeding to give yields of 60 to 70 q/ha, then the question of working on triticale is very relevant. However, the work reported by Ato Hailu has shown that triticale will give yields in areas with low soil fertility and other soil problems where other cereals give very low yields or none at all and the research is developing from year to year. However, the place of triticale research is constantly under review.

The Chairman then asked Mr. Pinto, who had worked with triticale for several years, to comment. Mr. Pinto said that he could not comment on the question of priorities as this was outside his terms of reference. However, he wished to commend Ato Hailu and his team for their excellent approach to this problem and Ato Hailu for his dedication to this crop. If this approach could be implemented for other crops then there would be a lot more to be said for research for its own sake. Ato Hailu had attempted first of all to show that here was a crop with a potential, perhaps upto 30% higher yielding than wheat, and that many of the problems are solved but that some others remain. Mr. Pinto believed that triticale has a tremndous potential; one that he, as a wheat breeder for almost fifteen years, can not fail to appreciate. Triticale has such tremendous vigour under such a wide range of conditions; it has good adaptation, good yield stability and good disease resistance almost all round and a range of protein qualities that are quite commendable. Thus three quarters of the problems as far as this crop is concerned are already solved. In Ethiopia, the problem is will this crop be acceptable and this is the challenge being taken up now. The programme at Endibir will see if this crop can be moved into an area and monitor how the peasant farmer will react. When he harvests the grain will he feed it to his chicken, will he try and sell it or will he use it for food and if so how will he benefit in terms of nutrition, etc.

Mr. Pinto also stated that he supported the triticale programme from another angle. The programme gave an opportunity to add to international research on a particular food crop. At present there is very little knowledge about the potential of triticale as a food crop in developing countries. If Ethiopia can show that this crop has potential as human food; not just in feeding animals or making alcohol, etc., but for feeding people then he felt that Ethiopia would have made a valuable contribution in research for the rest of the world. Therefore Mr. Pinto supported Ato Hailu's stand on this crop.

The originator of this topic came back with a comment. He felt that, as a breeder, before one started working on a crop one should take into consideration the acceptability of this crop to the people. Secondly one should consider the capital and marketing requirements of the country. The use of triticale as human food had not been proved beyond doubt. Therefore he still challenged the General Manager of the IAR for allowing research on triticale to continue.

A participant from the SORADEP area commented that the SORADEP project had concentrated on increasing the yield of maize, the main crop in the area. For the first two years the farmers had been satisfied but in the third year they had decreased the total area for the main crop and introduced other crops such as teff or wheat. This indicates to SORADEP that the farmers are now ready for diversification. However one of the main problems in cereal diversification in the Awassa region is the very high disease incidence in the more traditional cereals. Thus they were interested in joining the triticale programme because of its disease resistant/tolerant qualities.

Returning to the first topic, another participant commented that he felt that there was room for defending our own particular disciplines but this should not be at the expense of national priorities. He felt that the IAR was continuing to present triticale as a show piece and that critisms had always been met with similar remarks. He was sure that UNDP was also aware that the Institute should design programmes that meet the priority needs of the country. Although the money was coming from outside sources, he felt that the main consideration should be the best use of the scarce manpower available in the country. Therefore research should be on the crops that we use traditionally. We should aim to increase productivity and also concentrate on other parts of the agricultural sector which have not been paid much attention up till now. As already pointed out, our major export crop, coffee, has serious problems and there is no other commodity from animal production that can be exported to earn the same amount of foreign exchange. It is well realised that we need to diversify our export products but this will take time. Thus he fully supported the first questioner in challenging the relevance on triticale research in Ethiopia at this time.

The Chairman commented that he felt that triticale research has now approached the final stages. The team is approaching the crop from all angles, including nutrition, and shortly we hope to see whether triticale will make a break through or not.

Ato Hailu came back with some final comments. He was fully aware that the controversy over triticale was not new as he had come across it in several meetings and conferences. He also assured the participants that triticale was not being presented as a show piece. He had spent most of his time with the farmers and wished that many other research people would do the same. He thus believed that the farmers were interested in this crop. In fact the triticale team do their demonstration and utilization work with the farmers and their families. The farmers grow the crop and their families prepare the food and eat it. If they say that this crop is good then there is no point in discrediting it. Also triticale is not a big project and is supported by the IDRC of Canada, not by UNDP. Obviously from the point of view of priorities, he could not comment as he felt he was only a simple technitian working in the field. However of one thing he was sure and that was those of us who talk about policies and priorities would be wise to go to the peasants and spend days and days with them, seeing their problems and starting work there with them. Sitting and talking in Africa Hall can not help us understand the problems of the peasants at Endibir whose lack of food and need of something to grow is desperate. Cereals are not common at Endibir; the farmer grows his ensete and if his ensete dies, he dies there. We can talk about priorities for the next decade but this will not solve the problems of the peasant farmers at places such as Endibir.

STUDY ON THE YIELD OF ENSET (1)

by

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Abstract:

This survey was undertaken during three consective years 1972/73 - 1974/75. Harvesting of enset is mostly done during the dry months when the water content in the plant decreases as compared to the wet season.

The yield was arrived at by processing mature 8 years old plants at three different enset growing regions; namely Endiber, Kembatta and Sidama. Yield of enset varies with the fertility of the soil, altitude and rainfall in a given area. However, in all three regions low yield as well as high yield per plant was recorded. Generally, farms where a good stand of enset was noted and high yields obtained were where good cultural practices have been maintained. The primary advantage of adequate care of an enset plantation is to force each plant to maximize the build up of starch to be processed from the psuedostem and the corm.

Introduction

Previous records on yield of enset are limited. Stanley (2) attempted to establish the productivity of enset by having seven average sized plants processed. Jackson (3) suggests 60 kg/plant in southern Ethiopia. Various scholars (4) quote that 60-100 plants would supply all the enset food a household of 5-6 persons would need for a year. Farmers in Endebir area agree that 50-60 mature plants to be sufficient for a year while in Kembatta 30-40 plants are said to meet the need. On the basis of the yield study (Table 1) 50-60 mature plants seem to be required in Sidama area. However, because plants which are removed after thining a dense plantation(2) are also processed, the number of plants used each year by any family in Sidama is highly variable. It is useful to note that use of immature enset does not produce quality food.

Although cultivation of enset is mainly in the south and south-western parts of Ethiopia, the distribution of Ensete species in Tropical Africa is quite wide. The adaptation zone of Ensete spp. ranges from 1600-3100 m above sea level (5). There are 25 species reported (6) growing as both cultivated and uncultivated forms. The species particularily cultivated in Ethiopia is called Ensete ventricosum (1). Several clones of this species are being cultivated over an estimated area of 67,000 square kilometers (7). An estimated population of 5-6 million

TABLE 1. Yields of Mature Enset from Three Regions

Number of plants	Weight of processed food (kg) Before Fermentation	After Fermentation	Usable %	Refined food Usable kg	Yield/ Plant
A. ENDEBIR					
5	324	58	72	42	8
5	259	86	90	77	15
5	200	103	80	82	16
5	270	105	76	80	16
5	332	145	63	91	18
5	413	129	90	116	23
5	584	160	80	128	26
5	244	162	87	141	28
5	507	210	72	151	28
8	809	246	92	226	28
5	425	227	72	163	32
5	332	256	71	182	36
5	704	287	66	189	38
5	480	292	66	192	42
5	585	298	70	208	42
5	724	329	72	237	47
5	683	497	70	348	69
Total 93	8253	3723		2766	535
Mean	89	40		30	30
B. KEMBATTA					
5	288	151	60	91	18
5	538	173	52	90	18
5	341	162	61	99	20
5	480	139	77	107	21
5	538	188	60	113	23
5	778	221	61	135	27
5	986	326	63	205	41
5	836	370	66	244	49
5	805	410	67	275	55
5	895	544	64	348	70
Total 50	6485	2684		1707	342
Mean	130	54		34	34
C. SIDAMA					
5	303	65	77	50	10
5	331	73	88	64	13
5	433	181	68	123	25
5	709	157	84	132	26
5	586	181	82	148	30
5	850	235	87	205	41
5	790	250	85	219	44
Total 35	4002	1150		941	109
Mean	111	73		27	27

depends partly or completely on enset as a source of staple diet (7). One of the main objectives of this study has been to establish a basis for the measurement of yield in any of the future research undertakings.

Materials and Methods

A total of 178 mature enset plants from established plantations were processed at 35 different locations - 93 plants at 18 sites in Endebir; 50 plants at 10 sites in Kembatta; and 35 plants at 7 sites in Sidama. To conduct the study the sites and the plants at each site were selected at random. The plants were processed in groups of five in the same fashion as the farmers's practice (8). The processed pulp was weighed before and after fermentation. (Table 1.)

It was not felt plausible to process a single type of clone separately on any of the sites. The practical procedure adopted by the farmers is to process all available mature clones together. Therefore, clone types that might exhibit inherent characteristics of yielding higher than others were not considered separately and this might have influenced the mean.

Results and Discussion

The processed product is called 'kocho' in Amharic. The weight of raw, and fermented and refined 'kocho' is enumerated in Table 1. The refined food, recovered after fermentation and removal of excess moisture is made into flour. The hand dried flour is used to prepare various dishes.

The mean yield of the refined product obtained in Endeber was 30 kg/plant; in Kembatta, 34 kg/plant; and in Sidama, 27 kg/plant. The final yields are equivalent to 480, 544 and 432 quintals/ha (refined product) for each of the respective region. The figures/ha are based on 1600 plants/ha in the final transplant stage where the plants take four years to mature.

Yield figures given in Table 1 can be categorised into low, average, and high groups for each region. The percentage of each group is given in Table 2. In 40% of cases in all regions yield remained above average. The number of plants claimed to be sufficient to supply enough food for a family of 5-6 persons for a year at each location appears to be justified.

TABLE 2. Range of Yield of Enset

Region	Low kg	Low %	Medium kg	Medium %	High kg	High %
Endebir	8-18	30	23-28	30	32-69	40
Kembatta	18	20	20-27	40	41-70	40
Sidama	10-19	28	25-26	28	30-44	44

From the figures in Table 3 it can be calculated that an enset farmer with a household of five to six persons would require about 2,000 square metres of land for the last transplant stage and 500 square metres for the nursery stages where successive transplants would be made. It can thus be seen that 2,500 square metres of land could be sufficient to provide all the enset needed by such a household year after year.

TABLES3. Details of stage, spacing, area and duration to produce one enset plant

Stage	No. of Plants		Spacing (m)	Area (m^2)	Duration (years)
Rhizome (corm)		5	1.0 x 1.0	5.00	1
First Transplant	(20/RN	100	1.0 x 0.5	50.00	1
Second Transplant	(90%)	90	1.5 x 1.5	405.00	2
Last Transplant	(90%)	81	2.5 x 2.5	2025.00	4
TOTAL				2485.00	8

Methods of Processing Enset

Methods of processing enset vary from one general region to another. Depending upon the type of processing used fermentation takes from 20-90 days.

Processing enset is an ardous job. Only women are engaged in this activity. Processing, demanding hard labour, stands as one of the limiting factors in the extensive cultivation of enset. Tools used in processing enset in all regions are more or less similar. The tools offer neither mechanical efficiency nor have durability. In all cases major parts of enset processed are the pseudostem and the corm.

The tools are:

1. Wooden plank or board on which to rest the leafsheath while it is decorticated.
2. Bamboo internodes split into two to decorticate the leafsheath. (The splits are sharpened from inside).
3. Wooden club with teeth-like serations grooved at one end in a circular fashion. The club is used to grate the corm.
4. Various kinds of knives to remove leaves and other unwanted parts.

Three Methods of Processing are Practiced

1. Gurage Method of Processing Enset

After all leafsheaths are decorticated the mesophyll is kept in the one pile while the corm gratings are kept in another pile. After all desired number of enset has been decorticated and the corms grated, the two parts are put together systematically.

a. The leafsheath pulp is spread on enset leaves on the ground.
b. Then the corm pulp is spread on top of the leafsheath pulp. The pile is covered tightly with enset leaves.

The seventh day the top part is inverted bringing the leafsheath pulp on top and the corm pulp underneath. The new pile is tightly and neatly covered again by enset leaves. On the twelfth day the leafsheath and the corm pulp is mixed together. Then the whole mass is gathered together into a conical shaped heap. The new heap is covered with many layers of enset leaves and weight applied by putting large stones on the heap; this is left for six more days. The heap losses a considerable amount of moisture and ferments well. By the twentieth day the material is ready for preparing food and stored in a newly prepared pit for future use.

2. Kembatta Method of Processing Enset

The leafsheath pulp is put into a prepared pit directly after decortication. When the pit gets half-full, the corm pulp is mixed with leafsheath parts. After all plants are processed the pit is covered with enset leaves.

To accelerate fermentation a special fermenting agent is prepared separately. While harvesting plants selected for processing, some corms from larger plants are left without being uprooted. The leafsheaths are decorticated and the uprooted corms are grated. The corm remaining in the ground is chipped bit by bit until a funnel-shaped hole is formed. All the fleshy part of the corm is removed using the wooden club with tooth like serations at one end. The walls of the corm are bruised by the sharp pointed end of the weeden club without piercing through the layer. Next the soft innermost leafsheath pieces are put in the hole and beaten with the club until the pieces are crushed into a mash. After the hole is filled, a thin layer of pulp excavated from the corm is spread on top and covered with sufficient amount of enset leaves.

Two weeks after the initial processing, the material kept in the pit and the fermenting agent processed in the corm hole are brought together, throughly mixed, and placed in one pit. The mixture is compacted well while being put in a new pit for further fermentation. About six weeks after fermenting agent is added, the material is transferred into a new pit that is proportional to the new product. The new site serves as a storage place. Food can be prepared from the fermented product.

3. Sidama Method of Processing Enset

Plants designated for processing are uprooted, roots and debris removed, and brought to the working site. The leafsheaths are decorticated. The pulp is put into a very shallow pit. The depth of the pit is increased by constructing above ground a well-like structure with stick supports and enset leaves.

A portion of each of the corms is retained without grating for the purpose of raising the fermenting agent. About 50% of the corm surface is grated leaving the inner portion of the corm. The portions retained ungrated are rubbed throughly by previously prepared rotten pieces of blacknened leafsheath, After the corms have been rubbed well with the rotten leafsheath, they are wrapped up in enset leaves and put aside to soften. After a week the corms kept for raising the fermenting agent become very soft and pulpy. The softened corms are then beaten into fine mash and mixed with the leafsheath pulp put in the pit during the initial processing. It is believed by the local people that the softened corm pulp ensures a proper fermentation of the enset.

Six weeks after the fermenting agent has been mixed, everything is removed from the pit, thoroughly mixed again, transfered to another newly prepared pit, compacted, and covered with fresh enset leaves. After a total of about 90 days from the initial day of processing the material can be considered to have fermented sufficiently to enable food to be prepared.

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8 Note: Methods of Processing Enset.

DISCUSSION

The Chairman thanked Ato Teketel for his stimulating survey paper which contained so much new infomation.

A participant commented that the main problem with enset was not really yield but the drastic disease which had caused the loss of a quarter of the crop over the past few years. He asked Ato Teketel what was being done to tackle this disease problem. Ato Teketel replied they were very concerned about Enset Wilt or Bacterial Wilt. He was aware that this disease was devastating large areas and in some places it had distroyed all the enset. At the Institute and also at Debre Zeit they had to tried to find resistant or better tolerant varieties. However, so far none had been found from all the collections that had been made. Studies were now under way on propagating enset from seed and it was hoped that this might help identify resistant varieties. It had been clearly established that the disease was transmitted mechanically. For example, the previous week-end, he had been in Agereselam where the people were cutting the leaves of enset which shade coffee trees. Wherever a plant had been cut it was found to be infected with the disease. Research had clearly demonstrated that the disease could be prevented from spreading if the farmers carried out strict sanitary measures. An advisory leaflet had been prepared setting out these sanitary measures and if farmers would only adhere to this advise then the disease could be prevented from spreading further.

The Chairman, Dr. Taye, commented that at Debre Zeit they were trying to tackle the disease problem from two new directions. They had collected wild relatives of enset and these would be tested for resistance. Secondly, it was invisaged that a team of breeders and agronomists and plant pathologiests would work together in trying to develop disease resistant or at least disease tolerant varieties of enset.

The next participant asked a whole series of questions; first, he wished to know on what basis they were trying to develop a standard processing procedure, Secondly, he wanted to know how the different processes in producing food affected the quality of the food. Thirdly, what factors affected the yield of enset.

Ato Teketel replied that there were no clear ideas as yet on how to standardize food processing. However, his survey had shown that the fermentation period in Kembata and Sidama was very long, from 50 to 90 days, whereas in Gurage the fermentation period is only 20 days. He had asked farmers in Kembatta why they do not use a faster method for fermentation and they had replied that their plants behave differently. Ato Teketel had, therefore, tried an experiment where both the Kembata fermentation method and the Gurage method were carried out adjacently. The results of this test were not yet available but it was planned to do similar tests in other regions. In the project proposed to be carried out at Debre Zeit, we were going to ask questions such as is it necessary to have a fermentation period to start with any way. The result of such tests would determine the direction of future work. This project will involve mechanical engineers to produce improved processing tools and a biochemist to study the nutritional quality of the food and a micro-biologist in order to assist in developing the food processing. It could well be possible to introduce a yeast into the food process and thus shorten the length of time needed to get the end product.

On the question relating to yield Ato Teketel said that the size of a plant depended on the amount of care it had been given and this determined the yield; whether it had been given manure, whether the soil was fertile, etc. Even at the same altitude yield varies greatly from one farm to another and is not determined by the processing procedure after harvesting.

A participant commented that he was impressed by the fact that about a quarter of a hectare of land could suport an average family and give a yield of 60 q/ha of food. He wanted to know what other factors were associated with enset production. Ato Teketel replied that enset appeared to be a very suitable crop where the amount of land for a family is severely limited and also where there were problems of soil erosion. Cultivating annual crops on highly sloping land with very friable soils only accentuates the problem of soil erosion. However, the cultivation of enset helps to stablise such soils. There are other advantages to enset cultivation, the by-product such as fibers can give

a quite good income. The fibre companies use enset fibre to make salt and seawater resistant ropes, bags and twine. Secondly, in areas where enset is grown no nails are used in building houses and fences. The dry leaves particularly the mid ribs are used to tie the frame of the house together and also in constructing fences. The major problem in enset was its nutritional inadequacy, it was very low in protein. If it was possible to provide protein fortifying crops, then many problems for enset growing areas could be overcome.

A participant commented that he had not been aware how difficult it was to process enset. He asked the speaker about the possibilities for diversification for enset growing areas. Ato Teketel replied that diversification was a difficult problem. Once a person's taste has been developed they are not ready to change their eating habits. However, a catastrophe might force them to do so but at present if the basic carbohydrate requirements for a family can be produced on a quarter of a hectare then one should look for possible crops to grow with enset to improve the diets of the people. This could best be done by under planting or intercropping. This will mean that the planting of enset will have to be systematized to leave enough space for the intercrop to grow. As enset is found in a wide range of localities, it will not be possible to just give one or two recommendations for intercropping. The farmers at Kembata have been given potato and haricot bean which have been grown fairly successfully. The enset project was considering developing varieties particularly those that are grown from seed which will mature in three to four years. In the first two years intercropping should be quite possible because the plants are small and will not over shade the intercrop. However, for the last two years this will be more difficult.

INVESTIGATIONS ON THE POTATO AS A POTENTIAL FOOD CROP IN ETHIOPIA

by

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The Potato (Solanum tuberosum) is the world's fourth most important' crop, after rice, wheat and maize (3). Although potato originated in the mountain regions of tropical South America, its main agricultural impact has been in temperate zone countries. The potato has made a trivial contribution as a basic food crop in tropical areas of the world. However, through selection and breeding of potato clones adapted to tropical latitudes, it is now possible to transfer potato culture to the tropics and subtropics such as Ethiopia where it is expected to add substantially and advantageously to food supplies.

In cooperation with the Institute of Agricultural Research and the International Potato Center, the College of Agriculture has recently launched a potato program. The major aim of the program is to organize and promote a strong potato research project in a more coordinated manner. It is felt that this effort should rapidly stimulate a viable potato agriculture in Ethiopia. At present, the potato program lacks sufficient funds and personnel who are needed to develop technology for Ethiopian conditions and transmit this information to the farmers. In view of these limitations, one of the current top priorities of the potato program is to develop good yielding varieties and organize an effective method for the production and distribution of certified seed of the improved varieties. This paper summarizes the potential of potato in Ethiopia, as well as the preliminary results of the selection and screening project carried in the College of Agriculture at Alemaya.

The Need for Potatoes In Ethiopia

Potato can give very significant nutritional and economic benefits to both rural and urban communities in Ethiopia. In terms of its nutritional potential, the potato ranks first among the 10 major food crops in calorie production per unit area and per day (5). As shown in Table 1, potato comes second only to soybean in the production of net utilizable protein per hectare (6).

TABLE 1. Protein yield of various crops per unit of land (from Kaldy, 1972).

Crops	Net utilizable Protein/ha in kg
Soybean	376.3
Potato	276.8
Maize	251.3
Beans	148.7
Peas	141.9
Wheat	118.5

The essential amino acids and the extent to which these may be supplied by potatoes is presented in Table 2. According to Burton (1,2) and Simmonds (1), not only is the total protein in potatoes higher than is usually thought, but it is also of reasonably good composition with respect to essential amino acids for human nutrition. The daily consumption of 800 grams of potato of average composition, supplemented with 75 grams of whole egg, would supply the whole average minimum daily requirement for protein (1). Such superior production of both calories and very balanced protein per unit area per day over the major cereals is frequently overlooked especially the developing countries of the world, such as Ethiopia.

In addition, a significant fact about the nutritional quality of potato is that it is also an excellent source of vitamin C and the vitamin B group. As shown in figure 1, a medium size fresh potato can provide almost one-third of the daily vitamin C requirement of an average adult (11). At a consumption level of 200 grams potatoes per day, the whole of the daily vitamin C requirement can be supplied by freshly harvested potatoes alone (1).

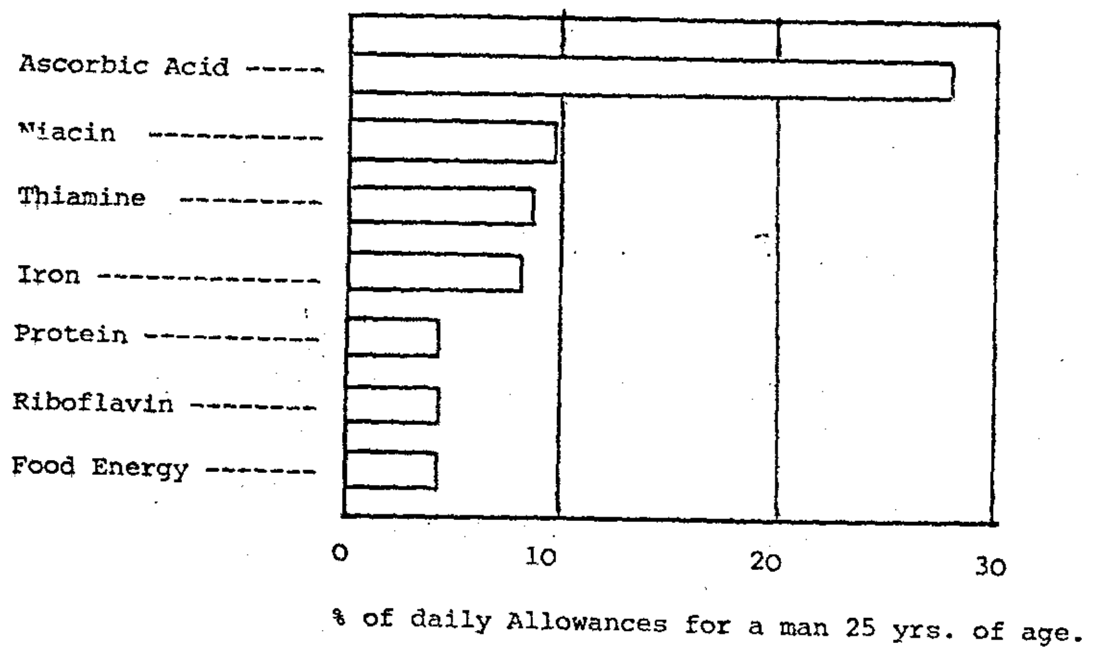
At present the vast majority of the population of Ethiopia depend on grain crops and the food potentials of the tuber crops such as potato have not been adequately exploited. Protein scarcity and insufficient calorie supplies are apparent nutritional problems in many parts of Ethiopia. It is not implied that the consumption of potatoes alone would close the protein and energy gaps, but it should help to improve appreciably the quality of the basic diet in rural areas of Ethiopia if a coordinated national effort is made in the promotion of potato production.

Potatoes are widely cultivated vegetable crops in Ethiopia. Most parts of Ethiopia have a very suitable climatic and edaphic conditions for quantity production of high quality potatoes. They are grown in home gardens and small truck patches in many areas in Ethiopia. People seem to like potato as a food in Ethiopia. They taste good alone and combine well with other foods. The consumption of potato in boiled form is common in the country side where it is grown. The culinary use of potato in making "wat" (our local spicy stew) is also note worthy.

TABLE 2. Requirements of essential amino acids and the extent to which these may be supplied by potatoes (from Burton, 1966)

Amino acid	Requirement of Average adult male (70kg). g/day to maintain N/balance	Average amount provided by 1kg raw potatoes (g)	Approx. average amount of potatoes necessary to provide daily requirement (kg).					
			boiled	mashed	baked in skin	roast	French fries	Chips
Tryptophane	0.28	0.32	0.9	0.9	0.6	0.5	0.4	0.3
Lysine	0.84	1.23	0.7	0.7	0.4	0.4	0.3	0.3
Leucine	0.95	1.33	0.7	0.7	0.5	0.4	0.3	0.3
Iso-Leucine	0.84	1.37	0.6	0.6	0.4	0.4	0.3	0.2
Methionine	0.45	0.32	1.4	1.4	0.9	0.8	0.6	0.5
Cystine	0.39	0.15	2.6	2.6	1.6	1.5	1.1	0.9
Phenylalanine	0.64	0.89	0.7	0.7	0.5	0.4	0.3	0.3
Tyrosine	0.46	0.76	C.6	0.6	0.4	0.4	0.3	0.2
Threonine	0.56	0.81	0.7	0.7	0.4	0.4	0.3	0.3
Valine	0.84	1.05	0.8	0.8	0.5	0.5	0.4	0.3

FIGURE 1. Nutritonal Contribution of One Medium Sized Potato to a Day's Diet (From Talburt & Smith, 1959)



Home made potato chips or fries (kesh kesh) and mashed potatoes are already popular in cities and rural areas of Ethiopia.

Potatoes also have a very considerable economic value in Ethiopia. An increase of potato production in Ethiopia during the last few years is due to both expanded domestic and export market. Potato has become one of the important alternative cash crops within about 100 km radius of the major cities in Ethiopia. It is also important to note that the value of potato exported to Djibouti market is one of the highest in Hareghe Province (7,9).

Production Problems

General observations indicate that in most of the major potato growing areas in Ethiopia the leading problems appear to be the lack of well adapted varieties, sufficient good quality seed potatoes, as well as adequate agronomic techniques. Diseases, especially blights, bacterial wilt, and other tuber rots seem to contribute to the reduction of yield of potatoes. Adequate storage and marketing facilities are also equally important factors that need to be solved in order to expand potato culture in Ethiopia.

Materials and Methods

The potato adaptation and screening project being carried out at the College of Agriculture, Alemaya, has indicated that there is a wide variation in the seedling introductions from the International Potato Center, as well as in the local and introduced cultivars as far as yielding capacities and disease resistance are concerned (8).

As part of this project, seedling introductions representing Andigenum-Tuberosum, Andigenum-Andigenum were obtained in a form of true botanical seeds in October 1973 from the International Potato Center. Additional seedlings of Tuberosum-Phureja crosses were also obtained from the Potato Introduction Station at Sturgeon Bay in August 1973. A total of 3075 seedlings were planted as first year seedlings. These included 840 seedlings representing Andigenum-Tubersum crosses, 1448 seedlings representing Andigenum-Andigenum crosses, and 787 seedlings representing Phureja-Tuberosum crosses. This program is in its third cycle of selection.

In addition, over 120 clonal and varietal introductions were made from various reliable sources and were evaluated under our conditions for the purposes of screening out some varieties with certain desirable traits. Local varieties were also included in the selection program to serve as reference materials for yield and other horticultural characterstics.

Preliminary Results & Discussion

In the Andigenum-Tuberosum, Andigenum-Andigenum, and Phureja-Tuberosum segregating populations, no specific yield data has been recorded. However, there were a number of very promising clones identified on the basis of (1) vine vigor, (2) uniformity of tuber and vegetative growth, (3) tuber shape and color, (4) set capacity, (5) maturity, and (6) disease reactions.

Among the varietal and clonal introductions, preliminary yield assessments have been done on 20-hill plots for the USDA and Mexican materials. The Tuber yields per 20 hills for the advanced selections from USDA are presented in Table 3. Some of these clones had not only very satisfactory tuber yields, but also appeared to have good tuber and vine characteristics.

TABLE 3. Tuber yields of advanced selections from USDA

Pedigree No.	Yield in kg/20 hill
B-5704	26.0
B-4972	20.0
B-6334	24.0
B-6402	34.0
B-5502	26.0
B-5505	28.0
B-6401	22.0
B-6403	32.0
B-5570	18.0
B-6332	24.0
B-5634	30.0

The original Mexican clonal and varietal introductions included 23 new clones, 15 Mexican varieties, and 20 Dutch varieties. As a result of the initial screenings in 5-hill and 10-hill plots, these were trimmed down to 10 new clones, 8 Mexican varieties, and 7 Dutch varieties. The yields per 20-hill and other information for these materials is presented in Table 4. It can be seen from this table that some of the clones are very promising in terms of yield and tuber characterstics.

TABLE 4. Yield and Tuber Characterstics of Mexican Introductions.

Entry No.	Pedigree No.	Skin Color[1/]	Shape	Eye[2/]	Yield in kg/20 hill
1.	CCU-69-1	W	Round	S.E.	21.2
2.	BJB-69-1	W	Round	S.E.	18.8
3.	BMJ-69-1	W	Round oval	S.E.	18.9
4.	ARX-69-1	W	Oval	S.E.	14.0
5.	AEN-69-1	W	Oval	S.E.	24.6
6.	ATK-69-1	Y	Flat	S.E.	24.4
7.	CGN-69-1	R	Round-knobby	D.E.	23.0
8.	CFR-69-1	W	Long flat	S.E.	21.6
9.	CFC-69-1	W	Round	S.E.	23.0
10.	CFN-69-1	W	Round	S.E.-D.E.	15.2
11.	ANITA	Y	Round	S.E.	21.6
12.	FLORITA	W	Round	S.E.	24.3
13.	GABRIELA	W	Round oval	S.E.	19.0
14.	GRETA	W	Round	S.E.	20.4
15.	HILDA	W	Long oval	S.E.	22.0
16.	JUANITA	R	Round	S.E.	13.2
17.	MONTSAMA	W	Round	S.E.	12.8
18.	ROSITA	W	Round	S.E.	16.2
19.	ALPHA	Y	Flat	S.E.	23.4
20.	PATRONES	W	Long oval	S.E.	19.2
21.	SPUNTA	W	Long	S.E.	21.0
22.	CARDINAL	Y	Long	S.E.	18.8
23.	RECTOR	W	Long oval	S.E.	17.5
24.	JAERLA	W	Round	S.E.	14.0
25.	EBA	W	Round	S.E.	15.2

1/ W = White
Y = Yellow
R = Red

2/ S.E. = Shallow-eye
D.E. = Deep-eye

The initial effort of the screening program has established the possibilities that local tuber yields can be significantly increased. Our projected yield target is to develop a variety with a capacity to give a marketable tuber yield of at least 1 kg per plant under normal conditions. The accomplishment of this target should enable the potato grower to obtain a yield of well over 40 tons per hectare. This is very significant. The estimated yield of potato in Ethiopia is a little over 5 tons per hectare (4). A close examination of the preliminary yield figures in Tables 2 and 3 shows that it is possible to develop potato varieties with a yielding capacity of atleast 1 kg per plant, indicating that local yields of potato can be more than trippled in the very near future.

The foregoing considerations indicate that potato has a very promising potential as a food, as well as an economic crop in Ethiopia. It seems justifiable, therefore, to put a coordinated national effort into exploiting the food and economic potential of this important crop.

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DISCUSSION

The Chairman thanked Dr. Haile Michael for his paper on this important crop.

It was commented that the nutritional value of crops varies between varieties and the questioner wanted to ask Dr. Haile Michael if the figures that he had given for the potato were average values or based on that of a particular variety. The speaker replied that the figures given were averages for potatoes as a whole, e.g. protein content of most varieties varies between 4 & 8%, however some exceptional varieties have been developed at the International Potato Center which have a protein composition as high as 25% on a dry weight basis.

A participant wished Dr. Haile Mickael luck in combating peoples preferences over food. He felt that it had been rather taken for granted that it was easy to change people's tastes in no time. Experiences from CADU had shown this is not quite so easy. They had started a potato programme and apart from preference problems the major difficulty in the programme had been storage. He had seen some storage facilities at Alemaya College which were far to sophisticated for the average Ethiopian farmer. He asked the speaker what plans had been made for tackling this storage problem. Dr. Haile Mickael replied that he had not intended to paint a rosy picture for potato, in fact, this crop has probably more problems than most crops. However if the potato research programme was able to overcome the problems of pests and diseases and is able to produce a clone which is early, high yielding and disease resistant this will have to be followed by a programme which will produce certified seed. He was also well aware that one of the major limiting factors for potato introduction in developing countries, particularly those in tropics, had been storage difficulties. It was therefore intended to investigate this problem very thoroughly. However, if it is possible to produce a potato clone which will yield in 40 to 60 days, this would still be valuable even without storage. As the potato programme develops, the other critical areas in potato production will be subject to investigation.

A participant pointed out to the seminar that Dr. Haile Michael was Chairman of the root crop committee of the national crop improvement committee. The root crop committee was responsible for root crops as a whole which included, apart from potato, sweet potato, yams, Taro (Colocasia) and others. He asked Dr. Haile Michael for the priorities which were to be given to root crops, especially the position for the dry areas which are famine prone, where a temperate crop like potato does not have as much potential as sweet potato. Dr. Haile Mickael replied that it was true that the root crop committee was not only

interested in potato; other root crops such as sweet potato, yams, enset were also important. However, the whole research programme was severely constrained by a shortage of personnel. The allocation of research encompasses all important root crops, but particular emphasis was being given to potato at this time because of its potential. At the same time germ plasms collections are being built up for sweet potato, yams, taroes etc. and these will be investigated when personnel become available. At present the responsibility for sweet potato had been given to Nazareth Research Station and that for Taro and yams to Jimma. Thus although the paper had emphasized the importance of potato work for Ethiopia, it was not intended to disregard the importance of the other root crops.

WATER REQUIREMENTS OF CROPS IN THE MIDDLE AWASH

by

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The question of when to irrigate a crop, how much water to apply and when to stop irrigation are difficult questions that confront farmers or farm managers in irrigation schemes such as in the Awash Valley. These questions become doubly difficult for farmers in the Middle, Upper and Lower Valley and other parts of the country due to the lack of adequate information on the water requirements of their crops.

The natural tendency of farmers and farm managers is to give as much water as possible. Frequent water application in excess quantities if carried out long enough will result in the loss of nutrients due to excess leaching and in the untimely rise of the water table to a level where it will become impossible to grow crops without the installation of expensive drainage schemes. The installation of drainage pipes may become so expensive that a farmer or farm manager may have to abandon his farm for lack of capital. In the Awash Valley no one apparently has any idea to what extent the build up of the water table is taking place. In summary, this is a warning that farmers must not give excess water because this leads to:

1. substantial rises in the water table and increased salinity hazard;
2. loss of nutrients:
3. wastage of water which may have implications for farmers farther down stream;
4. excessive fuel and other pumping costs if the water has to be pumped; and
5. lower yields if water excess is in the extreme - this may result in the prolongation of the maturity period, excess lodging, loss of quality, etc.

However farmers must not subject their crops, unless economically justified to excessive water stress, because the yield per unit area of most crops is reduced. The degree of reduction depends on the length of time the crop is under water stress; the stage of crop growth when the water stress occured and the evaporative demand of the environment during the period of water shortage.

Too shallow water applications should be avoided because:

a) the development of the full rooting potential of the plants will be inhibited leading to plants too weak to support themselves;

b) the efficiency of the plants to absorp moisture and nutrient is reduced because of the reduced number of roots;

c) in the longterm it may lead to the accumulation of salts within the root zone which will impair the growth of the crop.

Thus, as much as is practically possible, a farmer must apply water in the right amount and at the right time which is consistant with maximising the profit from his crop. In situations where water is a limiting factor the farmer will be faced with additional questions how of much area of land should be cropped with a limited water supply or limited pumping capacity to maximize profit in accordance with good irrigation practices mentioned above.

Another important question is what crops to grow in a crop rotation system. Some crops are very sensitive to the slightest water stress, while others are more tolerant and yield drops gently as water supply is limited. Some crops require much more water than others.

To summarize the problems for which answers are needed for farm managers are:

1. When to irrigate a crop?
2. When to stop irrigation?
3. How much water to apply?
4. Given a fixed pumping capacity or a fixed water supply how much area of land should be cultivated to maximize profit, consistent with good irrigation management practices?
5. In a crop protection scheme what is the best combination of crops that will result in the best use of the limited water supply keeping in mind the economic consideration of maximizing profits and good irrigation management practices?

Trials were conducted at Melka Werer Research Station to find answers or guidlines to the above list of questions. The results of these trials are summarised in the attached graphs. Primarily these trials attempted to answer the questions of when to irrigate and how much water should be given. The intervals for irrigation are given in weeks and the amount of water in centimetres, i.e. 7.5, 10, 12.5 or 15 cm per irrigation. These trials were carried out for the most important crops in the Melka Werer area; cotton, maize, groundnuts, alfalfa, sesame and haricot bean.

Materials and Methods

Varying intervals of irrigation and varying watering duties were layed out in split-plot or randomized block designs; in some cases in combination with other factors such as sowing date. Plot layout was such that lateral seepage and leakage were minimized. The water going into each plot was measured using Parshall flumes or rated syphons located near the plots.

For each crop, measurements of the relevant growth parameters were taken. In addition soil samples were taken before and after every irrigation from selected treatment combinations and analysed for moisture content. These analyses were made to get an estimate of the rate of water use, the depth of wetting and zone of soil water depletion. The results from these analyses are not reported here.

The trials sites were changed from year to year in line with the crop rotation scheme worked out for the Station.

Definitions of terminology used

The 'maximum water requirement' (WRmax) for any of the crops studied has been assumed to be the amount of water associated with the maximum yield obtained. The water requirement (WR) values associated with each treatment were then divided by the maximum water requirement $\left(\frac{WR}{WR\ max}\right)$. Similarly the yield values (Y) were divided by the maximum yield (Ymax)$\left(\frac{Y}{Ymax}\right)$. The pair of values thus obtained were plotted on a graph and the resulting curves are called 'crop water production functions'. (See Tables 2.1 - 2.15 and Figures 1 to 8).

The 'water requirement (WR)' is used here to mean the amount of water applied by irrigatinn during the growing season of the crop in a situation where the application efficiency is nearly 100% plus the effective seasonal rainfall.

The application efficiency in these trials was nearly 100% because:

a) the conveyance losses were negligible due to the proximity of the measuring device to the plots;

b) no runoff occured; and

c) the distribution of the water was uniform due to the small size of the plots and the uniformity of the slope.

However deep percolation may have occured in the heavier watering duty treatments.

The 'effective rainfall' is assumed to be 70% of the total rainfall that fell during the growing season.

'Seasonal irrigation requirement' is the amount of water applied by irrigation where the application efficiency is 100%.

The 'pumping or diversion requirement' is the amount of water that must be diverted or pumped to meet the irrigation requirement of the crop or crops.

The various terms are related as follows:

$$SIR = SWR - R, \text{ where:}$$

SIR = Seasonal irrigation requirement of a crop;
SWR = Seasonal water requirement of a crop;
R = Effective seasonal rainfall.

$$PR = \frac{SIR}{E}, \text{ where:}$$

PR = Pumping requirement;

E = overall irrigation efficiency

Results and Discussion

Crop water production functions have been developed for cotton, groundnuts, maize, haricot bean, sesame and alfalfa (Figure 1 to 8). Regression equations could have been applied to this data but the author had to leave for further studies and did not have time make the calculations. However the data from which the crop production functions were calculated are given in Table 2.1 to 2.15 so that anyone interested can also calculate the regression equations. Detailed comments for each of the experiments can be found in the Melka Werer Progress Reports 1973/74 and 1974/75.

The overall results from the trials has been summarised in Table 1. It is hoped that if a farmer or farm manager is equiped with curves such as those given in figures 1 to 8, he can use them to make certain management decisions, such as, given a fixed pumping capacity or a fixed quantity of water, how much area of land should be cropped and which crops would be the best to maximize his returns consistent with good irrigation management practices. Such graphs could help him derive a table such as is given in Table 1. Hence the final part of this paper is limited to a discussion of Table 1. This table contains the general recommendations for the crops which are currently thought to be of economic value in the Middle Awash. For each crop the seasonal irrigation requirement, frequency of irrigation, the rate of water application and the total number of irrigations are given. The last column gives the total amount of water required if the pumping or diversion requirement gives only 70% of the overall irrigation efficiency required.

Some crops require a lot of water in order to give their best yield. Under Melka Werer conditions, cotton sown at the beginning of May and established alfalfa require over 100 cm of water; alfalfa requires 233.0 cm annually to give 80-90% maximum yield. On the other hand cotton sown in June and July, groundnuts haricot bean and sesame require less than 100 cm of water. If by some mis-chance a farmer chooses a group of crops with high water requirements he may have considerable difficulty in fulfilling their requirements for the season. Thus by consulting such a table as table 1 he can arrive at a reasonable selection of crops in accordance with his water supply so that he can run his farm economically and in accordance with good irrigation management practices.

Following are some brief comments on the concept of the fixed interval approach in irrigation management. It is well known that the water requirement of a plant is never constant but changes with time and the evaporative demand of the environment. As the crop grows it needs more and more water until maturity. As the evaporative demand increases the plant also transpires more water. This suggests that a fixed interval for irrigation and a fixed watering duty do not fit with the changing needs of the plant. This is true. However, the simplicity of the system coupled with some flexibility on the part of the farm manager in adopting this system makes it a very useful and easy one to apply in practice. However an astute farm manager or farmer can make the following adjustments to a set irrigation interval and watering duty regime.

Early part of the season:

Generally longer intervals between irrigations may be followed in the early part of the season (0-35 days) for cotton and groundnuts; for haricot bean shorter irrigation intervals are recommended.

Middle part of the season:

Cotton sown in May should be irrigated more frequently than that suggested in the table from peak flowering to boll opening as this is when the plant has its highest water demand.

Soil type:

More frequent irrigations should be given on sandy and silty soils than in silty clay types.

Climate:

In years of low July - August rainfall, July sown cotton should be irrigated every three weeks.

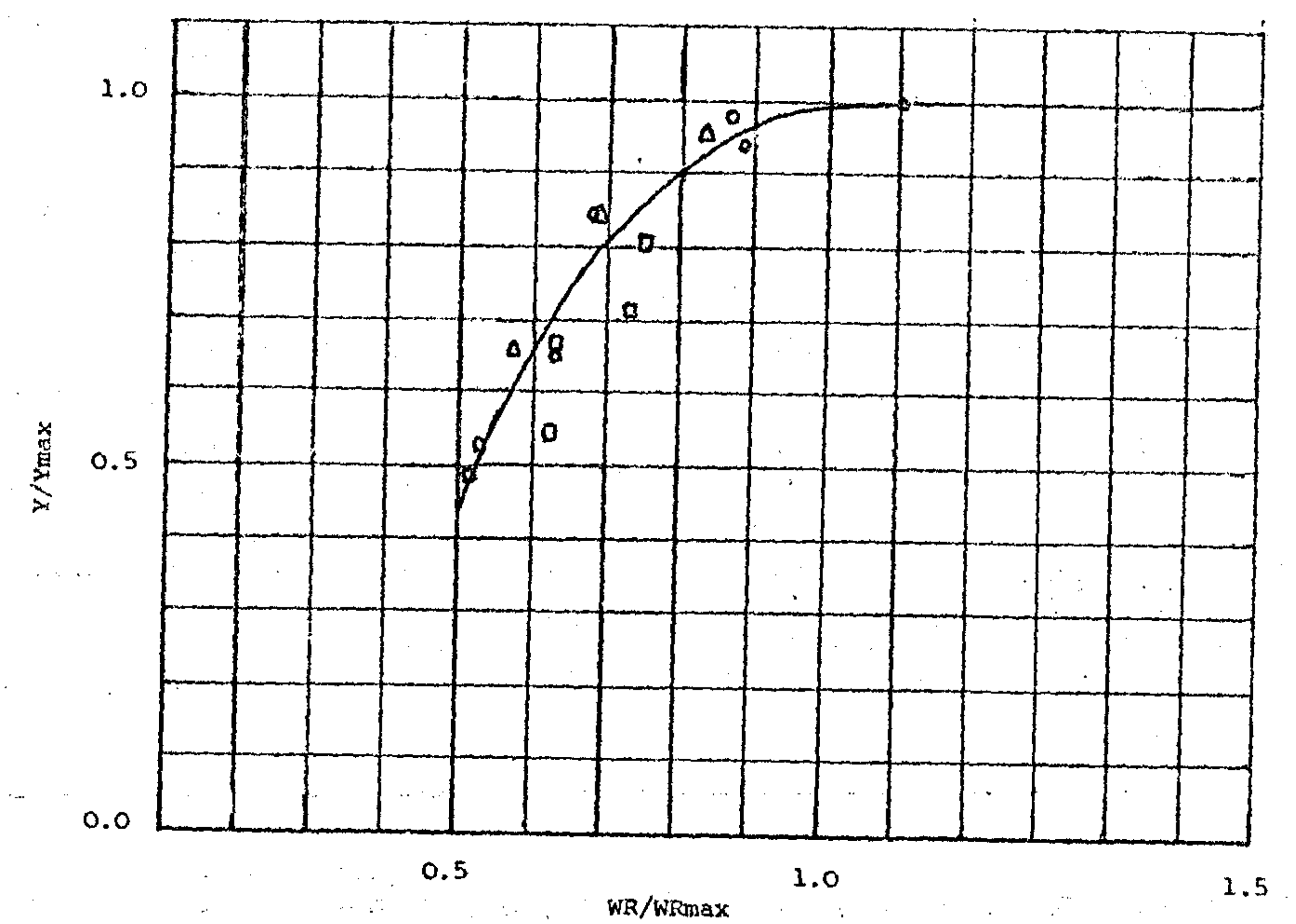
Saline soil: More frequent irrigations are needed in order to leach the salts below the root zone.

Adaptations to other parts of the Valley: More frequent irrigations should be given in the Lower Valley and less frequent in the Upper Valley.

TABLE 1. Irrigation Requirement of Various Crops in the Middle Awash Valley for Yield Expectations 80 - 90% of the Maximum

Crop	Variety	Sowing date	Recommended frequency of irrigation (weeks)	Rate of Water application (cm irrigation)	Total No. of irrig- ation	(SIR) Total Seasonal irrigation requirement (cm)	(SWR) Total seasonal water requirement (cm)	(PR) Pumping or diversion requirement at 0.7 over-all irrigation efficiency(cm)
Cotton	AMS1(70/74)	May 1	3	12.5	7	87.5	112.3	125.0
Cotton	AMS1(70/74)	June 1	3	7.5	7	52.5	84.3	75.0
Cotton	AMS1(70/74)	July 1	4	7.5	6	45.0	73.0	64.3
Groundnuts	NC2 or Viginia bunch	early June	4	12.5	5	62.5	84.3	89.3
Maize (grain)	Regular White. 170	early Nov.	2	12.5	8	100.0	100.0	142.9
Harricot bean	Mexican 142	late Oct.	2	10	7	70.0	70.0	100.0
Sesame	T - 85	late January	3	10	5	50.0	60.0	71.4
Established Alfalfa	Hairy Peruvian	Oct.-Nov.	4	15	13	195.0	233.0	278.6(annually)

FIGURE 1. Crop Water Production Function of Cotton sown on May 1, 1973 and 1974

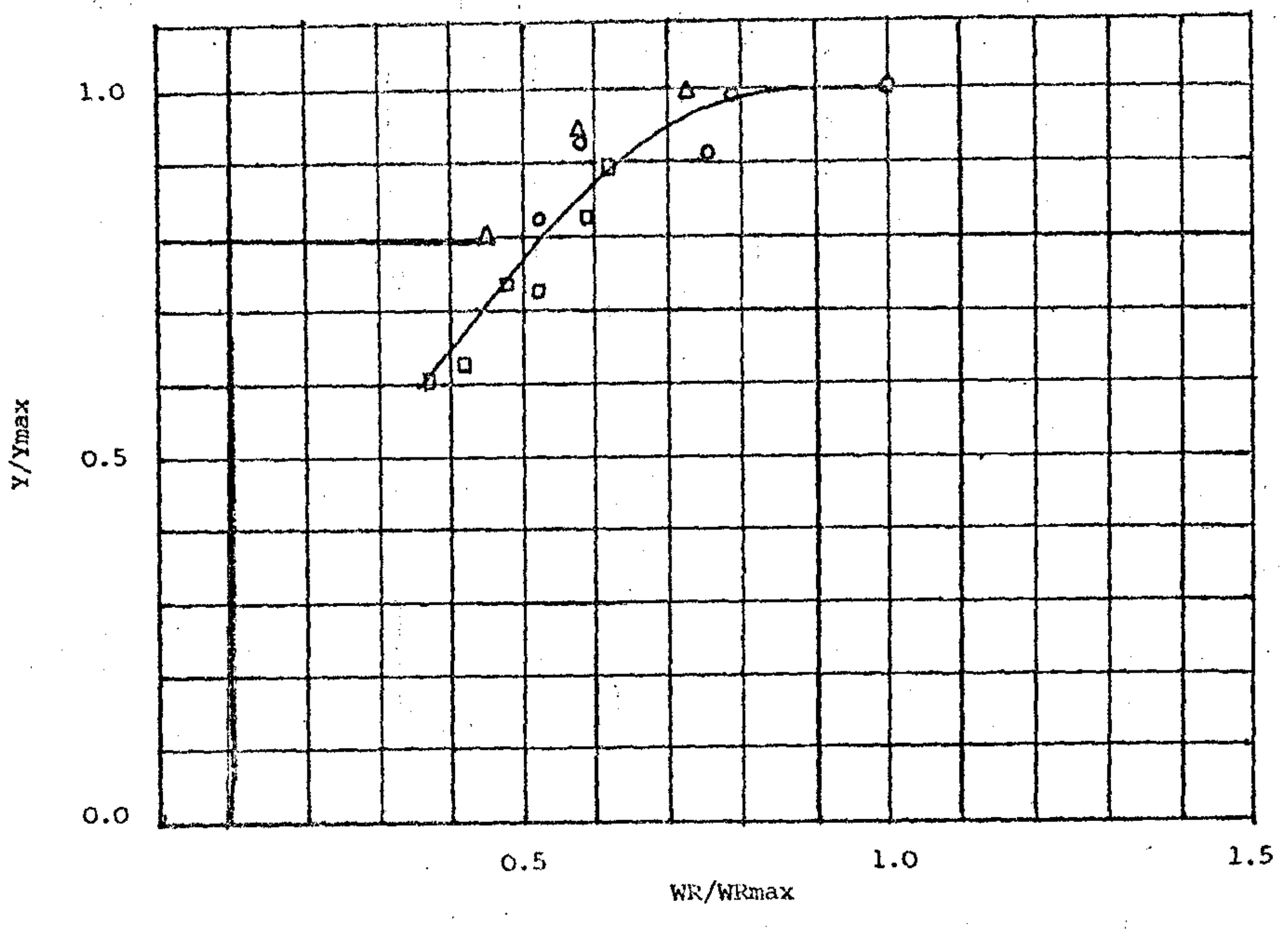


1973
Ymax = 77.7 Q/Ha (Seed Cotton)
WRmax = 1706 mm
Effective rainfall = 256 mm

1974
Ymax = 61.1 Q/Ha
WRmax = 1898 mm
Effective rainfall = 248 mm

o = Irrigated every 2 weeks
Δ = " " 3 "
□ = " " 4 "

FIGURE 2. Crop Water Production Function of Cotton Sowing on June 1, 1973 and 1974

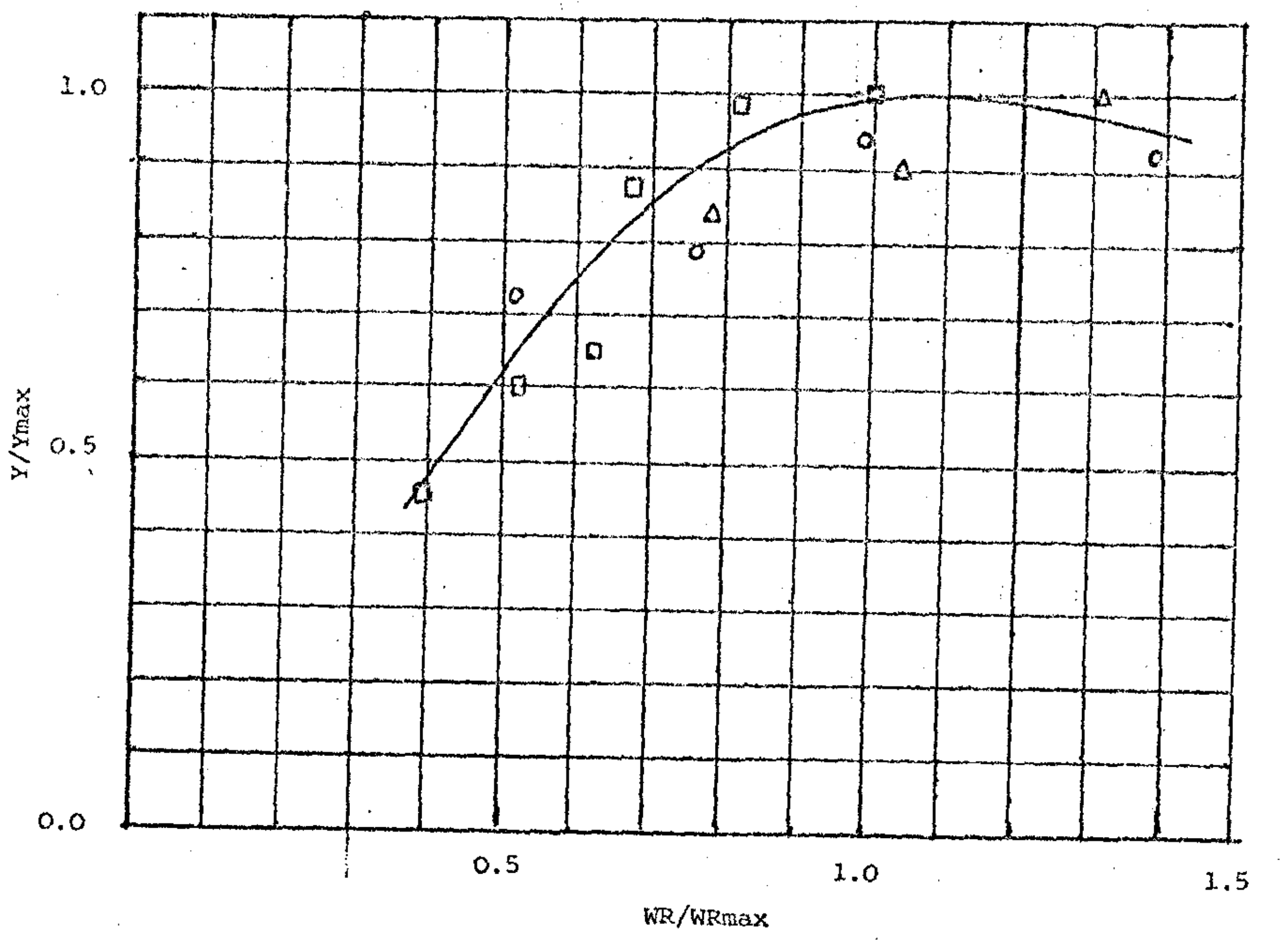


1973
Ymax = 62.7 Q/Ha (seed cotton)
WRmax = 1836 mm
Effective rainfall = 236 mm

1974
Ymax = 53.8 Q/Ha (Seed Cotton)
WRmax = 1868 mm
Effective rainfall = 218 mm

o = Irrigated every 2 weeks
Δ = " " 3 "
□ = " " 4 "

FIGURE 3. Crop Water Production Function of Cotton Sown on July 1, 1973 and 1974

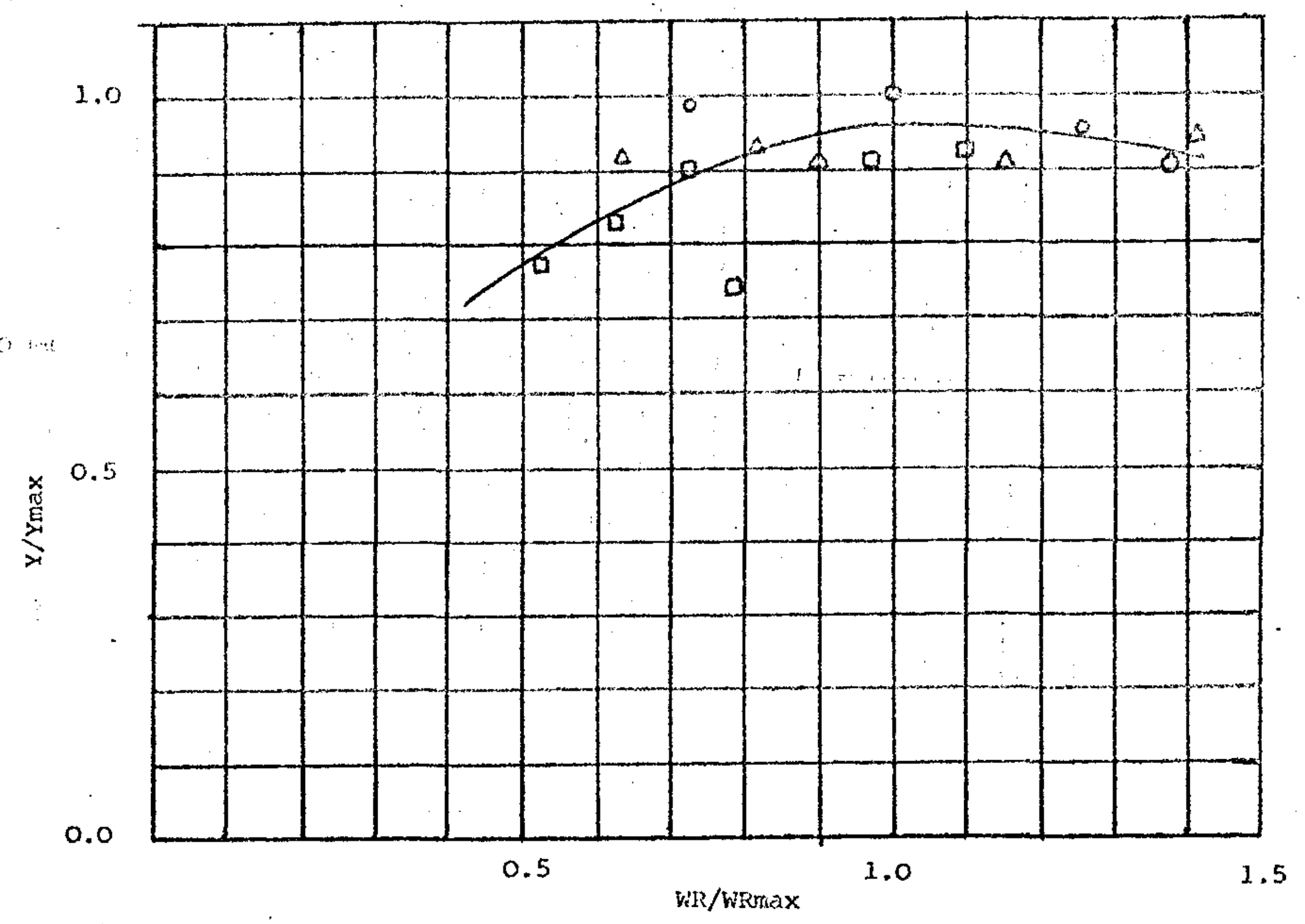


1973
Ymax = 45.2 Q/Ha (seed cotton)
WRmax = 1677 mm
Effective rainfall = 227 mm

1974
Ymax = 392 Q/Ha (seed cotton)
WRmax = 1130 mm
Effective Rainfall = 180 mm

o = Irrigated every 2 weeks
Δ = " " 3 "
□ = " " 4 "

FIGURE 4. Crop Water Production Function of Groundnuts 1973 and 1974

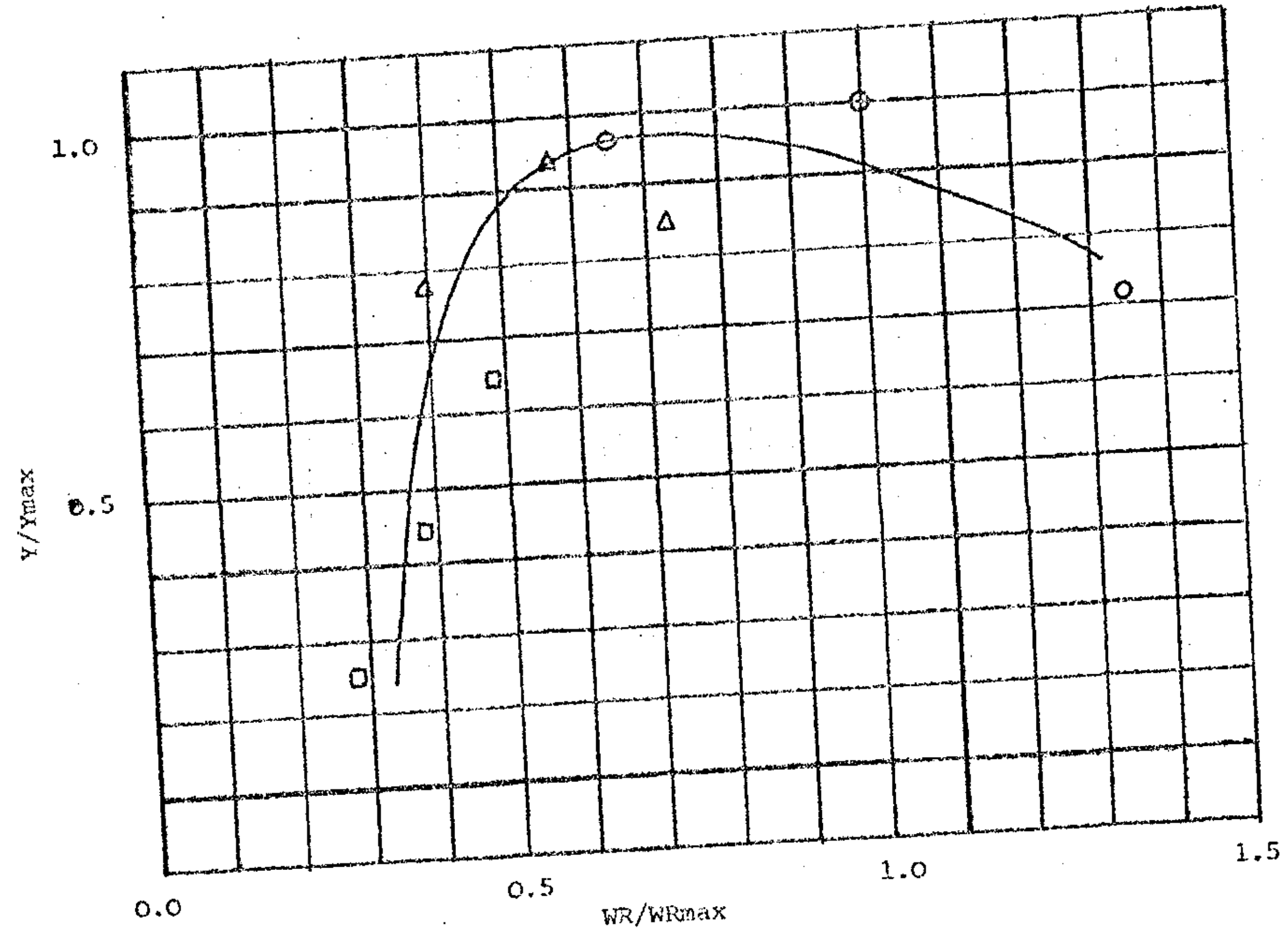


1973
Ymax = 40 Q/Ha (kernel)
WRmax = 954 mm
Effective rainfall = 244 mm

1974
Ymax = 45.8 Q/Ha (kernel)
WRmax 1343 mm
Effective rainfall = 218 mm

o = Irrigated every 2 weeks
Δ = " " 3 "
□ = " " 4 "

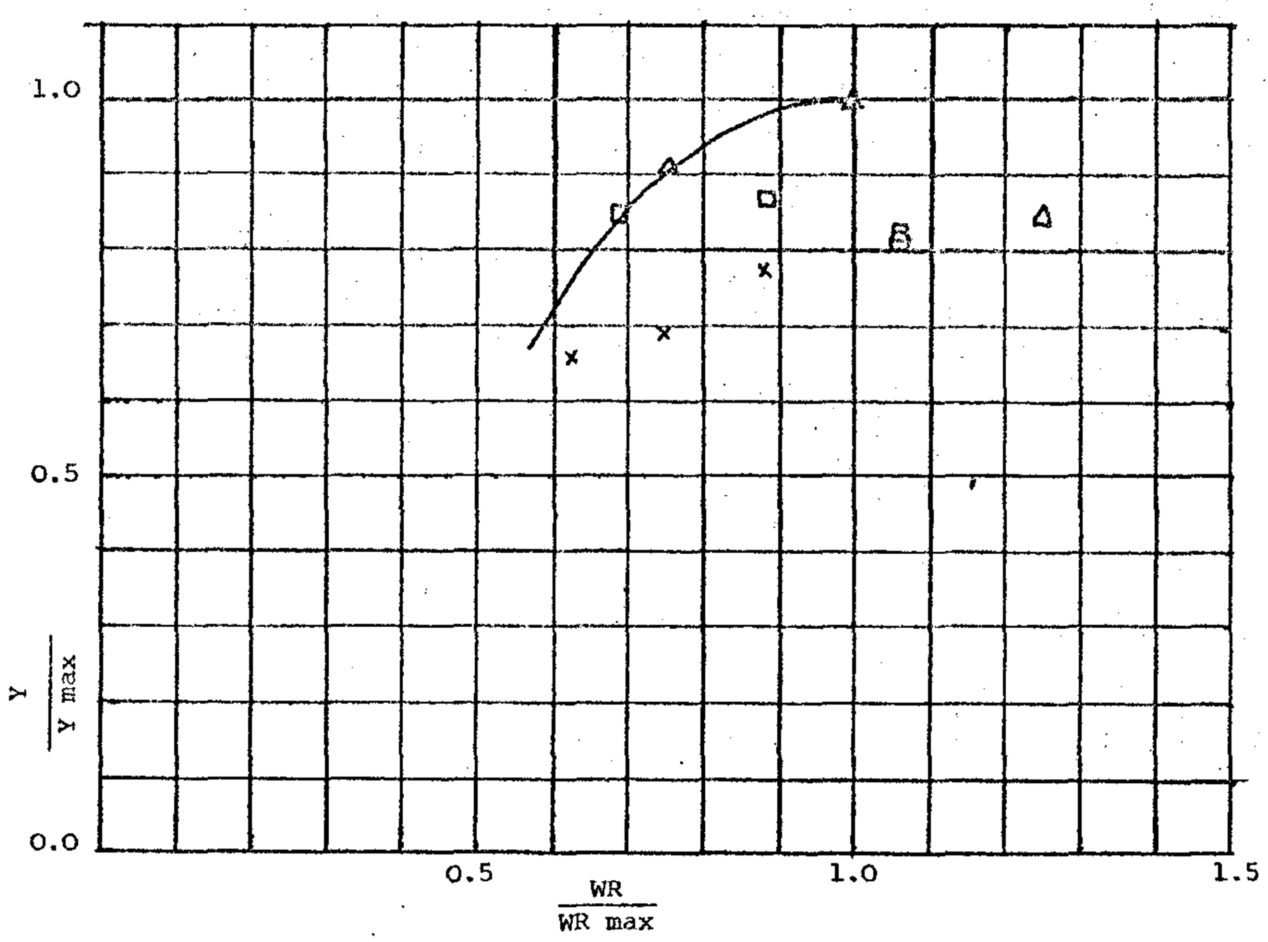
FIGURE 5. Crop Water production Function of grain maize sown on November 8, 1973



Ymax = 72.2 Q/ha
WRmax = 2050 mm
Effective seasonal rainfall = 0.0 mm

o = Irrigated every 1 week
Δ = " " 2 weeks
□ = " " 3 weeks

FIGURE 6. Crop Water Production Function of Sesame (Variety T.85) on January 25, 1974. MWRS

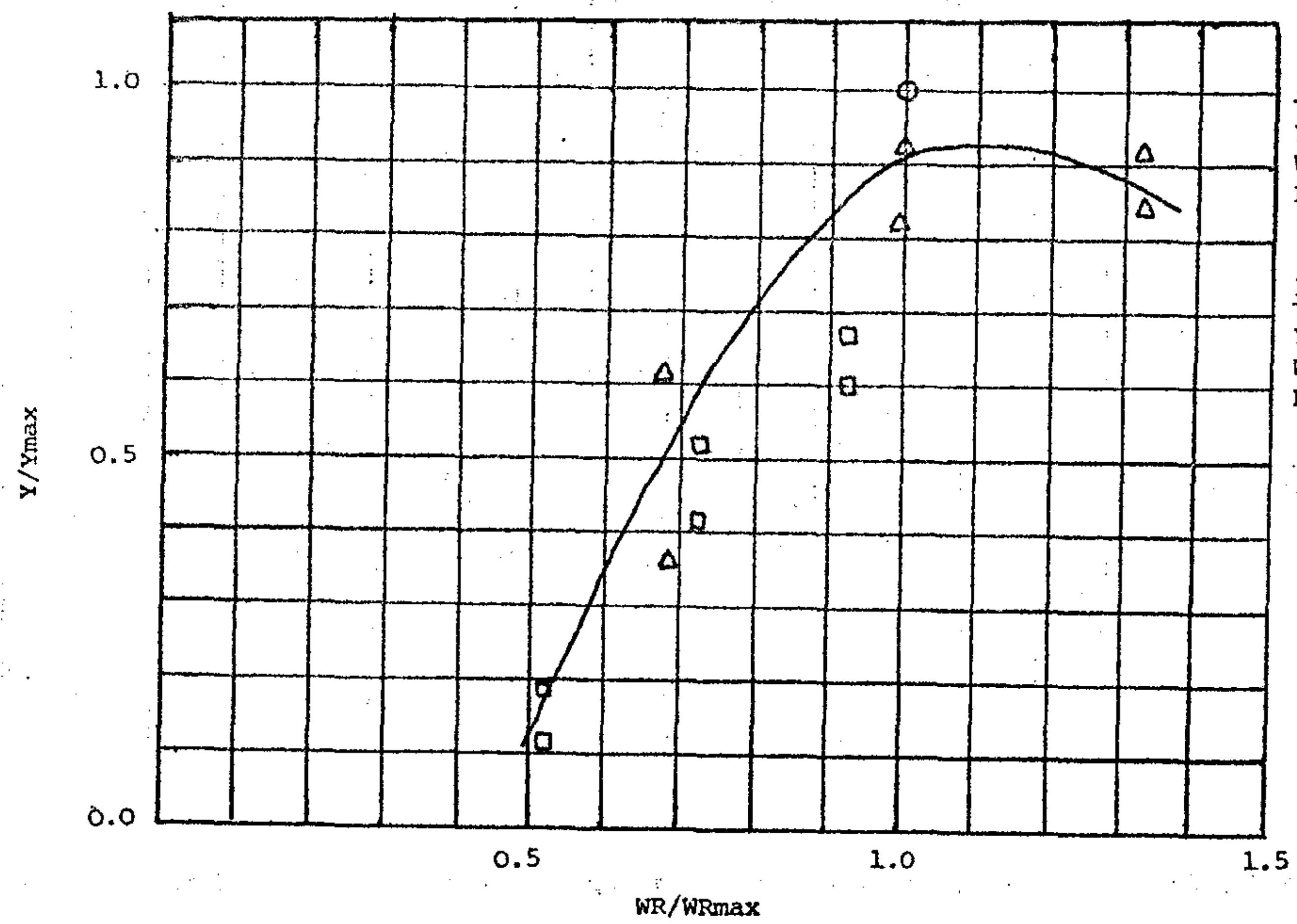


Ymax = 14.1 Q/Ha
WRmax = 798 mm
Effective rainfall = 98 mm

o = Irrigation every 1 week
Δ = " " 2 weeks
□ = " " 3 "
x = " " 4 "

NB: T.85
water stress tolerant
May be grown by rain

FIGURE 7. Crop Water Production Function of Haricot Beans (Var. Mexican 142) sown on the last week of October

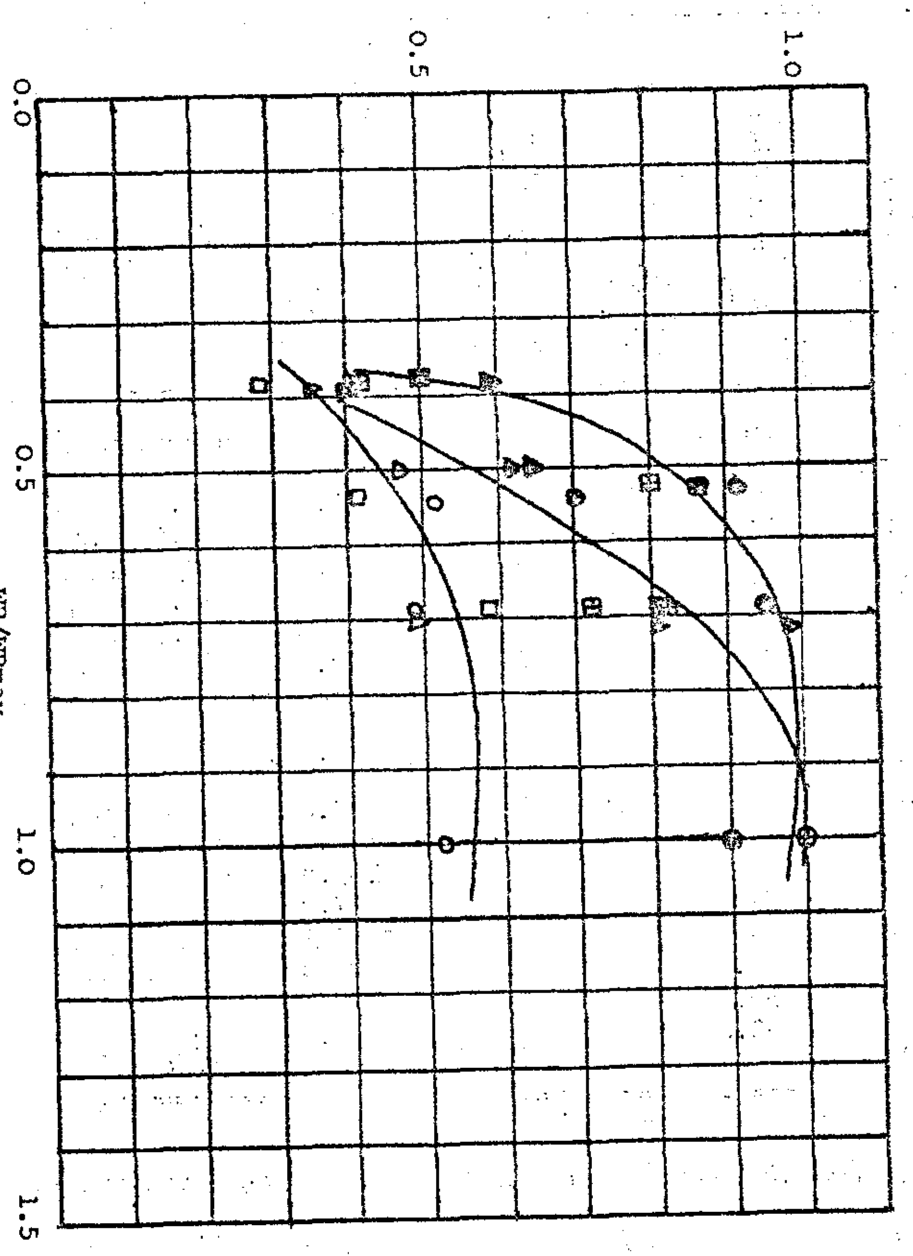


1973
Ymax 35.0 Q/ha
WRmax 750 mm
Effective Rainfall 0.0 mm

1974
Ymax 38.0 Q/ha
WRmax 750 mm
Effective Rainfall 0.0 mm

o = Irrigated every 1 week
Δ = " " 2 week
□ = " " 3 "

FIGURE 8. Crop Water Production Function of Alfalfa for cutting frequencies of every 21, 28 and 35 days (sown on March 6, 1973)



Cut every 21 days
○ - Irrigated 2 weeks
△ - " 3 "
□ - " 4 "

Cut every 28 days
● - Irrigated 2 weeks
▲ - " 3 "
■ - " 4 "

Cut every 35 days
◐ - Irrigated 2 weeks
▶ - " 3 "
▩ - " 4 "

March 1974 to March 1975 (Second year after planting)

Ymax = 33.4 ton/ha/year
WRmax = 4180 mm
Effective Rainfall = 280 mm

TABLE 2. Yield responses to different irrigation management situations

Irrigation Interval (weeks)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal amount of water received by (crop) (WR) (cm)	Yield (Y)	WR / WR max	Y / Y max
2.1 Cotton: Variety AMS 170; sown 1 May, 1973; yield in seed cotton q/ha									
2	5	8	40	25.6	25	90.6	49.6	.53	0.64
2	10	8	80	25.6	25	130.6	75.3	0.76	0.97
2	15	8	120	25.6	25	170.6	77.7	1.00	1.00
4	5	4	20	25.6	25	70.6	38.2	0.41	0.49
4	10	4	40	25.6	25	90.6	51.5	0.53	0.66
4	15	4	60	25.6	25	110.6	61.8	0.65	0.80
2.2 Cotton: Variety AMS 170; sown 1 May, 1974; yield in seed cotton q/ha									
2	7.5	8	60.0	24.8	25	109.8	52.2	0.58	0.85
2	12.5	8	100.0	"	"	149.8	57.7	0.79	0.94
2	17.5	8	140.0	"	"	189.8	61.1	1.00	1.00
3	7.5	5	37.5	"	"	87.3	38.8	0.46	0.64
3	12.5	5	62.5	"	"	112.3	52.0	0.59	0.85
3	17.5	5	87.5	"	"	137.3	58.2	0.72	0.95
4	7.5	4	30.0		"	79.8	31.3	0.42	0.51
4	12.5	4	50.0	"	"	99.8	33.9	0.53	0.55
4	17.5	4	70.0	"	"	119.8	44.0	0.63	0.72
2.3 Cotton: Variety AMS 170; sown 1 June, 1973; yield in seed cottonqq/ha									
2	5	9	45	23.6	25	93.6	51.8	0.51	0.83
2	10	9	90	23.6	25	138.6	56.9	0.75	0.91
2	15	9	135	23.6	25	183.6	62.7	1.00	1.00
4	5	4	20	23.6	25	68.6	37.9	0.37	0.60
4	10	4	40	23.6	25	88.6	47.3	0.48	0.75
4	15	4	60	23.6	25	108.6	52.1	0.59	0.83

TABLE 2. (Continued))

2.4 Cotton: Variety AMS 170; sown 1 June, 1974; yield in seed cotton q/ha

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water received by (crop) (WR) (cm)	Yield Y	WR / WR max	Y / Y max
2	7.5	8	60.0	21.8	25	106.8	49.8	0.57	0.93
2	12.5	8	100.0	"	"	146.8	53.0	0.79	0.98
2	17.5	8	140.0	"	"	186.8	53.8	1.00	1.00
3	7.5	5	37.5	"	"	84.3	43.3	0.45	0.80
3	12.5	5	62.5	"	"	109.3	50.4	0.58	0.94
3	17.5	5	87.5	"	"	134.3	53.4	0.72	0.99
4	7.5	4	30.0	"	"	76.8	33.2	0.41	0.62
4	12.5	4	50.0	"	"	96.8	39.4	0.52	0.73
4	17.5	4	70.0	"	"	116.8	47.9	0.62	0.89

2.5 Cotton: Variety AMS 170; sown 1 July, 1973; yield in seed cotton q/ha

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water received by (crop) (WR) (cm)	Yield Y	WR / WR max	Y / Y max
2	5	8	40	22.7	25	87.7	32.4	0.52	0.72
2	10	8	80	"	"	127.7	39.7	0.76	0.88
2	15	8	120	"	"	167.7	45.2	1.00	1.00
4	5	4	20	"	"	67.7	21.8	0.40	0.48
4	10	4	40	"	"	87.7	27.0	0.52	0.60
4	15	4	60	"	"	107.7	29.6	0.64	0.65

2.6 Cotton: Variety AMS 170; sown 1 July, 1974; yield in seed cotton q/ha

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water received by (crop) (WR) (cm)	Yield Y	WR / WR max	Y / Y max
2	7.5	9	67.5	18.0	25	110.5	36.7	0.98	0.94
2	12.5	9	112.5	"	"	115.5	36.5	1.38	0.93
2	17.5	9	157.5	"	"	200.5	36.3	1.77	0.93
3	7.5	6	45.0	"	"	88.0	32.8	0.78	0.84
3	12.5	6	75.0	"	"	118.0	35.1	1.04	0.90
3	17.5	6	105.0	"	"	148.0	39.1	1.31	1.00
4	7.5	4	30.0	"	"	73.0	33.7	0.65	0.86
4	12.5	4	50.0	"	"	93.0	38.0	0.82	0.97
4	17.5	4	70.0	"	"	113.0	39.2	1.00	1.00

TABLE 2. (Continued)

2.7 Groundnuts: Variety NC2; sown 19 May, 1973; yield in kernels q/ha

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal Rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water received by (crop) (WR) (cm)	Yield(Y)	WR / WR max	Y / Y max
2	5	7	35	24.4	36	95.4	40	1.00	1.00
2	10	7	70	"	"	130.4	36.0	1.37	0.90
2	15	7	105	"	"	165.4	36.6	1.37	0.92
3	5	5	25	"	"	85.4	36.3	0.90	0.91
3	10	5	50	"	"	110.4	36.7	1.16	0.92
3	15	5	75	"	"	135.4	37.7	1.42	0.94
4	5	3	15	"	"	75.4	30.0	0.79	0.75
4	10	3	30	"	"	90.4	34.7	0.95	0.92
4	15	3	45	"	"	105.4	37.3	1.10	0.93

2.8 Groundnuts: Variety NC2; sown 4 June, 1974; yield in kernels q/ha

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal Rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water received by (crop) (WR) (cm)	Yield(Y)	WR / WR max	Y / Y max
2	7.5	7	52.5	21.8	25	99.3	44.7	0.74	0.98
2	12.5	7	87.5	"	"	134.3	45.8	1.00	1.00
2	17.5	7	122.5	"	"	169.3	43.9	1.26	0.96
3	7.5	5	37.5	"	"	84.3	42.2	0.63	0.92
3	12.5	5	62.5	"	"	109.3	42.6	0.81	0.93
3	17.5	5	87.5	"	"	134.3	42.8	1.00	0.93
4	7.5	3	22.5	"	"	69.3	35.2	0.52	0.77
4	12.5	3	37.5	"	"	84.3	37.8	0.63	0.82
4	17.5	3	52.5	"	"	99.3	41.1	0.74	0.90
5	7.5	2	15.0	"	"	61.8	27.4	0.46	0.60
5	12.5	2	25.0	"	"	71.8	30.3	0.53	0.66
5	17.5	2	35.0	"	"	81.8	30.6	0.61	0.67

2.9 Maize: Variety Regular White 170; sown 8 November, 1973; grain yield 12% moisture q/ha.

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal Rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water received by (crop) (WR) (cm)	Yield(Y)	WR / WR max	Y / Y max
1	7.5	14	105.0	0.0	30	135.0	69.4	0.66	0.96
1	12.5	14	175.0	"	"	205.0	72.2	1.00	1.00
1	17.5	14	245.0	"	"	275.0	51.0	1.34	0.71
2	7.5	7	52.5	"	"	82.5	55.3	0.40	0.77
2	12.5	7	87.5	"	"	117.5	66.9	0.57	0.93
2	17.5	7	122.5	"	"	152.5	60.7	0.74	0.84
3	7.5	4	30.0	"	"	60.0	18.6	0.29	0.26
3	12.5	4	50.0	"	"	80.0	32.6	0.39	0.45
3	17.5	4	70.0	"	"	100.0	46.4	0.49	0.64

Table 2. (Continued)

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal Rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water Received by (crop) (WR) (cm)	Yield (Y)	WR / WR max	Y / Y max
2.10 Haricot Bean: Variety Mexican 142; sown 20 October, 1973; yield q/ha									
1	5	10	50	0.0	25	75	35.0	1.00	1.00
	10	10	100	"	"	125	31.6	1.67	0.90
	15	10	150	"	"	175	26.2	2.33	0.75
2	5	5	25	"	"	50	21.6	0.67	0.62
	10	5	50	"	"	75	28.3	1.00	0.81
	15	5	75	"	"	100	30.2	1.33	0.86
3	5	3	15	"	"	40	3.8	0.53	0.11
3	10	3	30	"	"	55	14.9	0.73	0.42
3	15	3	45	"	"	70	21.0	0.93	0.60
2.11 Haricot Bean: Variety Mexican 142; sown 24 October, 1974; yield q/ha									
1	5	10	50	0.0	25	75	38.0	1.00	1.00
1	10	10	100	"	"	125	38.0	1.67	1.00
1	15	10	150	"	"	175	32.4	2.33	0.85
2	5	5	25	"	"	50	13.6	0.67	0.36
2	10	5	50	"	"	75	34.8	1.00	0.92
2	15	5	75	"	"	100	34.6	1.33	0.91
3	5	3	15	"	"	40	6.9	0.53	0.18
3	10	3	30	"	"	55	20.0	0.73	0.53
3	15	3	45	"	"	70	25.6	0.93	0.67
2.12 Sesame: Variety T-85; sown 25 January, 1974; seed yield q/ha									
1	5	9	45	9.8	30	84.8	11.4	1.06	0.81
1	10	9	90	"	"	129.8	10.0	1.63	0.71
1	15	9	135	"	"	174.8	7.9	2.19	0.56
2	5	4	20	"	"	59.8	12.8	0.75	0.91
2	10	4	40	"	"	79.8	14.1	1.00	1.00
2	15	4	60	"	"	99.8	11.8	1.25	0.84
3	5	3	15	"	"	54.8	12.1	0.69	0.86
3	10	3	30	"	"	69.8	12.3	0.87	0.87
3	15	3	45	"	"	84.8	11.5	1.06	0.82
4	5	2	10	"	"	49.8	9.5	0.62	0.67
4	10	2	20	"	"	59.8	9.9	0.75	0.70
4	15	2	30	"	"	69.8	10.9	0.87	0.77

Table 2. (Continued)

Irrigation Interval (Week)	Watering Duty per irrigation (cm)	Total no. Irrigations/ Season	Differential amount of water applied (cm)	Effective seasonal Rainfall (cm)	Amount of water Applied for crop Establishment (cm)	Total Seasonal Amount of water Received by (crop) (WR) (cm)	Yield (Y)	WR / WR max	Y / Y max
2.13 Alfalfa: Cultivar Hairy Peruvian; Sown 6 March, 1973, but the data were taken from March 1974, to March, 1975; cutting frequency every 21 days; Yield in tons/ha/year.									
2	7.5	26	195	28.0	-	223	17.5	0.53	0.52
	10.0		260	"	-	288	16.3	0.69	0.49
	15.0		390	"	-	418	17.4	1.00	0.52
3	7.5	18	135	"	-	163	12.2	0.39	0.36
	10.0		180	"	-	208	15.7	0.50	0.47
	15		270	"	-	298	16.5	0.71	0.49
4	10.0	13	130	"	-	158	9.3	0.38	0.28
	15.0		195	"	-	223	14.1	0.53	0.42
	20.0		260	"	-	288	19.3	0.69	0.58
2.14 Alfalfa: Cultivar Hairy Peruvian; sown 6 March, 1973, but the data were taken starting March, 1974, ending March, 1975; cutting frequency every 28 days; yield in tons/ha/year									
2	7.5	26	195	28.0	-	223	30.6	0.53	0.92
	10.0	26	260	"	-	288	32.2	0.69	0.96
	15.0	26	390	"	-	418	30.2	1.00	0.90
3	7.5	18	135	"	-	163	19.8	0.39	0.59
	10.0	18	180	"	-	208	21.3	0.50	0.64
	15.0	18	270	"	-	298	32.8	0.71	0.98
4	7.5	13	130	"	-	158	16.7	0.38	0.50
	10.0	13	195	"	-	223	28.8	0.53	0.86
	15.0	13	260	"	-	288	27.3	0.69	0.82
2.15 Alfalfa: Cultivar Hairy Peruvian; sown 6 March, 1973, but the data were taken taken starting March, 1974, ending March, 1975; cutting frequency every 35 days; yield in tons/ha/year.									
2	7.5	26	195	28.0	-	223	23.3	0.53	0.70
	10.0	26	260	"	-	288	27.5	0.69	0.82
	15.0	26	390	"	-	418	33.4	1.00	1.00
3	7.5	18	135	"	-	163	13.3	0.39	0.40
	10.0	18	180	"	-	208	20.6	0.50	0.62
	15.0	18	270	"	-	298	27.0	0.71	0.81
4	10.0	13	130	"	-	158	14.5	0.38	0.43
	15.0	13	195	"	-	223	26.8	0.53	0.80
	20.0	13	260	"	-	288	23.6	0.69	0.71

DISCUSSION

The Chairman thanked Ato Amare for his interesting paper and felt that this topic was very important for future development. In the future increasing crop yields will probably depend as much on good water management, particularly in irrigated schemes, as it would be on good methods of disease control in different parts of Ethiopia. Thus this paper has raised an extremely important topic.

Ato Amare was asked to what extent a fresh set of tables and graphs would have to be drawn for different soil conditions. He replied that the results that had been presented were suitable for the area around Amibara. However, in areas where soils are extremely light or extremely heavy these parameters would have to be reassessed. The results could be applied to soils of an average silt loam type under climatic conditions similar to those of Melka Werer. Other conditions would necessitate drawing up a new set of tables and graphs.

A participant asked to what extent the amount of water had been based on the physical properties of the soil. Had Ato Amare used the water holding capacity of the soil in making the calculation for the water requirement of the crops? Ato Amare replied that they have not gone into details on the water holding capacity of the soil. However, from the past work it had been indicated that about 15 cm of water was needed for cotton assuming that the root zone of cotton reached 120 cms thus the optimum for cotton was an irrigation interval of 15 days with 15 cms watering duty taking into consideration rainfall and other factors.

In replying to the question on how farmers are expected to calculate the amount of water they can give crops, Ato Amare assumed that the farms wishing to undertake irrigation would have monitoring devises for estimating the amount of water they were using. There were standard devices on the market for measuring water and these generally had to be available to large farms. However for small farmers, he reckoned that the Government will have to subsidise or provide equipment so that small farmers could measure their water inputs.

Ato Amare was asked what consideration has been given to crop population and sowing dates in their influence on the water requirement for a given crop. He replied that in the trials they had used the optimum plant population from other trials that had been carried out for a number of years at Melka Werer, e.g. Alfalfa had been sown at the recommended rate of 3 kg/ha, groundnuts at the spacing of 10 cm whereas cotton was sown at a spacing of 20 to 25 cms. He thought that for most crops unless populations were extremely high or extremely low the water consumption would not be very different within a given range of plant population.

A participant asked if any work has been done on a combination of crops. His paper had indicated that water was the main constraint, however, he has also placed great emphasizes on maximizing profits and therefore had he any recommendations to farmers for maximizing profit. Ato Amare replied that yield alone was not enough; price also has an effect. From the point view of the Middle Awash and the water available, cotton could not be surpassed as a good cash earner. Second in importance he would put groundnut which was very water tollerant. Another crop, which although its yield is low will give good economic returns, is sesame, particularly Variety T.85 which has been found to have very good water resistance. Other consideration should take into account the development needs of the country.

A participant asked why although these trials has been done the reports from Melka Werer do not include as a standard a water requirement for any given trial or bulk cropping area.

Ato Amare replied that this was because the Parshal Flumes were only available for small experimental plots. However, steps were now being taken to measure the water use over the whole farm with checks and counter-checks on the water measurement.

An economist commented that he appreciated the work done but wondered what method of analysis had been used in carrying out the calculations. Ato Amare replied that they had used regression analysis. However the tables do not include regression equations though these would have been possible if more time had been available. From the curves in the graph and the relationship of the points on the graph it could be seen that a high correlation could be made. He also commented that the predicting value of this work needed to be tested for more years and it is planned to continue this set of trials for four or more years to see if these results were born out over a longer period. The economist replied that if the speaker wished data to be analysed further then he could make available computer facilities for doing this. Ato Amare thanked him for his offer.

NEW PROJECTS AT H. V A

by

Ato Sileshi Berhane, H. V A

First of all I would like to extend my appreciation to the Institute of Agricultural Research for the recognition given to our companies by inviting our people to attend this useful seminar and also for this opportunity to speak to you about HVA's new activities.

It is not my intention, nor am I competent, to provide you with all sorts of data on the findings from our trial projects. I have limited myself to some general information on our new projects.

The HVA Companies operating the Wonji/Shoa and Metahara sugar estates have for quite some time been eager to stimulate the development of new ventures in Ethiopia as part of a diversification programme.

Since the beginning of 1970, a number of studies have been made and trials laid out in horticulture, tea, and cattle fattening projects.

Horticulture

We started with experiments in growing certain types of fruits & vegetables - mainly french beans, green peppers and strawberries - for fresh exports in the European winter season which extends between December and March. Concurrently, through an extensive market research carried out in various European countries, it was possible to establish the most profitable products and markets. The products from the experimental and semi-commercial fields were exported fresh to Europe and in this exercise valuable experiences were gained on product handling, grading, packing, transport, and on product quality. Based on the overall results of the trials in growing, transporting and marketing, we came to the conclusion that it would be better to shift our horticultural activities from fresh exports to a form of processing. This provides the advantage that the growing of the crops may continue throughout the year, while the final produce will be less vulnerable to the problems connected with transportation.

We are now, therefore, concentrating on processing crops mainly gherkins and strawberries for which trials have been carried out for export as preserved and deep frozen products, respectively.

If all experiences in these trials prove successful/viable and provided we are able to acquire suitable land, it is our plan to

establish a farm and processing plant with a capacity of about 3000 tons of gherkins and 10,000 tons of strawberries per year. When this project can materialize, it could provide employment for about 4,000 people excluding those small farmers we plan to involve as outgrowers.

Such a horticulture venture allows for the possibility to integrate the activities with a cattle fattening farm which leads me to another project with which we are engaged.

Cattle Fattening Project

We started with a cattle pilot project about 3 years ago with the final aim of establishing a combined cattle fattening/slaughtering operation for export of high quality beef.

It still has to be seen from the results of the pilot project as well as from the prospects in the export markets if such a project will be economically viable.

During the first phase of the pilot project, we have been able to determine how local cattle respond to intensive feeding with locally available fodder and have thereby established the most suitable feed rations.

It is our intention to carry out this project along with our horticultural venture. The advantages are that, while the droppings from the cattle can provide the required manure for the horticultural farms, the cattle in the planned farm can benefit from the harvests of alfalfa which is to be grown as a rotation crop in the horticultural farm. In this way also the land can be economically utilized.

A farm for the cattle project is deemed necessary for various reasons such as:

1) to improve the condition of the cattle before they go into the feedlot for intensive feeding;
2) to serve as a quaranteen area for holding the cattle for vaccination and other treatments; and
3) to hold sufficient stocks of cattle to ensure regular supplies to the feedlot and thereby safeguard the operations from seasonal fluctuations in supplies and prices of cattle.

Assuming that all conditions to embark on the commercial project are favourable, it is the idea to fatten and slaughter about 50,000 heads of cattle per year which will provide about 8,000 tons of beef for export.

Tea Project

The last project I wish to inform you about is tea on which growing trials have been going on during the last 3 years at Wush Wush - approx. 130 kms south of Jimma along the Bonga-Mizan Teferi highway.

The purpose of these trials is to find out if the area is suitable for growing tea on a commercial scale and to select the right planting materials.

An area of 10 hectares has been planted with selected high yielding clones imported from Kenya.

A final feasibility study is now in the making and within a few months it will be known if the Wush Wush tea project will be economically viable. This project is undertaken jointly with AID Bank.

DISCUSSIONS:

A participant commented that he was glade to see that HVA envisaged the participation of small farmers in their new project. He wanted to know what percentage of the product were going to come from estate farms and what from the small farmers. Ato Seleshi replied that as yet none of their projects were on going. For tea it was envisaged that their own nuclear estate would provide the regular supply for the factory. It is thought that at the beginning 75% of the production will come from the nuclear estate and this will gradually decline to 50% of the total production. For horticulture HVA do not even have the land as yet. However, it could possibly follow the same ratio as that for tea.

Ato Seleshi was asked why HVA has concentrated on gherkins and strawberries in their horticulture programme. He replied that they had tried fresh export previously in the form of French beans. This project had run into a number of problems. Air transport had not been reliable and prices in Europe not competetive because of the EEC tax prevailing at the time. This latter constraint was now removed. Another factor against the fresh export business was that land was only in use for three months in the year and HVA wished to have it utilized for all 12 months.

In answer to a further question on fresh export Ato Seleshi replied that this trade was vulnerable to many factors such as labour strikes, lack of fuel, etc. However, if these constraints could be overcome and the prices changed then it would always be possible to come back into the market.

Ato Seleshi was asked why H V A has chosen only gherkins and strawberries for export. He replied that these crops had been chosen on the basis a market study carried out in Europe. This study had identified crops with a reasonable market in Europe, and cucumbers, or gherkins and strawberries had been chosen because they have been tested in the field and found to give reasonable yield.

It was often commented that fattening local cattle was not an economic proposition for a commercial organisation, Ato Seleshi was asked to comment. He replied that when they had started investigations into this venture the price for beef in the export market was very attractive, but it had subsequently fallen and was now about US$1,000/ton. Thus at this time such a venture would not pay.

The final question to Ato Seleshi was how he viewed the new enterprises of HVA in the context of Socialist Ethiopia. He replied that he felt they fit in even better than they could have done before. It would now be possible for the surplus funds from the profit to be siphoned off and given to development of a new project. The government is the major share holder in HVA and the dividends from the shares could provide a substantial source of income for developing new projects.

The Chairman thanked Ato Seleshi for his contribution to the seminar. He also commented that he felt the prospects for horticultural exports were good for the future. Ethiopia was now an associate member of EEC and the tax barrier had been removed. The major constraints in the past had been ensuring adequate and appropriately timed cargo space for fresh export. If this could be ensured then he felt that the export of fresh product from Ethiopia to Europe during the European winter months could well triple.

SOIL ANALYSIS AND PHOSPHATE RESPONSE

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INTRODUCTION

A main purpose of soil analysis is to provide a quick and cheap indication of soil fertility. Analyses for available phosphorus do not always provide a reliable indication of the response to applied phosphate. The available soil phosphorus measured in the laboratory is the phosphorus that is available or made soluble by the extracting solution used in the laboratory: there may or may not be an empirical relation between the amount of phosphorus extracted and the amount usable by a crop.

In Ethiopia, the most useful relation found to date has been obtained by Hammar (1), (2) in Chilalo Awraja. The soils could be grouped according to their analysis using the Acid Extract Method (dilute HCl/H_2SO_4, described in (2)) as below 10 ppm P, 10-20 ppm P and over 20 ppm P. Responses to applied phosphorus for a number of crops varied according to the group and advisory recommendations were planned on the basis of this analytical determination.

The above data were obtained from Chilalo Awraja, which covers a small part of the cultivated area of Ethiopia. Other investigations have been made on a wider area. Birch (3) found that response to applied phosphorus was inversely related to clay content. Grundy (4) used data from the 1971/1972, 1972/1973 and 1973/1974 EPID Fertilizer trials which are described in (5), (6) and (7). There was an indication that responses to phosphorus were related to soil analysis using the Olsen and Lactate methods as done in the IAR laboratories at Holetta and the Acid Extract method done in the Ministry of Agriculture laboratories in Addis Ababa. The relationship was however weak and was not judged useful for predicting response in the field. There are two major difficulties about using the experimental results of these trials: the first is the large experimental error in the trials and the second is in the design of the trials. They were single replications of a 3 x 3 NP factorial with one or two extra plots. In the

1) This paper was first presented at the FAO-NORAD Seminar on Fertilizer Use Development, .../

later trials the lowest rate in the factorial part of the trial was 23-23-0. Though one plot received the treatment 0-0-0, it was not possible to calculate the difference between the control and 23 or 46 Kg/ha P_2O_5 because of the interference of the effect of nitrogen.

Gowans (unpublished) made a small study comparing NP response to Acid Extract and Olsen available phosphorus each at two laboratories. The Olsen extract results appeared to give the best relation with response. Grundy (4) reported a small study on fertilization of natural pasture which gave an indication that the Olsen extract was related to response.

METHODS

The fertilizer trial data used in this study were:

- 22 EPID fertility demonstrations. These are described in (8). More than 200 sites were used for the demonstrations and soil samples have been obtained from more than 100 sites. But usable data could only be obtained from this number.
- 7 DDA demonstration sites on fertilization of natural pasture.
- Factorial fertilizer trials carried out by the IAR at Sheno, Endebir, Bedi, Chencha and two soil types at Holetta.

There are many possible methods of calculating phosphorus response from factorial trials. The response studied here was the difference between 0 and 46 Kg/ha P_2O_5. In the 2x2 NP demonstrations on the 22 EPID sites and the seven DDA sites the P-(1) and NP-N effects were averaged and expressed as a percentage of average yield at the site. A preliminary examination was also made of the data expressing the P effect as percentage over the control, a procedure that appears to have some advantages. However since some control yields were zero the P response would be recorded as infinity. This made certain calcultations difficult.

For the factorial trials carried out by the IAR the 0 to 46 Kg/ha P_2O_5 effect was calculated by interpolation.

On the EPID demonstrations and some IAR sites a number of crops were concerned (see Table I). For the EPID sites all low or very irregular results were excluded and the crop yields summed for estimating P response, concentrating on cereals and pulses. Two to six crops were used. The aim was to classify the soils into groups where crops in general respond strongly, little, or not at all. It is realized that this grouping involves loss of precision but the procedure is justified on the grounds of the rather high experimental

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error of individual crop results and data from the same crop could be obtained for only a few sites. There are probably more important matters affecting precision and these will be discussed later.

Soil samples were obtained from unfertilized land round the perimeter of the 1 ha EPID sites and from the control plots of the DDA sites and the trials at Holetta. The samples reported from the other IAR trials are from the general area of the site. There is a particular problem at the very variable Chencha site which is illustrated in Table I. The trials concerned were sited near the place from which composite sample 6743 was obtained, but the markedly different figures in samples 6741 and 6740 from less than 50m away raise some doubts about the connection between the trial responses and the soil analysis used. Analyses for Jimma, Nedjo and Kobo are given though yield data from these areas have not been obtained.

The methods of analysis are reported in reference (4).

RESULTS

The results are presented in Figs 1, 2 and 3. The best relation appears to be found with available phosphorus using the Olsen method. This gives the best correlation in the case of the five sites where phosphate responses are very high.

A freehand curve was drawn as indicated on Fig. 1 that might represent an underlying relationship. This relationship accounted for 47% of the variation of the original data. However the relationship is not very satisfactory because there were marked divergences from expectations at certain sites, some of which are numbered.

The high and low sites were tabulated to find if the deviation from expectation could be related to available phosphorus by lactate or acid extract methods or to pH, clay percent or extractable zinc. There appeared to be some correlation with lactate phosphorus but none with the other soil properties. It will be seen that four out of the five high sites have less than 3 ppm lactate phosphorus and the four low sites (10, 9, 17 and 4) all have over 3 ppm lactate phosphorus.

The graphical multiple correlation approach was used to examine this indication in more detail. The vertical deviation of each site from the freehand curve was plotted against the lactate phosphorus for that site. The result is illustrated in Fig. 4 where lines have been drawn to indicate the correction for lactate. The deviations from these lines were analysed and the multiple correlation was found to account for 60% of the variation of the original

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data. This correlation technique is approximate and the percentages of the variance accounted for are underestimates.

It should be mentioned that the scale of Figs 1 and 4 is not satisfactory for examining this multiple correlation. The original data were examined on much larger sheets of paper.

High and low points from Fig. 4 were tabulated to find if they could be associated with the available phosphorus by the acid extract method, pH, clay%, or extractable zinc. No association was found. The high and low sites were also tested against total nitrogen % and extractable copper (analyses not given here) with a negative result.

TABLE II

STATISTICAL RESULTS OF CORRELATIONS BETWEEN RESPONSE AND ANALYSIS

Units Phosphate response 0 to 46 Kg/ha P_2O_5 as percentage of average of (1), P, N, NP plots.

Analysis of Variance 1

	SS	d/f	Variance	Ratio
Regression on Olsen figures	38820	2	19410	14.0 xxx
Error	44341	32	1386	
Total	83161	34		

% Variation removed by regression $\frac{38820}{83161} \times 100 = 47\%$

Standard error of individual observation

$= \sqrt{1386} = 37.2$ units

Analysis of Variance 2

	SS	d/f	Variance	Ratio
Multiple regression				
Olsen and lactate figures	49868	5	9974	8.7 xxx
Error	33295	29	1148	
Total	83161	34		

% Variation removed by regressions $\frac{49868}{83161} \times 100 = 60\%$

Standard error of individual observation

$= \sqrt{1148} = 32.9$ units

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Practical Implications

Phosphate response is more closely related to available soil phosphorus by the Olsen method than by the lactate or acid extract methods. A closer relation can be obtained by examining the lactate phosphorus in conjunction with the Olsen phosphorus. Even if the Olsen figure is high at over 15 ppm large responses are reported. Most of these responses can be explained by unusually low lactate phosphorus. It appears that there are at least two forms of soil phosphorus supplying phosphorus to the plant: the Olsen extract measures one form and the lactate another.

In advisory work based on soil analysis it is usual that one composite soil sample is taken to represent soil in one area or at one site. The results of several samples may be used when reporting on a larger area. The important matter is the reliability of interpreting phosphate response at the site from which the sample was obtained.

The sites are grouped according to soil analysis in Table III. The average response in each group fits in rather well with the soil analysis. Many investigations have stopped at this stage and the conclusions have been accepted for advisory use (1), (2) and (9). It is believed that this is rather a dangerous procedure. The response is therefore recorded at each site and an estimate made from the data available of the reliability of estimating the response.

It is seen that the reliability of estimating response is expected to be around two out of three or better except in the case of Group III (Olsen 4.1 to 10 ppm and lactate over 3.1 ppm). This soil analysis range does not give a good indication as to whether there would be an important response of over 20% or whether the response would be very small. The standard error of an individual observation is high at over 30.

The relationships in Table III, though not as reliable as could be desired, can be used for advisory purposes until better data become available. Other relationships, some less precise, and many based entirely on average responses have been proposed and used with apparent success. In most cases the numbers of sites have been larger. However it should be pointed out that increasing the numbers of sites in each group beyond about five or ten may have little effect on the reliability of interpretation at a single site. There is rather strong evidence to suggest that no method or combination of methods will provide a precise indication of phosphate response.

The possible errors are discussed. Grouping of the crops will have resulted in loss of precision as will also the fact that the

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soil samples were not taken from the exact site of the trial before sampling or from each plot. There are difficulties in estimating phosphate response from factorial trials. However there are two more important reasons for the lack of fit of the relation between soil analysis and response. It will be seen from Table III that the responses on the IAR trials are generally higher than expected. These trials presumably received more attention than the 2x2 NP trials of EPID or DDA. The anomalous results for Jihur and for Bako (EPID) Ejaji and Goben suggest that the relationship proposed may break down at high soil pH or in certain regions such as Western Shoa.

These correlations relate soil analysis to response to 46 kg/ha of P_2O_5. They do not give a direct relation between soil analysis and the quantity of phosphate to be applied to obtain maximum or optimum yield. If there is no response to phosphate then no phosphate need be applied. But if a high response to 46 kg/ha P_2O_5 is obtained then it will follow that a high amount of phosphate will be needed? It is expected that it will be so and the expectation is supported by the results of IAR trials. At Endebir and Chencha yields of wheat, barley or triticale seem to level off around 60-90 Kg/ha P_2O_5. At Holetta, the valuable series of 4x4 NP trials suggest that yields flatten out above 30-60 Kg/ha on black soils and around 60 Kg/ha on red soils. At Bedi and Sheno yields level off around 23 or 46 Kg/ha.

Better information will be obtained from phosphate calibration trials, of which a number are now in progress and more are planned. But sufficient data will not be available for two or three years. Until then this relationship, as the best known at the time of writing, may be used and can be used.

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TABLE I

Soil Analysis and Phosphate Response

No	Lab. No.	Place	Avail. Phosphate Ols. (ppm P)	Lact	Acid	pH	Clay %	Extr. Zn ppm	Response %	Crop
1	2628	Finote Selam	9.5	1.1	1.2	5.8	49	16	15	Ma.
2	2629	Burie	11.1	2.5	1.0	5.8	52	19	6	Ma.
3	2644	Dabat	9.2	3.5	1.6	6.6	65	13	24	Leg.
4	2623	Woretta	9.8	3.8	2.8	6.1	63	21	-18	Te,So.
5	2625	Hamusit	9.5	1.3	2.3	5.5	63	13	35	Ma,Mi,Te.
6	5361	Ezo	4.0	0.0	6.4	5.0	55	40	127	Var.
7	5075	Asendabo	4.2	8.2	2.6	5.5	35	18	43	Ma.
8	5072	Sokuru	3.0	1.0	0.6	5.2	42	25	143	Var.
9	8418	Ejaji	4.9	3.2	0.9	5.4	54	13	4	Ma.So.
10	8427	Bako EPID	4.3	4.0	2.7	5.5	40	10	10	Ma.
11	4223	Suba	7.5	1.0	1.6	5.4	42	25	60	Var.
12	4189	Sheno EPID	49.0	2.5	1.9	5.9	48	14	58	Var.
13	4225	Addis Alem	26.0	1.5	2.1	5.8	46	27	20	Var.
14	6925	Aleltu	5.4	1.4	4.8	5.1	62	8	36	Wh.Be.
15	8417	Sire	6.6	3.2	3.4	5.4	60	12	24	Var.
16	8430	Anno	3.3	4.2	5.4	5.4	74	10	44	Var.
17	8431	Goben	5.9	3.6	3.3	5.0	42	24	6	Var.
18	8429	Tibe	3.0	6.4	2.2	5.2	60	11	122	Var.
19	4193	Deneba	66.6	7.0	4.8	6.8	53	14	-2	Wh.Te.
20	4196	Jihur	81.0	15.2	3.2	7.8	57	21	23	Var.
21	4195	Enewari	84.0	25.0	52.5	6.8	51	28	-21	Wh.Te.
22	4194	Mendida	40.0	1.0	18.8	5.4	33	27	25	Var.
23	5087	Jimma IAR	5.8	2.4	5.1	5.8	62	45		
24	4185	Sheno IAR	15.0	1.5	1.8	5.8	44	19	68	Ba.
25	7019	Nedjo IAR	1.3		1.0	4.5	28	3		
26	6746	Endebir	1.6	3.6	2.0	4.3	38	8	200	Trit
27	2991	Holetta red	8.5	5.0	1.6	5.7	64		51	Wh.Ba.
28	3111	Holetta black	5.0	5.0	5.0	5.6	54		27	Wh.Ba.
29	4298	Legetafu	8.0	1.7		5.5	63	15	38	Past.
30	4302	Mullo I	13.9	1.7		5.4	55	16	29	Past.
31	4303	Mullo II	12.4	2.0		5.3	35	25	21	Past.
32	4297	Sululta I	15.4	0.0		5.3	23	28	14	Past.
33	4300	Bekemariam	43.5	2.5		5.5	37	25	7	Past.
34	4301	Kabi Gezaw	27.5	3.0		5.6	37	30	3	Past.
35	4299	Sendafa DDA	10.5	2.0		5.5	45	16	2	Past.
36	4386	Kobo IAR	7.7	52.0	229.0	7.4	33	30		
37	6741	Chencha IAR	9.0			4.2	22	12		
38	6743	Chencha IAR	2.4	3.2	3.0	4.6	27	16	140	FP.Ba.
39	7176	Bedi IAR	12.0	5.6	4.6	4.9	42	12	22	Ba.
40	6740	Chencha IAR	7.3	1.2	4.4	4.5	20	13		

TABLE III

GROUPING AND EVALUATION OF RESULTS

Phosphate response Px is 0 to 46 kg/ha as percentage of average of (1), N,P,NP plots.

I Olsen 4.0 ppm P or less.

	Olsen	Lact.	Response Px	Average
26 Endebir	1.6	3.6	200	
8 Sokuru	3.0	1.0	143	
38 Chencha	2.4	3.2	140	129
6 Ezo	4.0	0.0	127	
18 Tibe	3.0	6.4	122	
16 Anno	3.3	4.2	44	

Reliability 5/6 of high response (or 4/5 if Chencha excluded).

II Olsen 4.1 to 10.0 ppm P, Lactate 3.0 ppm P or less

	Olsen	Lact.	Response Px	Average
14 Aleltu	5.4	1.4	36	
11 Suba	7.5	1.0	60	
29 Legetafu	8.0	1.7	38	37
5 Hamusit	9.5	1.3	35	
1 Finote Selam	9.5	1.1	15	

Reliability 4/5 of response between 30% and 60%

III Olsen 4.1 to 10.0 ppm P. Lactate over 3.1 ppm P

	Olsen	Lact.	Response Px	Average
27 Holetta red	8.5	5.0	51	
28 Holetta black	5.0	5.0	27	
7 Asendabo	4.2	8.2	43	
15 Sire	6.6	3.2	24	
3 Dabat	9.2	3.5	24	19
10 Bako EPID	4.3	4.0	10	
9 Ejaji	4.9	3.2	4	
17 Goben	5.9	3.6	6	
4 Woretta	9.8	3.8	-18	

Reliability 5/9 of response between 20% and 55%, but 4/9 of little or no response.

TABLE III (Cont'd)

IV Olsen 10.1 to 20.0 ppm P. Lactate 2.0 ppm P or less

	Olsen	Lact.	Response Px	Average
24 Sheno IAR	15.0	1.5	68	
30 Mullo I	13.9	1.7	29	
31 Mullo II	12.4	2.0	21	27
32 Sululta I	15.4	0.0	14	
35 Sendafa DDA	10.5	2.0	2	

Reliability 3/5 of response between 14% and 30%

V Olsen 10.1 to 20.0 ppm P. Lactate over 2.1 ppm P

	Olsen	Lact.	Response Px	Average
39 Bedi IAR	12.0	5.6	22	
2 Burie	11.1	2.5	6	14

Smallish response probable

VI Olsen over 20.1 ppm P. Lactate under 2.8 ppm P

	Olsen	Lact.	Response Px	Average
12 Sheno EPID	49.0	2.5	58	
22 Mendida	40.0	1.0	25	
13 Addis Alem	26.0	1.5	20	27
33 Bekemariam	43.5	2.5	7	

Reliability 3/4 of response of 20% or more.

VII Olsen over 20.1 ppm P, Lactate 2.8 ppm P or more.

	Olsen	Lact.	Response Px	Average
20 Jihur	81.0	15.2	23	
34 Kabi Gezaw	27.5	3.0	3	
19 Deneba	66.8	7.0	-2	1
21 Enewari	84.0	25.0	-21	

Reliability 3/4 of small or negative response. (The pH at Jihur is 7.8, a whole unit higher than at any other site in this table)

FIG 1

Response to phosphate and Available Phosphorus (OLSEN)

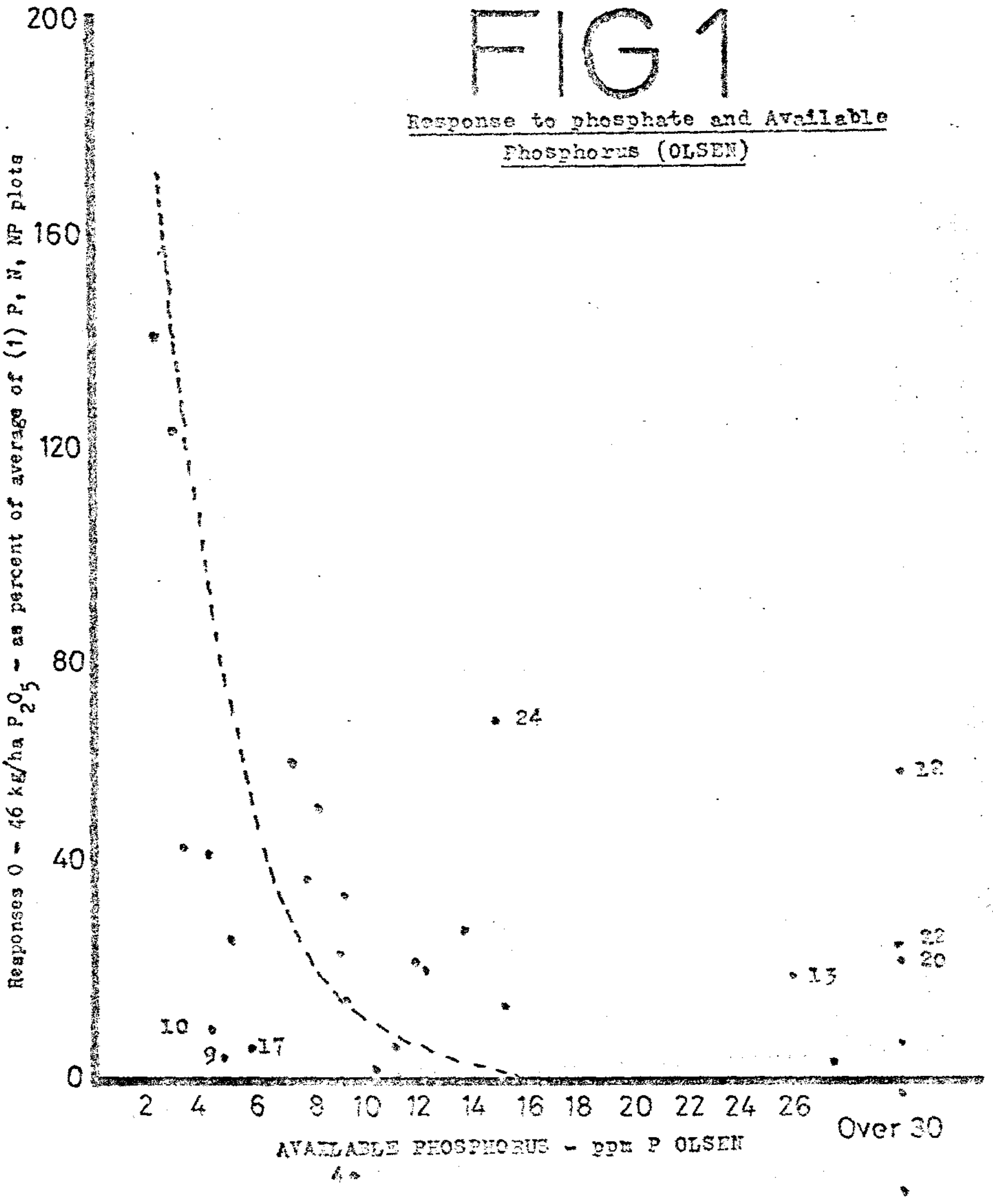


FIG 2

Response to Phosphate and Available Phosphorus (LACTATE)

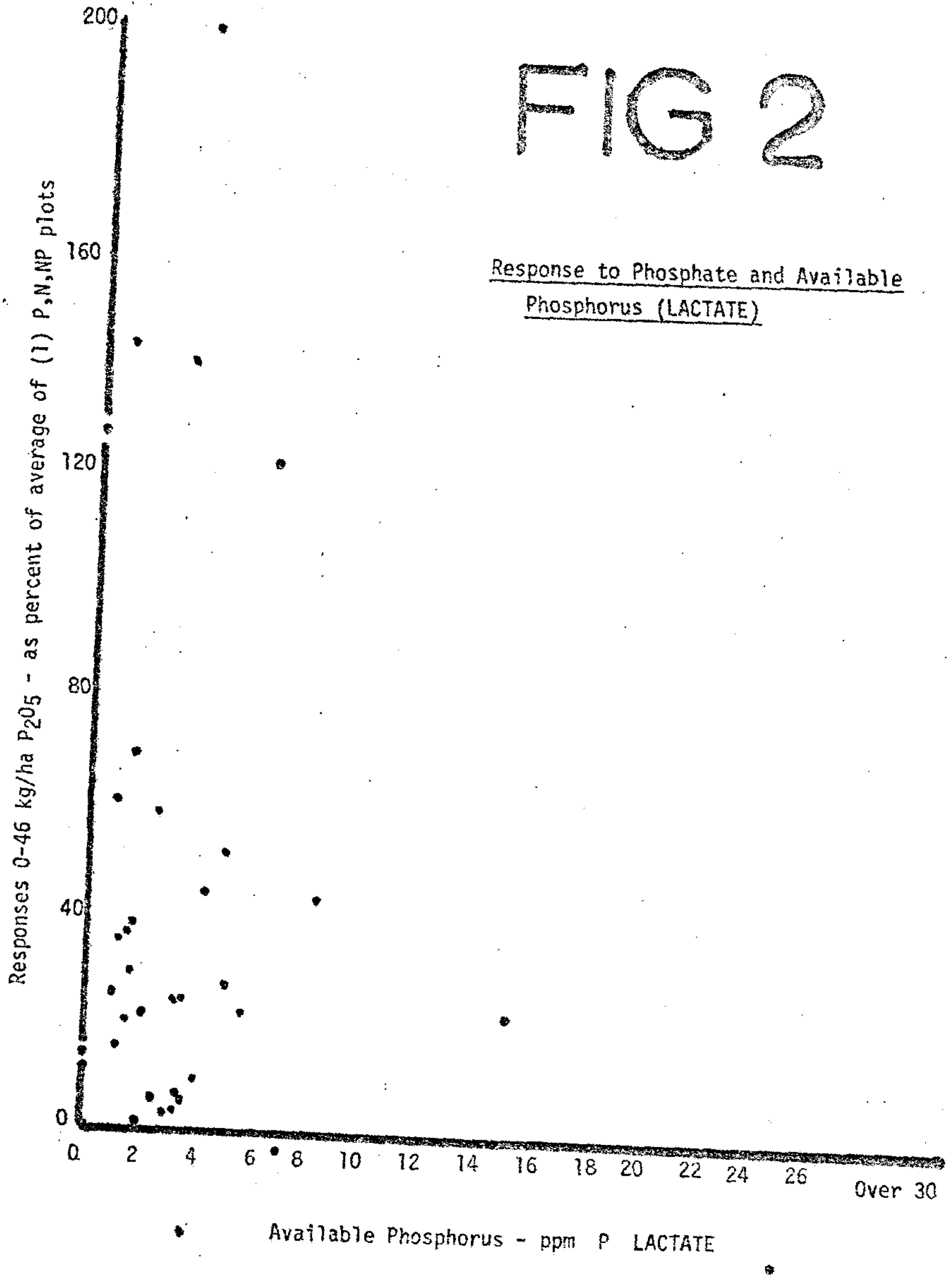


FIG 3

Response to Phosphate and Available Phosphorus (ACID EXTRACT)

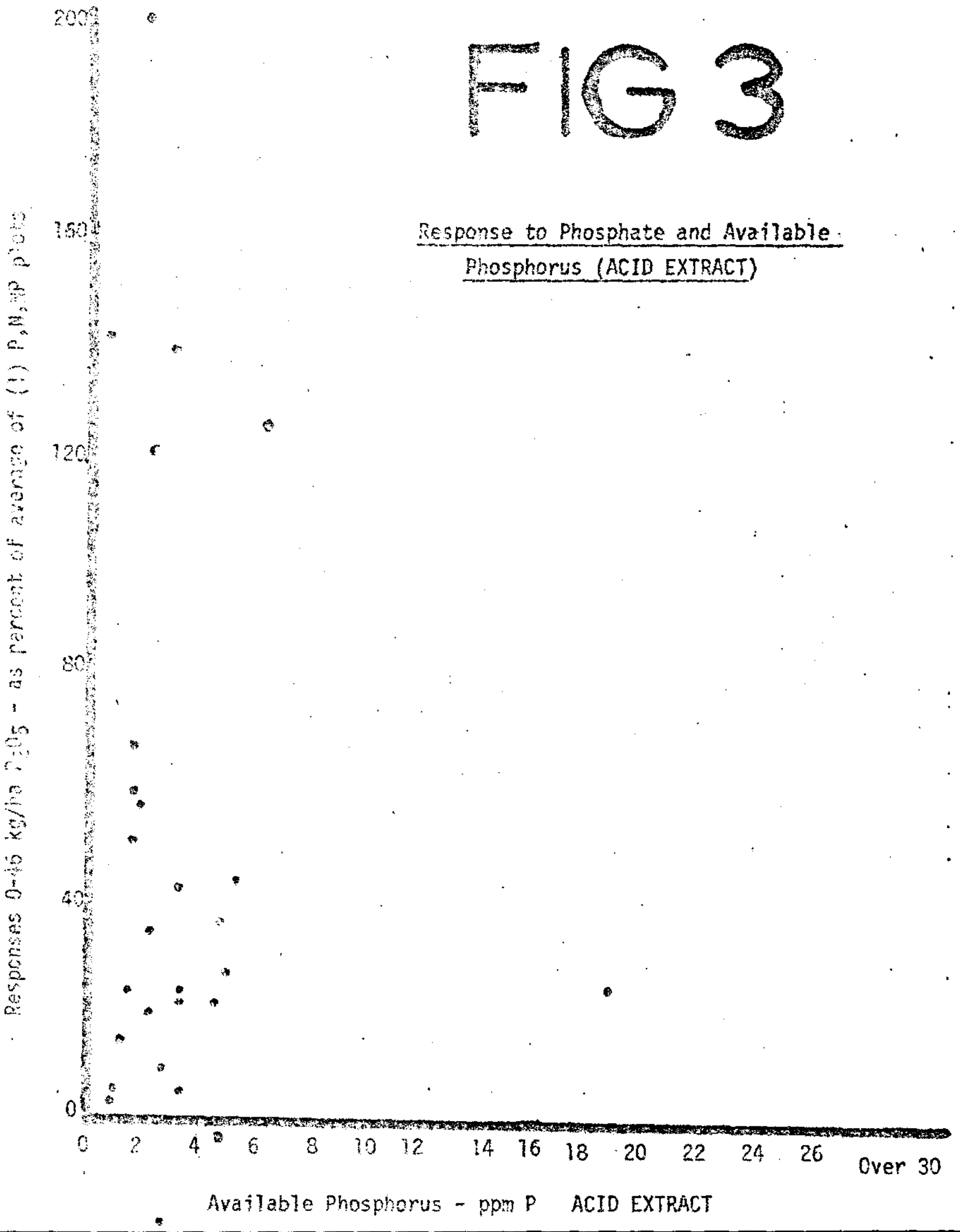
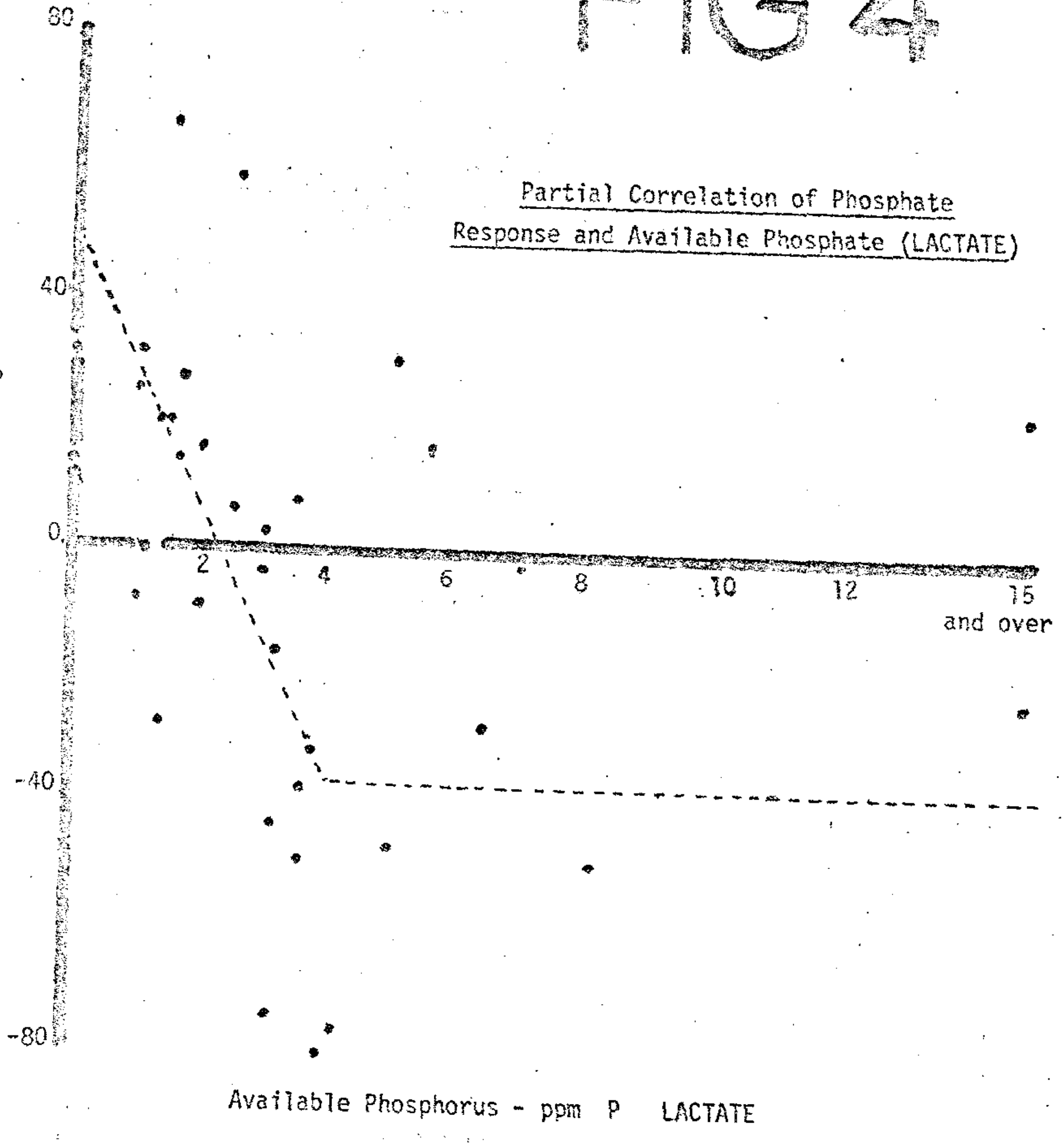


FIG 4

Partial Correlation of Phosphate Response and Available Phosphate (LACTATE)



DISCUSSION

The Chairman thanked Mr. Grundy for this paper and commented that there were many methods for estimating nutrient content of soils and soil analysis was just one of these. In fertilizer trials the question being asked is, if the plants need fertilizer or not? Data from other fields such as soil analysis can help in laying out more meaningful fertilizer trials.

The speaker was asked for his opinion on the applicability of phosphate analysis versus phosphate response in national programmes. He replied that results such as those that had been presented could be used by EPID and IAR immediately. Although they are not completely reliable, they would give a good idea what response to expect from phosphate fertilization. These results will be improved a great deal in the next three or more years when many more phosphate calibration trials had been done. An awful lot of work is needed to get better results, however, at this time these results are usable at the extension level if the person involved also has local knowledge. Such data can never be 100% precise because reponses change greatly with crop varieties and also, in some cases, with seasons.

It was commented that the cost of phosphate had gone up tremendously in the world including for Ethiopia. At the moment, if we ask the farmer to use phosphate fertilizer, we are asking him to put in equivalent of $40/ha. If a method can be devised which, for less than $5/ha, will tell a farmer whether he needs phosphate fertilizer or not; this is very important. This is one of the main points of such analyses and the one demonstrated in this paper has been shown to be most promising. This approach deserves a lot more work, because we are now spending a lot of money on applying phosphate fertilizer and building up the phosphate content of the soils. And we are now probably putting in phosphate where we do not need to at this time.

A participant asked the speaker if he thought that soil testing kits had any value, they were being extensively used in China. Mr. Grundy replied that he has no experience of soil testing kits, also from what he has read they are not very reliable. However, even some laboratory analyses are not reliable. It was hoped that soil testing kits will be looked at in the future but they may or may not work. In replying to a question about the relationship between soil analysis and response Mr. Grundy said that he had worked out the coefficient determination for the relationship between the two values. It had been between 0.47 & 0.60; the square root of 0.6 somewhere near 0.8 which is a reasonable indication of reliability.

Mr. Grundy was asked if he had done any work on phosphate response in native pastures. He replied that some trials had been

carried out in water logged pastures at DDA sites. The response to phosphate seemed to be in the same order as a response to barley in other land. As to economic aspects he has not done any work on this as yet.

It was commented that phosphate fixation is known to be a problem in tropical areas. Would the speaker please comment if the lack of phosphate response could always be attributed to phosphate deficiency in soil. Mr. Grundy replied that this was a difficult matter. Phosphate fixation did occur. However, if a soil analysis showed low available phosphate this should give an indication of what the phosphate response could be. This might be the case even if there was a lot of fixed phosphate in the soil. It is considered that the response of crops will be related to the availability of phosphate in the soil. It is true that if phosphate fertilizer is added some of it may become fixed. However, in the long run more of this should be available than fixed.

SUMMARY OF THE RESULTS OF FERTILIZER TRIALS AT BAKO

by

Desta Beyene
(Assistant Research Officer, IAR - Holetta)

Introduction

It is of paramount importance that the main findings from field experiments are properly presented so that they will be readily utilized by EPID agents. The experiments under discussion have been conducted for five sucessive years in order to obtain reliable results which can be of direct use to the farmer. Results of fertilizer trials conducted at Bako Research Station are summarized in this paper in the hope that the EPID agents in and around the Bako area will use the available information.

During the period 1970-1974 inclusive, fertilizer trials on maize, sorghum, beans, potato and red pepper were conducted, the purpose being mainly to determine the rate of nitrogen and phosphate fertilizers which will give maximum yields.

Methods

The experiments were carried out at various locations in the Bako experimental fields where the soil is mostly nitosol . The soil is a freely drained sandy clay loam to clay loam and the average annual rainfall is about 1300 mm. The soil is acid in reaction having a pH value of 5.7. The organic matter content is high (2.6 - 3.8%). The cation exchange capacity (C.E.C) of the soil varies from 18 to 24 m.e.q/100 g. containing K in the range of 0.47-0.96 m.eq/100 g. The nitrogen and phosphate levels in the soil are 0.13-0.19%N and 11.8-18.7 ppm P_2O_5 (Olsen) respectively.

The design used in the experiments was a split-plot with nitrogen in the main plot and phosphate in the subplots. Nitrogen was applied as urea and phosphate as triple superphosphate. Normally, the fertilizers were side-dressed at emergence of the crop. In general, the N and P treatments for maize, sorghum, and beans were 0, 25, 50, 75 and 100 kg/ha of each N and P_2O_5; and, for potato and red pepper the treatments were 0, 50, 100, 150 and 200 kg/ha of each N and P_2O_5. In some cases additional plots of potassium were included.

The grain yields of maize and sorghum were adjusted to 12.5% moisture level; and yields of beans, potato and red pepper to 7% moisture.

Results and Discussion

The results of the fertilizer studies are summarized in Tables 1 and 2. The results of each crop will be discussed here briefly.

Maize:

Local maize showed a relatively bigger response to N and P fertilization as compared to the hybrid variety. It also appeared that the response to phosphate was greater than that to nitrogen.

The response of this crop to N and P fertilizers seemed to be greatly influenced by the immediate presursor(s) and the fertilization of the preceding year. For example, the response percentages for the years 1970 and 1971 were low mainly because the trials were carried out on areas where heavily fertilized pepper and neug were grown in the preceding year(s). This tendency was clearly shown in the 1971 fertilizer trials carried out using different presursors (Bako Progress Report, 1971/72). Maize showed the least response when preceded by red pepper, sunflower or neug and the greatest response when planted after itself or grown on virgin soil. Apart from the variation in the degree of response to N and P fertilizers, however, the trials consistently showed that there was only a small yield increase to be gained from fertilizer rates higher than 75 kg/ha of each N and P_2O_5.

Sorghum

Sorghum responded well to NP fertilizer application. The response to either N or P was large, but, the highest response was found with the application of 75 kg/ha of each N and P_2O_5.

Beans

This crop showed a marked response to both N and P fertilizers. The average response for the five-year period was almost 50%. Most of this increase in yield could be attributed to the application of P. As shown on the Table of mean yields, phosphate fertilizer alone increased the yield by 37% while nitrogen did so by only 8%.

Potato

The response percent for the year 1973 was unusually high and as a result raised the figure for the average response. Although nitrogen fertilizer showed a slightly higher response than phosphate, tuber yield was increased by 50% when both N and P fertilizer were applied together.

Red Pepper

The yields of this crop are generally low because of damage from termites and diseases (a virus and/or bacteria which causes bleaching of pods). Response to both N and P is, therefore, greatly reduced under these unfavorable conditions. However, when conditions are favorable, the response to N and P fertilization seems to be marked. It is also interesting to note that significant yield increases of up to 30% could be obtained through the application of 250 q/ha of cattle manure. The yield found from this rate of manure application was directly comparable to that obtained by using 100 kg/ha of each N and P_2O_5.

Conclusion

Based on the results obtained from the fertilizer work conducted at Bako Research Station, the following fertilizer rates can be recommended to areas with similar soil and weather conditions:

	N	P_2O_5
	kg/ha	
1. Maize	75	75
2. Sorghum	50	75
3. Beans	50	75
4. Potato	150	100
5. Red pepper	50	100

Because of the continuous variation in the prices of fertilizers and crops, it was not possible to make an economic analysis on the response curves. However, using the recommended rates as a basis one can easily calculate for the economic optima depending on the prices existing at a given location.

Potassium is generally non-limiting for all crops but could be important in the future especially for potato production.

TABLE 1. Fertilizer response of crops. Yield in q/ha

CROP	1970 Unfertilized 0-0	1970 Fertilized NP Mean	1970 Response %	1971 Unfertilized 0-0	1971 Fertilized NP Mean	1971 Response %	1972 Unfertilized 0-0	1972 Fertilized NP Mean	1972 Response %
Maize	80.1	83.9	4.7	80.7	94.0	14.1	27.0	39.5	46.3
Sorghum	19.8	22.0	11.1	43.0	51.7	20.2	37.1	48.3	30.2
Beans	10.2	15.2	49.0	8.3	13.9	67.5	13.5	17.7	31.1
Red Pepper	-	-	-	10.8	15.9	47.2	8.4	9.8	16.7
Potato	98.0	122.0	24.5	88.0	98.1	11.5	-	-	-

Exp. Details:

	1970	1971	1972
Maize: Variety	H613B	H613B	Jimma-Bako
Plot size m^2	18	18	27
Spacing	75 x 25 cm	75 x 25 cm	75 x 25 cm
Sorghum: Variety	Asfaw's White	Asfaw's White	Asfaw's White
Plot size m^2	18	18	27
Spacing	75 x 20 cm	75 x 20 cm	75 x 20 cm
Bean: Variety	Small White Awassa	Small White Awassa	Mexican 142
Plot size m^2	27	18	24
Spacing	50 x 20 cm	50 x 20 cm	50 x 20 cm
Red Pepper: Variety	-	P44-5-69	Shotte
Plot size m^2	-	18	18
Spacing	-	50 x 20 cm	50 x 20 cm
Potato: Variety	Gineke	Gineke	-
Plot size m^2	19.5	19.5	-
Spacing	65 x 30 cm	65 x 30 cm	-

TABLE 1. (Continued)

CROP	1973 Unferti-lized 0-0	1973 Ferti-lized NP Mean	1973 Resp-onse %	1974 Unferti-lized	1974 Ferti lized NP Mean	1974 Resp-onse %	Average Response %
Maize	48.3	60.9	26.1	42.5	63.6	49.6	28.2
Sorghum	35.0	38.2	9.1	33.8	38.8	14.8	17.1
Beans	19.0	24.3	27.9	8.1	12.1	49.4	45.0
Red Pepper	12.0	12.9	3.2	5.0	6.7	34.0	25.3
Potato	121.8	248.9	104.4	74.8	114.0	52.4	48.2

Exp. Details

		1973	1974
Maize:	Variety	Jimma-Bako	Jimma-Bako
	Plot size m²	28	18
	Spacing	75 x 25 cm	75 x 25 cm
Sorghum:	Variety	Asfaw's White	Asfaw's White
	Plot size m²	18	18
	Spacing	75 x 20 cm	75 x 20 cm
Bean :	Variety	Mexican 142	Mexican 142
	Plot size m²	18	18
	Spacing	50 x 20 cm	50 x 20 cm
Red Pepper:	Variety	Shotte	521 H3
	Plot size m²	12	18
	Spacing	50 x 20 cm	50 x 20 cm
Potato:	Variety	Cosima	Cosima
	Plot size m²	19.5	19.5
	Spacing	65 x 30 cm	65 x 30 cm

TABLE 2. Mean Yields in q/ha

CROP	YEAR	N - P rates in kg/ha 0	75-0	0-75	75-75
Maize	1970	80.1	83.2	85.3	87.2
	1971	80.7	64.1	94.2	108.1
	1972	27.0	35.2	27.3	49.5
	1973	48.3	54.1	59.4	64.9
	1974	42.5	48.1	59.6	63.6
	Mean	55.7	56.9	65.2	74.7
Sorghum	1970	19.8	22.4	20.5	22.0
	1971	43.0	45.1	52.2	64.2
	1972	37.1	50.5	47.5	56.7
	1973	35.0	43.5	44.8	41.5
	1974	36.3	43.7	38.7	41.2
	Mean	34.2	41.0	40.7	45.1
Beans	1970	10.2	-	-	15.3
	1971	8.3	7.2	14.6	15.6
	1972	13.5	17.0	19.4	19.3
	1973	19.0	17.5	20.1	25.4
	1974	8.1	9.0	10.8	11.9
	Mean	11.8	12.7	16.2	17.5
*Red Pepper	1970	-	-	-	-
	1971	10.8	14.8	12.5	17.2
	1972	8.4	8.0	8.3	8.8
	1973	12.5	11.3	13.7	14.7
	1974	5.0	6.3	5.4	6.0
	Mean	9.2	10.1	10.0	11.7
*Potato	1970	98.0	128.0	97.0	157.0
	1971	88.0	82.1	91.5	102.6
	1972	-		-	-
	1973	121.8	-	-	245.7
	1974	74.8	102.8	97.8	134.3
	Mean	95.7	104.3	95.4	159.9

*For red pepper and potato the N-P rates are 100-0, 0-100 and 100-100.

Discussion:

The Chairman thanked Ato Desta for his paper and opened the floor for comment and questions.

An economist said that the paper had indicated that the limitation of the recommendations were the economic aspects. However, if regression equations had been used to determine the coefficient of the yield without going into the price of the fertilizer, any one in any given year could have plugged these two variables together to get a recommendation on the rate of fertilizer that the farmer should use. Ato Desta replied that he was aware that an economic analysis could have been included, but he thought this would have been difficult given the time limitation of 20 minutes for the seminar presentation. He also considered that although linear and quadratic response curves could have been calculated, at the moment, it was more useful for extension agents to use the actual yields than response curves in applying these results.

It was commented that EPID recommends that both the crop and the fertilizer be put in rows. However, it had been observed that the farmer does not fertilize in rows because of lack of labour. When fertilizer is broadcast this gives an uneven spread. In some places where concentration is high the crop gets burnt, and in others it does not give the promised yield expected. Ato Desta replied that in recent meeting with EPID and other agencies it had been suggested that there was some relationship between the rate of fertilizer and the method of application, particularly where the rate is lower. However, it was still considered that in order to improve yield row planting should be recommended and fertilizer should be either band-placed or side-placed, this was very important. The Agronomy sectinn was doing its best to convince the farmers of the advantages in these techniques and therefore they will still try and get the farmers to apply the fertilizer in rows. A participant from EPID also commented that the impression about broadcasting was incorrect. Farmers were capable of broadcasting very evenly.

SYSTEMS OF PRODUCTION OF AGRICULTURAL COMMODITIES AND THEIR INTEGRATION WITH AGRICULTURAL RESEARCH IN CHINA AS I OBSERVED

by
Dr. Dejene Mekonnen
(Allemaya College of Agriculture)

This paper, is based on my personnal observations for the few weeks that I was in China, and thus by no means presents a complete picture on the systems of agricultural production and their integration with agricultural research. The information contained in this paper is based on: visits to the north, south, east and south-east China, and individual and group discussions with our Chinese hosts and some readings.

The visit included Kajan, Najuan, Katchang, Li-Chan-Chung Peoples communes, Kiansu Provincial Research Agricultural Institute, water Reservoir at Chantsi and Water Conservation Exhibition at Peking.

After the liberation of China in 1949 land reform was undertaken by the communist party. Every peasant got a cropping share which gave an incentive to work. However, under individual land ownership the few peasants who were better off for capital items such as farm equipment and draught oxen produced more. Thus although a few climbed the economic ladder still more remained poor. As a result Chairman Mao made a call that peasants work as mutual aid teams. This reduced the problem to certain extent. Shortly afterwards in 1953 elementry cooperatives were formed where the peasants had some of their property in common. Elementary cooperatives developed into advanced farm cooperatives, and in this the farmers worked more systematically and had more of their property in common. In 1958, collectivisation was announced and the first peoples commune was formed at Shilling in Hunan province. Other cooperative organizations also formed all over China at about the same time. Now the peoples communes are the important nuclei in the production of agriculture and other commodities. Thus the agricultural enterprises are either

1. State owned by the Government; or
2. Collectively owned by the peoples commune.

All the peoples communes are alike in China in their organizational set-up and motives. Nevertheless, the geographical location, fertility of soil and other resources create differences with respect to income and the number of commune members. The peoples communes are agricultural organizations accounting for 70% of the population in China which depends on agriculture. To effectively utilize manpower and maximize agricultural output, each commune is divided into production brigades. A production brigade in turn is divided into production teams. The number of production brigades and production teams varies from commune to commune depending on its size. The commune revolutionary committee is responsible for the overall organization. Each production brigade also has its own revolutionary committee responsible for that particular production brigade. The production team in each production brigade is assigned to a specific project such as producing grain such as rice, wheat, sorghum or maize, or vegetable crops, livestock, poultry or fish production. All the products are primarily for the commune with very little taxation by the Government. As the mode of socialism is as to each according to his ability and to each according to his work; every member of the community is paid according to his contribution to the commune. Grain is rationed on the basis of the individual and pay, that is cash, is made against the total work bonds that one accumulates. The maximum work bonds for any one day is ten or eleven. The criteria for obtaining the maximum number of work bonds are 1) political consciousness of the individual; 2) physical fittness; (3) skill. If a person can successfully fulfil the above three criteria, he or she will get the maximum number of work bonds. The pay for 10 work bonds is 1.3 Yen (=Eth. 81¢). A field workers can earn upto 30 yen a month.

Before liberation the agricultural production systems in China were so poor that the most of peasants were hunger striken. Sometimes they were compelled to sell their children to the land lord for a few kilos of rice. The bitterness of the peasants vanished with over-throwing of feudalism and the emergence of the communist party. In the new era, peasants work for the common good in the spirit of socialism. They have transformed bad and poor agricultural fields turning them into fertile and productive farms. In the old times, peasants depended on rainfed agriculture and accepted crop failure due to drought as a virtue. Now they have planned and worked out the proper conservation and utilization of underground and surface water resources by building dams and reservoirs. This has secured them with stable production all the year round. Thus two to three harvest are possible within one year boosting the annual harvest and putting up the annual income.

The importance of soil fertility is fully realized by the peasants who do all they can to improve the fertility status of the soil. Organic fertilizers such as farm yard manure, compost and green manure are extensively used. To a lesser degree chemical fertilizers are also applied, sewage, after being treated, is used by being mixed with irrigation water and this also adds to the fertility of the soil. The proper cultural practices such as spacing, weeding, time of planting, which contribute to higher yields, are exercised by the peasants. Most of the commune farms are semi-mechanized. Small tractors of 10, 20 and 30 horse power and walking tractors are popular. With the improved

agricultural production techniques grain yields and other agricultural products have more than doubled as compared with the time before liberation.

Water Conservation

China is reaching its water resources. Chairman Mao has written much on water and its importance. He used to visit rural areas personally and give advise that water conservation has to be undertaken. He said that irrigation is a life blood of agriculture. Big rivers such as the Yansi and the Yellow River and others have been harnesed and put into use. Underground waters have been investigated and wells dug to use the water for irrigation and other purposes. Rain water is also properly conserved in correctly constructed reservoirs. Although the sizes of reservoirs vary greatly they all have spill ways to control overflow and a gate or tunnel to remove siltation. As these gates are at the lower part of the reservoir when they are opened the lower part of the water plus the accumulated silt is washed out. By the end of 1974, 70,000 reservoirs and 1,240,000 power operated wells had been constructed for the purpose of water conservation. Basically the water conserved is used to advance agriculture by using it for irrigation and for raising water animals that can be used as foods. In addition, it is also used as a means of transportation and for generating tremendous power. For example, the Yansi River, one of the biggest rivers in China, passes through ten provinces. Its total length is 5,800 kilometers, in the past it used to flood and adversely affect a number of places, so canals, dikes and gates were made to control the floods. Later on the river was made navigable for 1,700 kilometers.

TACHAI Production Brigade

This Production Brigade is situated in the north western part of China. It has served the nation as a model for agriculture production. In 1964, Chairman Mao made a great call and said, "follow the example of Tachai Production Brigade". As a result thousands of people visit Tadji Production Brigade both from within China and from abroad.

The Tachai Production Brigade is situated on a rugged, hilly, dry and uneven relief. Prior to liberation the peasants in Tachai were very poor and they lived in caves. The very few arable lands were occupied by the land lords. Now land is collectively owned and the production brigade has 83 households with 430 people. It has a labour force of 160, male and female, With this labour force they have filled 24 gullies and in filling the gullies they have recovered ploughable fields in terrace form. The rest were embanked with stone; 15,000 cubic meters of stone were used in making the embankments, and 570,000 cubic meters of soil were used to fill the gullies. The recovered areas were small in the beginning; now the size has increased so that the areas can be mechanized. In transforming the topography they have transported very large quantities of both soils and rock using only human labour. Since 1965 they have had five electrically operated transportation cables installed; each cable carrying 250 - 300 kilogrammes. They have also constructed roads for transporting farm inputs and outputs. To get a stable agricultural production the Brigade have made use of irrigation farming. In order to conserve rain and underground water a reservoir was built. Water is pumped from the underground wells into this reservoir and an aqueduct was made to serve as a water passage. The Tachai production brigade is now semi-mechanized with a reasonable number of small farm machinery of 10, 20, 30 horse power. Some of the gullies have been left untouched. This has been mainly to teach the younger generation about the conditions in Tachai before liberation.

Agricultural Research

We have seen how agricultural products are produced by a commune, now we will see how a research unit fits with these production groups. Since Kiansu Provincial Agricultural Research Institute was visited, the major emphasis given below will be pertinent to that institute. The Institute is directly under the Ministry of Agriculture. It is a comprehensive institute which deals with the local problems in the province. The Institute has 8 divisions with a total staff of 800. The divisions are:

1. Grain crop division, which deals with the breeding of rice, wheat, maize and sorghum.
2. Animal husbandry & veterinary division, which undertakes the study of swine breeding, and the study of various small animals combined with studies of their diseases.
3. Division of Economic crops, which deals with cotton, rape, soyabean and others.
4. Plant Protection Division, which deals with the control of the economically important pests and diseases.
5. Soil fertility division, which is concerned with the improvement of soil with a particular emphasis on salinity, alkalinity and fertility. Green manuring, application of commercial fertilizer and crop rotation are practiced to ameliorate soil fertility.
6. Horticultural Division which is concerned with the breeding of fruit and vegetable crops.
7. Agricultural chemistry and physics. In this division radiation is practiced to produce gamma rays which are used to produce mutations in crops that have economic significance.
8. Water products division, which is mainly for breeding of fish including the prevention of fish diseases.

The agricultural research institute basically serves production.

Organization of the Agricultural Research Institute

The Institute has the following infrastructure for disseminating its results to the peasants:

1. In the province within every country there is a branch agricultural research institute.
2. In every commune there is an agricultural research station.
3. In each production brigade there is an organized scientific technical research team linked with the agricultural research institute.
4. Every production team in a production brigade has its own scientific technical research group.

These are the four basic comprehensive ways through which agricultural research results effectively and efficiently reach the peasants. The results of a particular study are put to practical use within a short span of time. Peasants problems emerge from the scientific technical teams and groups within the production brigades and teams. These problems are usually forwarded to the head research institute and a solution is searched for exhaustively. The Agricultural Research Institute has contact points within the province where the research staff make demonstration tests. In all aspects research staff and technicians and the peasants get together and learn from each other; they sharpen their outlook and increase their consciousness both scientifically and politically. Two thirds of the research staff are engaged in out-of-campus activities to help the communes by solving practical problems. Only one third of the staff stay on the campus to do basic research and much attention is given to practical ways of solving problems. However, attention is also given to theoretical studies which will be useful to overcome existing problems and those that may arrive in the immediate future. For studying or/and undertaking research in a particular project, the Institute of Agricultural Research cooperates with factories, communes and other agricultural institutions. In practice it has been realized that through cooperation solutions for a particular problem can been found easily and within a short period of time. The peasants in the communes maintain and multiply improved varieties for seed purposes with the aid and supervision of the researchers. The research staff teach the peasant about improved systems of agricultural production and their implications for a higher yield. Major cereal and other crop diseases and insect pests are displayed to the peasants so they can be aware of and familiarized with them. In the research endevour some improved varieties of grains and horticultural crops are being developed, but the research staff believe much remains to be done in the immediate future.

In conclusion it may be pointed out that agricultural products are mainly produced by the peoples communes. The peasants and others in the communes are very aware of improved techniques for agricultural production. They exercise improved cultural practices, reclaim their soil and have a properly conserved water resource. The research institutes of agricultural sciences work within the peoples communes and in close association with their problems to enhance production and to apply research findings directly. Taking into consideration Ethiopia's condition I would suggest the following:

1. In this the third day of the seminar there are three bodies which are affiliated with agricultural research. These are IAR in the Ministry of Agriculture, EPID in the ministry of agriculture and the College of agriculture in the University. These three bodies need to be integrated and combined into one unit so that research and extension be better channeled for the service of the Ethiopian farmers.

2. Research priorities need to be set up if the requirement of Ethiopia's grain supply is to be met at this time. The research approach needs to be both quantitatively and qualitatively oriented with the end emphasis on quantity and not quality.

3. Farmers Associations which may be equated to mutual aid teams would be a good media for disseminating research findings to the peasants. A researcher and extension worker have to conduct research with the Farmers' Association in order to train the farmers about improved methods of agricultural production.

4. Ethiopia's agricultural production, until today, depended on rainfed production. The rain pattern has been found to be erratic and non-dependable in most parts of Ethiopia. To stabilize production our big rivers need to harnesed and utilized along their basins to produce enough crops and animal products.

5. Potentials of underground water need to be investigated and wells be dug for immediate use in agriculture.

6. Proper reservoirs have to be constructed to conserve rain water.

DISCUSSION

The Chairman thanked Dr. Dejene for his paper and expressed the hope that visits of this kind to other Socialist Countries will help Ethiopian experts in arriving at solutions to problems within Ethiopia.

A participant who had also visited China commented on the basic difference as he saw it between a research worker China and in Ethiopia. In China a research worker spends one-third of his time with the farmers; one-third in fields carrying out trials and one-third doing office work. In this way the research worker had a direct connection with the farmers. He felt, that this was one of the vital factors that was missing for research workers in Ethiopia.

NOTE: Due to lack of time the discussion on this paper was cut short and it led to the general discussion and closing session of the seminar.

GENERAL DISCUSSION*

The General Manager of the IAR opened the closing session of the seminar with the following remarks:

'We have now reached the final stage of this, the Sixth Annual Research Seminar, and I am sure that all of you will agree with me that the papers presented this year have been of a high standard and exceedingly interesting. Many papers have also suggested or stimulated discussion for positive action.

'The main theme running through many of the papers has been the basic question of research coordination, and particularly the relationship between research stations, extension personnel, national and other development projects and the farmers. Three basic issues have been raised.

1. We should have immediate and long-term strategies for research policies.
2. Research should be carried out in a coordinated and integrated fashion.
3. Researchers should always keep in mind that our customers for research results are the small farmers and for that research and extension should work together hand-in-hand for the better development of Ethiopia's agriculture.

'With these issues in mind and also their constant mention, particularly the last, we nominated an 'ad hoc' committee to examine the last issue and present a working paper to the meeting which would form the basis for general discussion. This working group met twice and their findings will be presented by their chairman, Dr. Berhane Gebre-Kidan.'

The 'ad hoc' working group, had consisted of the following people:

Dr. Berhane G. Kidan, Alemaya College of Agriculture
Dr. Bekele Sissay, IAR
Ato Alemu Gebre Wold, IAR
Ato Tafere Mekuria, EPID
Ato Mulugetta Taye, Planning Commission
Dr. Taye Bezuneh, Debre Zeit Agriculture Experiment Station
Dr. Dejene Mekonnen, Alemaya College of Agriculture

*Note: Due to the nature of the last section of the Seminar, it is being reported almost in full.

In their deliberations, the committee had been assisted by contributions from Ato Emmanuel Gebre Mariam of EPID.

The terms of reference given to the working group were to prepare a draft paper on ways to improve the existing research and extension linkage system. The working group reviewed their responsibility and after lengthy discussion decided to present a number of alternatives to the meeting.

Working Paper

Preamble

One topic that has been raised repeatedly at research seminars and conferences is the question of the most appropriate link between agricultural research and extension in Ethiopia. This issue appears always to be oriented to the individuals who wish to see Ethiopia derive immediate and maximum benifit from advances in agricultural technology. Since the country has relatively extensive networks of research and extension, it is mandatory that these networks should be organized in such a way that rural Ethiopians can make the maximum possible use of them.

The Sixth Annual Research Seminar, November 1975, organized by the Institute of Agricultural Research but representing all agricultural research, extension and development organization in the country deliberated on the above issue with all the seriousness the question deserved.

- Believing that agricultural research and extension efforts will lead to increased productivity and an improved quality of life for rural Ethiopians;
- Cognizant that Ethiopian peasant farming has been introduced to very few improved technologies in agriculture;
- Realising that the existing agricultural research stations and centres are the cradles of technologies in agriculture;
- Realising the existing agricultural research stations and centres are generally the source of most appropriate rural technologies;
- Further realising that there are a good number of appropriate technologies and research results within the confines of the research centres which aught to be used by extension;
- Stressing that a constant contact and dialogue between researchers, extensioners and farmers be initiated;

- Feeling that research irrelevant to the efforts of extension are not appropriate for research stations;
- Believing that research without extension and extension without research is of little value to Ethiopian farmers now;
- Adding that the limited trained manpower in research and extension is not productively used at this time; and
- realising that the existing linkages between research organisations and EPID are weak, loose, ineffective and informal, the Sixth Annual Research Seminar of 1975 strongly recommends to the Minister of Agriculture that the following be done as soon as possible if research and extension efforts are to be more meaningful in the lives of rural Ethiopians.

Alternative One

The existing system of research and extension linkages should be maintained with a few modifications made in consultation with the appropriate agencies. The possible advantages of this system are:

a) it continues to permit an overall national extension scheme;

b) it continues to permit an overall national research scheme;

c) it encourages cooperation between research and extension on a good will and voluntary basis;

d) it allows EPID to perform its functions as it sees best for agricultural extension; and

e) it enables EPID to supply funds to research organisations for conducting research of special interest to EPID.

The main disadvantages of this alternative, as the working group sees them, are:

a) this system has not been effective in that research results have been unable to reach the farmers; and researchers have not generated technologies relevant to the needs of the peasants;

b) at most EPID sites extension agents do not appear to have much technical information and methodology to extend to the farmers;

c) a great deal of the research activities are undertaken without sufficient involvement of extension workers and farmers; and

d) extension agents are unwilling to receive technical directions from two direct sources, i.e. research organisations and EPID.

Alternative Two

A coordinating committee made up of research and extension specialists be established to coordinate the activities of research and extension at the national and regional levels.

The main advantage is that it offers some possibilities for improved linkage with a minimum destruction of the existing system. In addition to functional difficulties, which are obvious, this alternative appears to carry almost all the disadvantages mentioned under Alternative One.

Alternative Three

Immediate steps be taken towards formal and legal integration of research, extension and development on a regional basis by transforming the existing research centres/stations into regional rural development centres. This integration is proposed at both the administrative and technical levels.

The main advantages of this system are as follows:

a) This alternative is much more compatable with the progressive changes in our social and political system, that is farmers' associations, regional autonomy, rural development, rural based development projects, etc.

b) In this way research centres can serve as nuclei for overall regional development out of which agricultural technologies and innovations and related activities can radiate to the immediate vicinity.

c) This alternative provides the possibility for placing under the same administration and technical umbrella all research and extension activities in a region.

d) Extension can have a direct bearing on the activities of research and vice versa, thus maintaining a continuous feedback.

e) The limited trained manpower is expected to be more efficiently utilized.

f) This alternative provides a continuous opportunity for training research and extension specialists in agricultural problems and further offers training possibilities in agricultural innovations and technologies for the peasant farmers.

The main possible disadvantages of this alternative are:

a) this system is diruptive to the existing research and extension systems and linkages;

b) some administrative difficulties could arise if this alternative is followed.

The working group prefered alternative three fpr the advantages enumerated above. If this alternative is adopted, it is suggested that the following be done for its implementation.

1. The resolution be passed onto the Minister of Agriculture on behalf of the Seminar by the General Manager of the IAR.

2. A committee consisting of administrators, researchers and extension specialists be appointed by the Minister of Agriculture to work out the logistics for the proposed integration.

Discussion

Dr. Solomon, the Director of EPID, was asked to comment. He said that he genuinely hoped that the subject under discussion would be examined by all of us with an open mind and that some positive action would be taken. If there was no follow-up then this issue will only be a topic for discussion once a year. Some of us have been to China, others to Russia or other socialist countries. These countries all have the own systems. We must not delude ourselves into believing that we can solve Ethiopia's problems just by adopting a system. A system or set of factors in a system is set up or developed to achieve certain objectives and we must not confuse the objectives with the system. If we take this attitude to its logical conclusion then we would all have to be Chinese or Russian, etc. in order to be developed.

He felt that the real question was not one of organisation. The real question we should be asking is, is there any new research success, agricultural innovation or technology that has been produced in Ethiopia and which is adapted to the national needs but which the extension systems has failed to extend. The other side of this question is, is there any situation known where the extension system has failed. If this question is asked then we can identify the bottlenecks. He did not feel that this was a problem of organisation and cited the case of CADU as an illustration.

He felt rather strongly that the issue had not been given sufficient consideration for such a sweeping resolution to be passed as that presented in Alternative Three. If a hasty conclusion was made and acted upon then we may be back together the next year trying to reverse the situation. He also felt that such a structure as that proposed would be very large and thus it was questionable as to whether we could run it effectively.

He thus suggested a fourth alternative.

Alternative Four

The whole issue should be studied rather thoroughly both as a policy and a technical matter. Both research and extension should be represented in a committee set up to study this issue which would pass its recommendations onto certain higher authorities through the Minister of Agriculture.

He felt that such a resolution would serve the intensions of the meeting better than the other alternatives put forward by the working group. The reasons for suggesting alternative four were that he did not think that what IAR does or what EPID does had been adequately reflected upon. With due respect to the working committee he felt that some of the analyses were somewhat hasty and that the subject had hardly been treated fairly in the short time given to the working group. A lot of things concerning IAR appeared to have been conveniently forgotten or avoided in order to reach such a conclusion.

Dr. Solomon concluded by reminding the meeting that he was not saying that we should not integrate. But we need to find the best way to serve the small farmers. We should not make hasty conclusions and then find in the end that we are not serving the farmer very well.

Dr. Solomon's remarks were followed by a vigorous discussion in which the following points were made by different people in the Seminar.

- Suggestions can often sound very crisp on paper. It is quite probable that the order of organisation is not really the main factor. What is urgently needed is a sense of positiveness. We all need to put a sincere and zealous effort into our work in order to create a sense of excitment which will catch on. This needs a very hard and continuous effort. Only then can we hope to help push the wheel of development. Proposals tend to pile one on top of another and create yet more problems. Thus this issue needs to be thoroughly studied. There are many factor involved in setting up an organisation; people, technologies, environment, etc. However, it is very apparent that there is a need for change.

- The topics of the first day of the seminar had concentrated on the relevance of research and emphasised the fact that results are not reaching the farmers. This suggests strongly that the link between research and extension is weak. This is not a new issue as it has been the concern of many for many years. Thus we have reached a time when something should be done because; the existing systems have not worked as we would like to see them do so and they are not very effective having given the impression of yet another beurocracy.

- The fact that the peasant farmer has not benefited is not the fault of either research or extension because they have not been together. For example, there is an EPID site just outside the gates of the College of Agriculture but the contacts between the two have been very few. This seems to indicate that this is an organisational issue. When extension is taken as one issue and research as another the farmer gets left in the middle and does not benefit.

- Whether lack of contact between research and extension is intentional or unintentional is not the real issue. Since 1974 IAR and EPID have been working jointly at 7 five hectare sites and 16 research areas of one hectare each. EPID gave about Eth.$200,000 to IAR to work on some of the main problems concerning EPID. This joint programme is continuing. The main complaint from IAR is that they expected all the work to be done by EPID agents. EPID resisted this because extension agents are not research agents and they have many things to do which do not concern research, such as soil and water conservation, home economics, facilitating credit agreements. All seeds tried have been taken from IAR, similarly suggested fertilizer treatments and other recommendations. Thus there appears to be a misunderstanding.

- We need sufficient analysis and consultation and we also need to talk to some of the farmers where IAR and EPID are working. It is suggested that these organisations should share a common headquarters building. But we need analysis before making recommendations. For more than fifteen years the College of Agriculture has attempted to build up extension activities around the campus but have been frustrated by administrative bottlenecks.

- There is a constant feeling that something is lacking and research and extension agents are frequently mentioned. In order to identify the problem we can look at examples in our own country, such as CADU and SORADEP where results have reached the farmers and been applied by them. Why is this? CADU, SORADEP are part of comprehensive systems for rural development. Thus it would appear appropriate to support Alternative Three. This is just a paper to start things moving. The existing research stations could become the centres for moving the economy in the regions. This suggestion is just a beginning and it will take time to build up. However let us think along this line. One problem has been that appropriate research has not been carried out and this is hardly surprising with the present linkage and communication system being as weak as it is.

Mr. Hamersley offered the following comments based on his own experiences. He had spent 26 years as an extension worker in East Africa and now he was in the research camp. He pointed out that both IAR and EPID are, comparatively speaking, very new organisations for the work that they have to do. IAR is nine years old on paper and the process of building up the Institute is far from complete. It is very very small compared to the needs it has to meet. The work being asked

of it is way beyond its present capacity. EPID is in the same position; it was first established by the Ministry of Agriculture only four to five years ago. The meeting had been very impressed by the paper from SORADEP but they had an extension to farmer ratio of one to about 250. A At this ratio EPID would require 1,600 extension agents to assist the four million farmers they were already trying to contact. This number might be reduced with the formation of farmers' associations where they could be contacted as groups. Now we are talking about more effective linkages and Mr. Hamersley had no bias for research or extension. The fact is that neither organisation has anything like the number of staff to meet its needs. We are all desperately struggling to be more efficient but we will never be able to service the farming community effectively until we have far, far more people in both research and extension. At the moment it is also extremely difficult to recruit more educated people. Thus even if we forge links, they will not work until both sides have many more people.

- SORADEP recalled that they had filled their extension gap with middle and low level people. Thus if we could train such people, and there are many without jobs at this time, give them about Eth.$80 a month and a bicycle then perhaps the basic needs of EPID could be met within ten years.

A spokesman from the AID Bank said that they were very interested in better links between research and extension because they need a feedback inorder to assist development organisations. Previously they had not been able to finance small farmers but they were now hoping to help cooperatives. They were not intending to replace the efforts of EPID, only to assist.

- Some of us tend to be overprotective of our institutions. It is high time to set aside our personal attachments and give priority to our farmers. Directed by the political change most of us feel a great responsibility for the future but we have not done as much work as we should. We get high salaries and should do all we can to serve the farmers. Caution has been suggested but caution will not work. We need formal coordination so we do not go ahead and waste our resources. We must use our own initiative.

- We can not just sit and deliberate. Research should be much more self critical. We can not wait as time is against us. This new approach must be on broad disciplinary lines for integrated systems. For example it is not sufficient just to develop new sorghum varieties, this is only one aspect of a set of problems. Such varieties must be seen as a package which will fit into a system which has considered all angles; agronomic, social and economic. Extension should do a similar exercise. Then the two aspects can be brought together and see how they match. It may then be seen that formal merger is not required. But the two sides must be made to synchronise. If a few items were pursued in depth from start to finish, i.e. research to extension to the farmer, then the end result could be far more useful. The most appropriate place to start such an approach would be the regional level.

- Of all division in the Ministry of Agriculture, EPID appears to be the most productive and has made tremendous growth since its inception. This division has done an enormous amount of work, building roads, managing state farms as well as dramatically increasing its extension coverage year by year. In this past year of crisis it has often been said that if you want something done, give it to EPID. This organisation is involved in so many tasks which are all part of rural development and this requires some specialization. The expenditure for the first phase was in the order of Eth.$18 million; that for the second phase is expected to be about Eth.$220 million. Good linkages are not only needed with EPID; there are all the other specialist division of the Ministry of Agriculture and the Ministry's own regional structure. There are various ways to create a good linkage; merging two weak organisations is not the only answer.

- We must look at the reality; administration, critical shortage of manpower, education, etc. We need a good education policy and we also need people who have soiled their hands. All such factors have to be considered for integration.

Before the meeting put a resolution and voted, Ato Haile-Lul, the Commissioner of the Science and Technology Commission commented as follows. Ato Haile-Lul said that this was a very important issue. There appeared to be a very strong and genuine desire on the part of the researchers present to come into closer contact with extension. Thus they will be more useful than they have been in the past and this is good. However, he had failed to see any analysis of the internal problem in any of the papers presented; the subject had only been examined in a very general fashion. There had not been any paper to show why research and extension should not function more closely together. He wondered if the IAR had presented its views on this problem to EPID or EPID its views to the IAR. He did not feel that it was in the national interest just to ask the Ministry of Agriculture to merge the two organisations. Supposing there are other solutions. What do we do then? Supposing these other solutions are superior to the alternatives suggested now. What do we do then? He was not advocating caution for caution's sake but he did advocate caution because of the gravity of the problem. Development now has tremendous importance for our country, therefore, it deserves to be given very serious consideration. So far we have only been discussing the problem privately amongst ourselves. Now what should be done at

Government level? What should the research seminar send to the Minister of Agriculture? Are we going to decide on this issue here and now?

Could it not be put to the Minister that he should have this issue studied and decided upon within a limited time. We do not have much to loose by doing that. He can be shown the alternatives suggested and an experts committee could come up with other alternatives. He felt that the topic could not be given the seriousness that it deserved if the meeting decided upon it immediately. However, it would be absolutely proper for the Seminar to recommend to the Minister that this question is examined and resolved within a limited period of time. But his hands should be left free to come up with the best solution. Maybe it will be the solution that you recommend now but it could equally well be some other solution.

Before a resolution was put and voted upon, the chairman of the working group commented that one of the reasons that the group had suggested alternative three was for it to act as a starting point for formal meetings. He felt that the group had given sufficient leaway in their alternative for the issue to be treated fully and they had suggested that as a follow-up a committee be established to work out the logistics for formal integration. However, the core of this alternative was a formal and legal linkage between research and extension.

Dr. Berhane concluded by saying that some action was required from the meeting. If everyone just disperses then this issue will come up again and again.

A suggestion for re-wording was made as follows: 'The highest priority be given to the study of Alternative Three and that the assembly give the mandate for studying this matter to the Minister of Agriculture.' However, it was pointed out that it had already been proposed from the floor that the meeting adopt alternative three with all the spirit included in the overall proposition. This motion was seconded and a vote taken. Voting was 54 for the proposal and 12 against (abstentions were not counted).

Dr. Semu-Negus, the General Manager of the IAR, accepted to pass on this proposal to the Minister of Agriculture on behalf of the meeting. He also commented that the whole discussion had been taped and the proceedings would minute this discussion fully so that the Minister could examine the background to the proposal.

Other Matters:

Two other topics were raised from the floor. These concerned the priorities for research, how should they be appraisedaand the training and supply of the urgently needed manpower. Dr. Samu-Negus replied that at the preceding Seminar, the meeting had recommended that a National Research Council be established to set priorities. Since then the Science and Technology Commission had been established and the Commissioner had been present for a large part of the meeting. This was very encouraging for the research staff present and he thanked Ato Haile-Lul for the time he had given to be at the Seminar. He then asked Ato Haile-Lul to comment on the two topics raised.

Ato Haile-Lul replied that he felt he did not have much to say about training policy. What he hoped was that an Agricultural Research Council would get to work very soon in order to take up the urgent questions of the agricultural sector.

The first item that this Council will consider is the priorities for the agricultural sector in the future. Once these priorities have been worked out it will then be possible to determine the level and type of manpower needed to implement them. Decisions on the level of training required and the time in which to do it must follow from the priorities. Of course, the Agricultural Research Council will be guided by the development policies of the Government. The agricultural research body is very fortunate in having a system of Task Forces for separate areas of agriculture. The structure and function of these task forces is very close to what he thought should be formed throughout the agricultural sector. However the Commission has no preconceived ideas or worked out views on what should be done for training and agricultural priorities. These questions must be solved within and by the agricultural sector itself in line with overall Government development policies.

Closing Remarks

The closing remarks were made by Mr. Hamersley, the Project Manager of IAR.

'Mr. Chairman, ladies and gentlemen, I do not want to make these remarks long; that would be an anticlimax to the last three days. I would like, however, to make a few observations about the Seminar.

'This was advertised and people were invited to attend this gathering as the Sixth Annual Research Seminar under the heading of the IAR. In my view it has developed into something much, much more than that, and it is a very good thing that it did. But this gathering of the last three days did not in the end finish up as what I would define as an annual research seminar. It ended up as an Agricultural Sector

Development Conference and this is also a very good idea. In fact I noticed this evening that speakers had dropped the word 'Seminar' and were using the words 'this conference', which is a much more substantial gathering and much more weighty proceeding than a research seminar. Thus I would like to leave you all with a thought from the events of the last three days. Should we not in future contemplate convening a gathering at about this time year and making it in an Integrated Agricultural Sector Development Conference. At such a gathering we would not just sit and listen to and discuss research papers. Such a conference could be the occassion at which all of us interested in any aspect of agricultural see agricultural development as a whole once a year. I leave this thought with you. But if that is to be the case, I leave another thought with the General Manager. That, perhaps, when it comes to the presentation of technical papers, we try and do that on another occassion. We do not try and combine a major discussion on sector development policies and organisation with purely technical papers. Not because they don't link up but because, on this occassion, we did rather jump from one aspect to the other and then ended up with a really major discussion on agricultural sector development structures.

'To conclude the last three days have been fantastically interesting and great deal of credit for this should go to the people who organized the meeting and to ECA for letting us have the use of the hall. It is likely that a great deal of the value in the discussions and attendance has been because people did not have to travel 45 kilometres to Holetta. Having the meeting in Addis Ababa probably meant that we got a bigger attendance and wider range of interest represented at the Seminar. Thus it would not be a bad idea to hold future meetings of this kind in Addis Ababa.

The following people are mentioned because of the amount of time and effort they put into getting the meeting arranged;

Ato Yilma Seyoum, the Public Relations Officer
W/o Alemtsehaie W. Semayat, Mr. Jack Saunders and M/s Sue Edwards of the Publications Department, IAR. and their assistants at IAR Headquarters.

It is to be regretted that Ceiba-Geigy, who offered to show the film 'Responsibility in Agro-Chemicals' and who were the first to offer a contribution to the Seminar, could not in the end show their film due to shortage of time. However, the firm is thanked for its offer and it is hoped that a showing will be made possible at a future date.

LIST OF SEMINAR PARTICIPANTS

The following persons attended one or more of the three Seminar sessions, and identified themselves with organisations indicated.

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