DEVELOPMENT OF THE AWASH VALLEY PROJECT
ETHIOPIA
AGRICULTURAL RESEARCH INSTITUTE
TOBACCO RESEARCH PROGRAMME
TECHNICAL SUPPORTING MISSION

(February 1973)

TOBACCO CONSULTANT:
R. VANBERCIE
DEVELOPMENT OF THE AWASH VALLEY PROJECT

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AGRICULTURAL RESEARCH INSTITUTE

Tobacco Research Programme
and
Technical Supporting Mission

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R. VANBERCIE
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CHAPTER I

INTRODUCTION

The mission undertaken in February 1973 by the tobacco consultant, R. Vanbercie, at the request of FAO, comes under the programme of two annual supporting missions for the tobacco experiments carried out by the Institute of Agricultural Research for the development of the Middle Awash Valley irrigated area.

The previous missions are described in:
- the Mission Report for February 1972
- the Mission Report for September 1972

As before, the mission objectives consisted of:
- checking the execution of the experiments in progress, and particularly the grading of the tobacco grown in the 1972 season,
- the technical training of the counterpart who is to specialize in tobacco,
- determining the 1973 experiment plans and research objectives within a medium-term programme.

The mission was carried out from 28 January to 2 March 1973; due to administrative delays it was not possible to start this mission at the beginning of the year as planned.
CHAPTER II

EXPERIMENT PROGRAMME

1. RECAPITULATION

The 1972 crop season experiment objectives are included in the medium-term objectives planned at the beginning of the year in agreement with the I.A.R. Management, and are given in the mission report for February 1972.

The 1972 tobacco research programme consisted of:

A: Monthly planting observations on three types of tobacco on alluvial and vertisols from June 1972 to May 1973.

B: Experimental trials, consisting of variety trials, fertilizer and irrigation trials, a harvesting method trial and a collection for observations and multiplication, which were carried out in the growing season from May to September 1972.

2. COUNTERPART AND FELLOWSHIP

2.1. The tobacco programme is at present carried out in the following way:

- periodic supporting missions by a tobacco consultant responsible for the implementation of the experiment programme bearing in mind the general objectives as determined by the I.A.R.

- a programme, carried out by the Ethiopian counterpart, which is particularly difficult since it includes both a growing phase and a technological phase for processing the produce up to the marketing stage when quality represents a determining factor.

- invaluable but informal assistance from the general agronomy expert at the Melka Werer Station.
Method for the technological phase of tobacco trials

- barns
- waiting piles
- fermentation piles
- grading
- baling

FC
DAC
LAC

weight/hv/plot
weight/hv/plot (control)
weight/grade/plot
The present arrangement is unsatisfactory, and the best system would, as has already been emphasized, consist of having an expert working full time on this programme.

If this is not possible, it has been suggested that:

- either a request be made for the general agronomy expert at the Station to take part in the tobacco programme officially. This decision lies with the Director of the I.A.R.
- or an associate expert or Peace Corps Volunteer, with practical rather than academic knowledge, be recruited to take charge of the execution of the programme.

On the second possibility, the consultant has contacted the Peace Corps Headquarters in Addis Ababa with a view to getting a tobacco technician as soon as possible. An outline description has been drawn up and given to the I.A.R. Headquarters.

2.2. Headquarters have been informed (cf. IRAT letter No 14851, 17 November 1972) of the possibilities of training courses in the United States for the counterparts.

A practical technical training course may also be possible in a tobacco growing area in Zambia (Mount Makoulou). The First Adviser at this country's Embassy in Addis Ababa has been contacted on this matter and is shortly to provide the I.A.R. Director with information.

2.3. The willingness of the field assistants working on the tobacco operation must be emphasized in this report. Very special mention should be made of ATO OLODODJEW, an ordinary contractor who, due to his special capacities, acts as field supervisor.

3. GENERAL REMARKS

3.1. As the crop season for the experimental season (B) had finished, with the curing stage, in October, the main objective of the mission consisted of starting the tobacco grading operations.

It had been agreed that as soon as the tobacco had been cured (between July and October), it was to be handled and bulked for active fermentation or aging, according to the types of
tobacco (*), in the technology laboratory. As the installation of the humidifier, in the fermentation room, which is necessary for preparing the tobacco for fermentation, had been delayed, the technological operations (fermentation, grading and baling) were held up.

When the expert arrived, the situation was as follows:

- the flue cured Virginia tobaccos were stored in bulk and were far too dry to be handled for grading;
- active fermentation had not been possible for the dark air cured tobaccos, which were also dry, and it was feared that their natural tendency to ferment might have been impaired by the long period in storage since the end of curing;
- the light air cured Burley tobaccos were still hanging in the barns where they had been for several months.

3.2. Lengthy use of the processing equipment, which had just been installed, was therefore necessary to moisten the tobacco already stored in the technology laboratory, so as to be able to:

- put the dark air cured tobaccos into a compact mass for active fermentation,
- grade the flue cured Virginia tobaccos.

At the time of the mission, the natural environmental conditions were not suitable for the light air cured Burley tobaccos in the barns to be untied. A portable humidifier had,

(*) Note

It should be remembered that:

- flue cured tobacco is only bulked for aging with slow maturation, without a significant rise in temperature;
- dark air cured tobacco must undergo active fermentation (microbial or enzymic) with a high rise in temperature in order to obtain the desired characteristics with this type of tobacco;
- light air cured Burley tobacco can undergo either active fermentation when no re-drying system is available, or, when it is available on the production site, natural aging before grading.
it should be mentioned, been planned to deal with such problems but some difficulties arose for delivering it. The tobaccos which had been in the barns too long had undergone alternating rates of humidity which affected their general qualities.

The greatest precautions were taken to protect the 1972 season experimental tobacco from the dangers due to the exceptional conditions encountered during this technological phase. Nevertheless, when sorted, most of the elementary batches of experimental tobaccos were found to have deteriorated, which led to an exceptional increase in the "refusal grade" percentage.

3.3. The tobacco from each plot must be weighed, quite logically, when it is untied, before fermentation and grading. This method, which had been agreed upon beforehand with the counterpart, makes it possible to obtain the weight results of the trials quickly and also provides a check for when the different harvests from the elementary plots in each of the trials are graded.

This procedure was not followed, which has caused delays in assembling the experiment results and also puts their validity in question.

An annexed plan outlines the procedure of the post-curing operations which will provide:

- a balanced time-table for the use of labour,
- a better distribution of grading operations in the technology laboratory,
- valid weight and quality results.

3.4. It had been planned to harvest seed from the varieties used in the different 1972 trials so as to provide a batch of seed to cover the requirements for future trial seasons. The bad quality of the seedbags used by the Station for protecting the inflorescences (even though sulphurized paper had been provided for this purpose), together with inadequate care and supervision during this operation, has meant that the purity of the seed batches harvested in 1972-73 is far from certain. Unfortunately, the lines are quite likely to be heterogeneous in the next season (see the "Seed Production" annex in the report for February 1972).

3.5. It was agreed with the I.A.R. authorities concerned that the counterpart should provide, at the end of April 1972, all the data collected in the fields and after grading for the whole season, so that the statistical interpretation of the results could be carried out as quickly as possible by the tobacco consultant.

The basic data to be supplied for each of the trials are given below (Chapter VI).
4. **WORK STUDY**

The general opinion is that growing a hectare of tobacco for processing requires 1.5 to 2 men a day throughout the season from the nursery stage to the baling of marketable produce, when the only mechanized operation involved is land preparation.

Under experimental conditions, experience has shown that 2.5 to 3 men per day per hectare are needed in trials.

After a year of experiments at Melka Werer, labour requirements are, bearing in mind the total trial area involved, found to amount to 4.2 men per hectare per day.

These high production costs are no doubt due to the inexperience of the labour force, but also to inadequate supervision which does not produce the best output from the workers. In future, the work must be better organized, supervision increased and the workers selected for their ability, adaptability to different jobs and output.

The supervisory staff must constantly strive to improve the use of labour, cut down movements and reduce waiting time during the operations. The idle periods on the sites should not be allowed to become pretexts for working overtime at the end of the day. It would however be advisable to give bonuses to workers who acquire good technical knowledge.

5. **TRIALS IN PROGRESS**

5.1. *Monthly planting observations* (code 72/8)

5.1.1. These performance study trials with 3 types of tobacco on the two characteristic types of soil at Melka Werer are spread over a year with monthly plantings which started on 1st June 1972. The first series of observations will therefore continue until the planting on 1st May 1973.

The objective is to determine the optimum growing period or periods for the 3 types of tobacco planned under the hydro-agricultural development scheme. The best period in theory, which the facts also seem to confirm as the best period, appears to be from May to August, which would have the advantage of providing worthwhile weight yields and enabling the tobaccos to be untied, fermented and graded under suitable atmospheric conditions. This period is thought to be favourable a priori because of the natural environmental conditions, but it is also the time when the other crops on the site are grown, which will therefore form a bottle-neck for the use of labour. So it would be advisable to find a supplementary growing period for one type of tobacco or another, in order to try to include tobacco in an economic rotation to be planned for the area.
In the initial phase (1972), these monthly planting experiments are used to draw up the annual weight yield graph and check the effects of diseases and pests over the year.

5.1.2. Without judging the results beforehand, the weight yield at Melka Werer may already be considered to depend on both the intensity and duration of daylight and the minimum temperatures which, at certain times of the year, from December to February, limit vegetative development and especially the weight of fresh matter per leaf area unit.

5.1.3. But it must be admitted that the effect of these factors has been greatly obscured by badly implemented cultural techniques, and especially the following points:

- not enough homogeneous seedlings produced in the nursery, in spite of the instructions given beforehand (Report for Sep. 72, pp. 2 and 3),

- uncontrolled watering after planting, which covered and suffocated the seedlings,

- no checks on the amounts of water applied at each watering,

- inadequate ridges which do not contain the water in the irrigation furrows properly (Report for Feb. 1972, pp. 11, 7-8 and 9),

- picking of unripe or overripe leaves.

5.1.4. From the plant protection standpoint, pests were observed (virus and bacterial diseases) which can easily be controlled by the few prophylactic treatments that have already been suggested, such as treating the nursery with methylbromide and the seed with silver nitrate.

The only serious problem for tobacco crops at present seems to be a fungus, Erysiphe cichoracearum (White Mould). Preventive and curative treatment with benomyl appears to give satisfaction at certain times of the year. Varieties that resist or tolerate this fungus have already been or are being introduced into the programme.
5.2. Experimental Trials

5.2.1. Comments

(i) The 1972 season trials have been harvested and cured. At the present time they are in the fermentation and grading stage. Bearing in mind the working site which has been organized with the facilities available and the growing skill of the labour force to be trained in this particular work, the crop season may be expected to finish in April 1973 and biometric interpretation of the results should be possible next May.

Emphasis has already been placed upon the fact that the working process was held up because the research service was not provided, at the right time, with the equipment needed for proper fermentation, grading and baling. Most of the elementary batches have deteriorated by accident, which has distorted the real crop values of the treatments.

(ii) A special remark should be made about the irrigation trial carried out by the irrigation department on the Station. Some phenotypic observations suggested that an extra dose of nitrogen had been applied in addition to the rate recommended (cf. Report for Feb. 1972, p. 20). This impression was confirmed by examination of the cured and graded tobacco. It is regrettable that through a well-intentioned but misplaced desire to do things properly, the experiment plan should have been modified without prior warning.

5.2.2. Quality of the tobaccos

(i) The general quality of the flue cured Virginia tobaccos, which could be observed while being graded, is good to fairly good. At the present stage of observations, it has obviously not been possible to differentiate the characteristics of the different treatments being compared.

The flue cured tobacco on the international market is sorted into some 170 different grades. Due to the difficulties encountered with the qualifications of the counterpart and the initial skill of the workers, it was thought advisable to limit the different grades to 10 for this season. This number, it should be noted, is already twice the number of grades required for purchasing by the Ethiopian Tobacco Monopoly.

The high proportion of rejected or "refusal" tobacco in most of the batches is due to:

- harvesting unripe or overripe tobacco,
hanging tobacco in quantities unsuited to the sizes of the rooms in the barn, which made it impossible to control humidity during the yellowing phase,

- handling and storing tobacco under far from ideal conditions.

An initial sample of the flue cured Virginia tobacco bulk was submitted to the valuation department of the Ethiopian Tobacco Monopoly. An initial analysis shows that it is suitable for the Ethiopian industry and the prices offered are particularly attractive:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade</th>
<th>Eth.</th>
<th>Relative value</th>
<th>Grade</th>
<th>Eth.</th>
<th>Relative value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primings:</td>
<td>$P_1$</td>
<td>2.10</td>
<td>100</td>
<td>$P_2$</td>
<td>1.90</td>
<td>90</td>
</tr>
<tr>
<td>Lugs:</td>
<td>$X_1$</td>
<td>1.80</td>
<td>85</td>
<td>$X_2$</td>
<td>1.60</td>
<td>76</td>
</tr>
<tr>
<td>Cutters:</td>
<td>$C_1$</td>
<td>1.80</td>
<td>85</td>
<td>$C_2$</td>
<td>1.60</td>
<td>76</td>
</tr>
<tr>
<td>Leaf:</td>
<td>$B_1$</td>
<td>2.00</td>
<td>95</td>
<td>$B_2$</td>
<td>1.60</td>
<td>85</td>
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<tr>
<td>Tips:</td>
<td>$T_1$</td>
<td>1.60</td>
<td>76</td>
<td>$T_2$</td>
<td>1.60</td>
<td>75</td>
</tr>
<tr>
<td>Refusal:</td>
<td>$R$</td>
<td></td>
<td></td>
<td>$R$</td>
<td>0.30</td>
<td>14</td>
</tr>
</tbody>
</table>

These figures are very near the f.o.b. prices for Rhodesian (before 1965), Korean and Thai tobacco. They are higher than those for Indian tobacco which is well established on the international market. It should be emphasized that the relative scale of prices offered for these tobaccos is rather different from that usually found in the other tobacco-growing areas. In the United States, for example, the relative price classification for the main grades of leaf is as follows:

$p_1 : 65$  
$x_1 : 90$  
$c_1 : 80$  
$b_1 : 70$  
$t_1 : 30$  
$r : 0$

The following comments were made on the flue cured Virginia samples examined by the Monopoly:

- the priming and leaf grades have the desired characteristics,

- the other grades show some shortcomings which are limited to: texture (close grain), colour (dull, whereas it should be shiny, to indicate essential oils) and taste (plain),
- the refusal grade is good enough for use in the Ethiopian industry.

The criticism passed on the experimental tobaccos, which, it must be emphasized, were submitted in composite samples (variety, fertilizer, irrigation, staggered planting, etc.), involves, finally, various production factors, namely:

- the texture of the experimental soils which are rather heavy and therefore quite different from the typical flue-cured tobacco soils,

- the dynamics of nitrogen nutrition, which is difficult to control in alluvial soils, and made even more problematical by the nitrogen source used in 1972 in view of the sources available locally (cf. Report for Sept. 1972, p. 7, § 2-3 ii),

- the N-P-K formula being used, until the results of the fertilizer trials in progress are available which will show the effects of P and K on quality,

- the uncontrolled irrigation parameters which have a considerable influence on some production characters.

In addition to these observations, the important problem of combustibility must be mentioned. The tobaccos analyzed burn very irregularly. Analysis will show the effect of chlorine and therefore of the salinity of the irrigation water (cf. Report for Feb. 1972, p. 11, § 9 and Report for Sep. 1972, p. 7, § 2-3 iii). Some physical features of the leaf suggest that an excessive chlorine content is in fact involved. Water and soil analysis proves to be indispensable in the future and drainage measurements in the irrigated area also seem to be necessary.

Whatever the case may be, the grading results of the trials and the statistical study of crop values, based on the assessment by the valuation department, are necessary before an overall idea can be formed on the primary tobacco potential of the region.

(ii) Neither light air cured Burley tobaccos, which were still tied in the barn nor the dark air cured tobaccos, still in active fermentation, could be graded at the time of the consultant's visit. Grading instructions were given on the spot and are repeated in the annex to this report.

(iii) In addition to the preliminary valuation and the results based on the crop values, chemical analysis in the laboratory has been planned for the 1972 experimental tobaccos (except for the staggered planting trials).
Samples are taken when the tobacco is being graded, with two bundles taken for each sample, starting at the C1 grade for flue cured Virginia and Burley, and at the 1st grade for dark air cured, from each treatment in each of the 1972 trials. These tobaccos, properly labelled, will be sent to the following address:

SERVICE D'EXPERTISE DU SEITA
(c/o IRAT, 110 rue de l'Université, PARIS)
59, quai d'Orsay
PARIS 7e FRANCE
marked: "ECHANTILLONS POUR ANALYSE".

5.2.3. Quality Factors

Many factors are known to affect the quality of the leaf. Some factors are inherited, some are the result of cultural practices and some are the result of post-harvesting handling.

The whole problem of leaf quality for tobacco is the balance between the total leaf area and the productive capacity under a given condition.

The best quality of a given tobacco can only be obtained under such a balanced condition. The following factors may play a part in shifting that balance:

1) Factors which contribute to the dilution or dispersion of quality:
   a. close spacing increases the total leaf area produced per space unit, which results in thin chaffy leaf,
   b. high topping, failure to top or failure to remove suckers,
   c. too much water,
   d. over-fertilization.

2) Factors which contribute to over-condensation of quality:
   a. wide spacing does not permit sufficient leaf area for the proper distribution of all the quality factors present, resulting in coarse heavy leaf,
   b. low topping.

3) Factors which contribute to dissipation of quality after its formation:
   a. harvesting overripe leaves (weight loss, dull colour, lack of oil),
b. holding yellowing temperatures too long during curing (same as overripe).

4) Factors which contribute to suppression of quality:
   a. harvested before fully ripe (slickness),
   b. drought,
   c. improper use of growth regulators.

5) Factors which contribute to physical damage or contamination:
   a. hail, insects, disease, sunscald, and decay in storage,
   b. agricultural chemicals,
   c. smoke damage from malfunctioning heating units in curing barns,
   d. absorption of foreign odours.

6. 1973 EXPERIMENT PROGRAMME

After this first tobacco experiment season, it was thought advisable to repeat the series of seasonal and staggered planting trials a second time, as planned under the medium-term objectives described in the report for February 1972 (cf. p. 18).

A herbicide trial has been added to the programme.

Modifications to the experiment plans have had to be considered in order to provide the best conditions for curing, particularly for flue cured Virginia tobacco which must fill the curing compartments completely.

Bulk production had at first been planned on an area large enough to provide a uniform batch of tobacco to be submitted for valuation on the foreign market. Furthermore, this would have given an initial notion of production costs. Due to the size of the programme already planned and the apparent financial difficulties of the project, a trial of this type has had to be ruled out. It is nevertheless hoped that some of the monthly plantings will provide uniform batches of the different types of tobacco for valuation.

6.1. General recommendations

The information obtained during the crop season has led to modifying some cultural techniques suggested in the reports for Feb. 1972 and Sep. 1972:
(1) The plant stand should be as follows:

- flue cured Virginia: 20,000 plants/ha (1 m x 0.5 m)
- dark and light air cured: 18,000 plants/ha (1.1 m x 0.5 m)

(2) The initial height of the ridges must be raised substantially to avoid waterlogging during the pre-planting and subsequent waterings.

(3) The unmarketable sandy leaves must be stripped off just before the topping operation.

(4) The seed must be cleaned and treated before being sown in beds to be treated with methylbromide. The seeding rate per square metre should be adjusted according to the germination capacity determined before sowing, so as to have 150 mg. of living seed per square metre.

(5) The annual nursery site must in future be prepared on a regenerating and uniformisation break, using Rhodes Grass or Love Grass preferably. This cover could then be put to good use for mulching the seedbeds.

(6) A simple mulching trial could be carried out in one seedbed using two rates of mulchgrass and sugar cane bagasse (seedling observations: number and weight after 6 weeks).

(7) A complementary fertilizer should be applied to the seedbeds by a side-dressing of NaNO₃ at the rate of 5 g of fertilizer/sq. metre/week, from the 3rd to the 6th week, applied by watering followed by clear irrigation.

(8) The fact has been emphasized that nitrogen should be supplied in the field in a fertilizer that provides it in a rapidly assimilable form and is likely to lead to a certain lack of nitrogen when the leaf ripens in the fields. Providing N with urea cannot be advised (cf. Report for Sep. 1972, p. 7, § 2-3, iii) either for the soil or the quality of the tobacco, and a nitric fertilizer should be preferred, like:

- potassium nitrate (13% N and 44% K)
- calcium and magnesium nitrate (13-15% N and 8% Mg)
- nitrate of ammonia (35% N)
- ammonium nitrate (20.5% to 34.5% N).

(9) The water and soil analysis which had already been planned are absolutely essential to confirm, particularly in the field of chlorine evolution, the general leaching investigations made by the irrigation section.
The seedlings must be planted out with a flat-bladed dibble, for which a drawing has been yet supplied.

As for irrigation, until more accurate information is available, the frequency will be every 14 days from 1/5 to 15/7 and from 15/8 to 1/5. From 15/7 to 15/6, irrigation will be applied according to the rainfall. Warping of the soil must be avoided at all costs. If necessary, the soil should be cultivating before each watering.

The last watering will be applied after the 2nd leaf picking operation.

Over the past season, dull colours have been observed on flue cured tobacco. This fault may be due to:

- harvesting overripe tobacco,
- too long a yellowing phase in the barn.

It is therefore essential to harvest the flue cured tobaccos at the right stage of ripeness and control the length of the yellowing phase carefully.

A preliminary sucker control trial could be carried out on some guard rows using chemicals such as the MH-30 potassic salt or preferably Off-Shoot-T. Some authors suggest the use of a contact treatment followed by a systemic treatment.

**Recommendations**

<table>
<thead>
<tr>
<th>Contact</th>
<th>Systemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>products</td>
<td>(1) PENAR</td>
</tr>
<tr>
<td></td>
<td>(2) OFF SHOOT T</td>
</tr>
<tr>
<td></td>
<td>(3) CONOCO T-504</td>
</tr>
<tr>
<td>quantity</td>
<td>(1) 4 l/ha</td>
</tr>
<tr>
<td></td>
<td>(2) 23 l/ha</td>
</tr>
<tr>
<td></td>
<td>(3) 18 l/ha</td>
</tr>
<tr>
<td>dilution</td>
<td>500 l/ha</td>
</tr>
<tr>
<td>time</td>
<td>early flowering</td>
</tr>
<tr>
<td></td>
<td>end of afternoon</td>
</tr>
<tr>
<td>nozzle</td>
<td>wide</td>
</tr>
<tr>
<td>mist</td>
<td>rough</td>
</tr>
</tbody>
</table>

The trial blocks should be surrounded by a plant barrier to protect the trials from dust. This screen could usefully consist of a dense growth of sorghum or maize sown a month before the tobacco is transplanted.
(16) Before being put in active fermentation (LAC and DAC) or being graded (FC), the tobacco will be stored in compact bulks formed by placing the bundles back to back with the heads towards the middle.

(17) The cigarette beetle, Lasioderma serricorne, found in the technology laboratory make continual curative (Phosphine, DDVP) and then preventive treatments necessary throughout the year. This insect can be easily found by using a light trap (ask the entomology section).

6.2. Barn Capacity

The sizes of the trials and elementary plots, including the guard rows, have been calculated so as to make the best use of the barns and make the indoor conditions as suitable as possible.

6.2.1. Flue-curing barns

- The Conventional flue-curing barn (5 rooms)
  - 1 room : 180 sticks of 66 leaves : 12,000 leaves
  - 1 harvest of 3 leaves/plant :
    - 4,000 plants will the same planting date
    = planting on 2,000 m²

- The Bulk curing barn
  - 80 racks of 500-700 leaves = 40,000 leaves
  - 1 harvest of 3 leaves/plant : 16,000 plants
  = 8000 m² with the same planting date.

6.2.2. Air-curing barns

- The small barn (6 rooms)
  - either - 1 standard room :
    12 sticks x 5 x 3 = 180 sticks of 66 leaves = 11,880 leaves
  - or - 1 max. room :
    200 sticks of 66 leaves = 13,200 leaves

- The big barn (7 rooms)
  - 1 minimum room :
    7 sticks x 66 leaves x 4 floors x 5 sections = 2,200 leaves
  - 15 sticks x 66 leaves x 5 floors x 5 sections = 24,750 leaves
Note: The numbers of leaves calculated indicate the number of leaves to be picked at the same time to fill a room in a barn and isolate them from the other harvests.

6.3. 1973 Experimental Designs

Code numbers of the trials:

73/1 : Fertilizer trial on flue cured Virginia
73/2 : Variety trial on dark air cured
73/3 : Irrigation trial on flue cured Virginia
73/4 : Variety trial on light air cured
73/5 : Harvesting method on light air cured
73/6 : Variety trial on flue cured Virginia
73/7 : Collection
73/8 : Herbicide trial
73/9 : Monthly planting observations.

6.3.1. Monthly Planting Observations (code 73/9)

From 1st June 1973 to 1st May 1974, transplanting, once a month, each of the FC, LAC and DAC on alluvial and vertisol soils.

- Records: height, number of leaves, leaf area/plant, flowering date (50%), dry weight and quality.

- Harvesting seed from the first two planting dates (50 mother plants per variety on the guard rows).

- Varieties: flue cured: KE2
  light air cured: Burley 21
  dark air cured: Amarelo Mauritius (IRABOURBON N 1)

- Design: observation plots, without replications.

Plot sizes:

FC: 1 plot on each type of soil: 2,280 plants/month
= 1,140 sq.m./plot
= 38 m x 30 m

on 2 types of soil

LAC: 1 plot on each type of soil: 1,020 plants/month
= 560 sq.m./plot
= 18.7 m x 30 m

on 2 types of soil

DAC: as for LAC
Nursery requirements:

Requirements/variety/month
- FC: 5 beds of 10 sq. m.
- LAC: 2 beds of 10 sq. m.
- DAC: 2 beds of 10 sq. m.

Nursery requirements/year: 1,080 sq. m. seedbeds = 2,160 sq. m. nursery

Remarks:
- The discard rows are harvested first and filled into the upper section of the F.C. barn.
- 5 observation plot rows of 30 m. are chosen and marked, the harvesting of these rows must be indicated by using strings of different colours (6 colours).

5.3.2. Variety Trials

- Variety trial on flue cured Virginia (code 73/6)
- Variety trial on light air cured (code 73/4)
- Variety trial on dark air cured (code 73/2)

General Conditions:
- Same varieties as in the 1972 trials
- Observation plot: 2 rows of 30 metres: 120 plants
- Total plot: 4 rows of 30 metres: 240 plants
- Randomized blocks: 6 replications
- 2 m. pads between replications
- Fertilizers: according to the types of tobacco
- Stand: idem

Plot sizes:

- FC: observation plot: 2 m x 30 m
  total plot: 4 m x 30 m
- LAC: observation plot: 2.20 m x 30 m
  total plot: 4.40 m x 30 m
- DAC: as for LAC.

Nursery requirements:

- 1 variety: 2 beds of 10 sq. metres
- 6 varieties: 120 sq. metres
- Nursery: 240 sq. metres
- FC + LAC + DAC = 740 sq. m. nursery.
6.3.3. Harvesting method on LAC (code 73/5)

- Effects of leaf harvesting and stalk harvesting methods on the quality.

- Treatments, according to last season's results:
  - leaf harvesting
  - mixed harvesting: 3 leaves + stalk harvesting
  - mixed harvesting: 3 leaves ($P_1$) + 3 leaves ($P_2$) + stalk harvesting

- Design: Observation trial, without replications
  - plot size: 300 plants/treatment: 5.5 m x 30 m
  - variety: Burley 21
  - nursery: 1 bed of 10 sq. m.
    20 sq. m. nursery.

6.3.4. Fertilizer trial on flue cured Virginia (code 73/1)


The procedure proposed for the previous season was not followed as planned due to some comments made by the I.A.R. Headquarters.

The present procedure takes these comments into consideration and at the same time includes study of the response to nitrogen as originally planned.

Treatments: 1. NO  PO  KO (control)
  2. NO  $P_{150}$  $K_{75}$
  3. $N_{45}$  $P_{150}$  $K_{75}$
  4. $N_{30}$  $P_{150}$  $K_{75}$
  5. $N_{45}$  $P_{150}$  $K_{75}$
  6. $N_{30}$  PO  KO

Sources of nitrogen: ammonitrate or other nitric fertilizer

Design: randomized blocks, 6 replications

Plot: Observation plot: 2 rows of 30 m (120 m)
  Total plot: 4 rows of 30 m

Variety: K-E_2

Nursery Requirements: 9 beds of 10 m^2: 90 sq. metres
  nursery: 160 sq. m.
6.3.5. Irrigation trial on Flue Cured Virginia (code 73/3)

The experiment procedure of the previous year is repeated on a new basis.

This year, use will not yet be made of the equipment for applying water at rates and intervals which depend upon knowing the field capacity evolution.

Without this basic information, the validity of the results expected from a trial of this type will be limited.

Treatments:
- main plot: watering intervals: 1-2-3-4 weeks
- sub plot: watering rates: 50-100-150 mm
- control plot: without any irrigation.

Design: randomized blocks, with split plots in 6 replications.

Plot:
- observation plot: 5 rows of 6 metres = 60 plants
- total plot: 7 rows of 10 metres

Nursery requirements:
- 9 seedbeds of 10 sq. metres
- nursery: 100 sq. metres

Last irrigation: applied after the second harvest.

6.3.6. Collection (code 73/7)

Target:
- to bulk up seed of new varieties and study their vegetative development (field observations)
- and at the same time provide a constant supply with satisfactory germination capacity

- design:
  - unreplicated plots
  - 1 variety: 6 rows of 6 metres
    - with 2 outer rows, not topped, used as mother plants
    - 4 inner rows tapped for field observations
Varieties:

**Flue Cured**
- K1
- K2
- Speight 28 (I 6)
- Coker 411 (I 7)
- Georgia 1096 (I 8)
- Coker 347 (I 9)
- KE1 (I 17)
- KE2 (I 18)
- Speight 933 (I 29)
- Bell 110 (I 30)
- NC 95 (I 31)
- Coker 254 (I 32)
- Coker 258 (I 33)
- SC 71 (I 34)
- Vamoor 48 (I 35)
- Vamoor 50 (I 36)
- Vamoor 770 (I 57)

**Light Air Cured**
- Burley one (I 37)
- Burley 2 (I 38)
- Burley II B (I 39)
- Burley 37 (I 40)
- Kentucky 14 (I 41)
- Kentucky 56 (I 42)
- Kentucky 151 (I 43)
- Kentucky 165 (I 44)
- Kentucky 170 (I 45)
- Burley 21 L.N. (I 58)

Nursery: 1 variety/one sq. metre
20 sq. m. of nursery

6.3.7. Herbicide Screening Trial (code 73/8)

**Target:** To study the effectiveness of certain herbicides, that are already used for tobacco elsewhere, on the physical behaviour and yields of the tobaccos.

**Observations:**
- physical assessment (weed control and crop damage)
- quadrat count of weeds
- stand count on tobacco plants
- harvesting and yield in fresh leaves

**Treatments:**
- Nitralin
- Trifluralin
- Pebulate
- Diphenamid
- Metribuzine
- Devrinal
- Metabromuron
- Handweeding

Two rates for each product.

**Design:** randomized blocks, 4 replications
Plot size: 5 rows of 6 metres (3 observation plots)
6.4. **Land Requirements**

6.4.1. **Nursery**
- 3,340 sq. metres
- 167 beds of 10 sq. m.

6.4.2. **Field (ha)**

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6.5. **Fertilizer and chemical product requirements**

In September 1972, the counterpart had been asked to assess the fertilizer and plant protection product requirements for the 1973 season.

These requirements are as follows:

- **fertilizers**
  - sodium nitrate : 10 kg
  - ammonium nitrate : 4 T
  - triple super : 1.5 T
  - potassium sulphate : 1.5 T
  - 15-15-15 : 100 kg
- **pesticides**
  - Benolate : 15 kg
  - Karathane : 10 kg
  - Zinab : 20 kg
  - Methylbromide : 200 kg
  - Phosphine
  - D D V P
  - Monocrotophos : 30 litres
  - OFF-SHOOT-T : 30 litres
  - Royal MH-30 (K)
- **miscellaneous**
  - plastic sheeting : 100 m²
Note: The sucker inhibitor suppliers are:

- **OFF-SHOOT** (or T-146)
  - PROCTOR and GAMBLE DISTRIBUTING Co
    Box 599, Cincinnati, Ohio 45201, USA

- **MH-3D** (potassium salt)
  - UNIROYAL CHEMICAL
    ELM Str. NAUGATUCK, Conn. 07205, USA

  - EASTERN CHEMICAL CORP
    Industrial Rd, Pequannock, N.J. 07440, USA
### I - EXPERIMENTAL PROGRAMME 1973

#### Observations

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#### FIELD

| ploughing | 1 28.4 | February 73 mid April |
| disk | 2 8.5 | 28.5 15.6 7.6 12.6 17.6 12.6 17.6 20.6 |
| pre-irrigation | 3 25.5 | 3.6 4.6 9.6 13.6 16.6 13.6 15.6 20.6 |
| transplanting | 4 19.7 22.6 | 3.6 4.6 9.6 13.6 17.6 22.6 27.6 20.6 30.6 5.7 10.7 |
| gapping | 5 25.5 | 15.6 30.6 22.6 27.6 20.6 30.6 5.7 10.7 |
| reridging | 6 25.5 | weekly 30.6 5.7 30.6 5.7 30.6 5.7 |
| priming | 7 25.5 | weekly 30.6 5.7 30.6 5.7 30.6 5.7 |
| topping | 8 | weekly 30.6 5.7 30.6 5.7 30.6 5.7 |
| harvesting | 9 | 30.6 5.7 30.6 5.7 30.6 5.7 |
| begin | 10 | 30.6 5.7 30.6 5.7 30.6 5.7 |
| end | 11 | 30.6 5.7 30.6 5.7 30.6 5.7 |

#### SHED

| curing | 1 19.7 | 29.7 8.8 19.8 20.8 24.8 29.8 3.6 4.9 |
| begin | 2 2.1 | 7.9 27.9 23.1 24.1 13.1 10.1 8.1 10.1 45 days after 1st harvesting |
| end | 3 7.9 | 2.1 7.9 23.1 24.1 13.1 10.1 8.1 10.1 45 days after 1st harvesting |
| aging | 4 | Sept. 73 to Jan. 1974 |
| grading | 5 | Oct. 73 to Feb. 1974 |
| baling | 6 | Sept. 73 to March 1974 |

N. B. : The transplanting, harvesting and curing dates are estimates given as an indication.
### II - MONTHLY PLANTING OBSERVATIONS

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**Observations**

- methylbromide
- N₂NO₃ (3-4-5-6th week)
- insecticide + fungicide
- according to flowering
- 70-90 days after transplanting
- depending on tobacco type

**N.B.** The transplanting, harvesting and curing dates are estimates given as an indication.
CHAPTER III

BUILDINGS AND EQUIPMENT

The curing buildings and technology laboratory needed for carrying out a coherent tobacco experiment programme have now been built and can be used on the Melka Werer Station.

Those installations, built at an estimated cost of 60,000 Ethiopian dollars, enable the experimental flue cured Virginia, light air cured Burley and dark air cured tobaccos to be cured, fermented, graded and baled.

The overall cost of the detailed fittings, which were specified and requested during the mission in September 1972 (cf. Report, pp. 9 to 13), has been assessed at 9,000 Ethiopian dollars. Most of these fittings, which are necessary to enable the 1972 tobacco season to be completed, could not be installed in time. Consequently, some of the results which could quite justifiably have been expected from the experiments started at the beginning of 1972, have been lost. Many batches of tobacco have deteriorated, and the operation calendar has been held up, which will have repercussions on the results expected from the previous season and cause a bottle-neck in the use of the labour.

The equipment requested is cheap and does not represent a luxury outlay which could have been put off. The necessary financial effort must be made if advantage is to be taken of the financial investment and research expenses already provided.

1. BUILDINGS

The suggested fittings are repeated briefly here, with slight modifications when necessary (cf. Report for Sep. 1972, pp. 9-13).

1.1. Bulk curing barn (barn No 1)

(i) regulation of water supply
(ii) wet and dry bulb thermometer
1.2. **Conventional flue curing barn (barn N° 2)**

(i) an extra tier at the top of each compartment  
(ii) flat boards  
(iii) inspection holes to be fitted  
(iv) gravel area along furnaces  
(v) gable end  
(vi) completed  
(vii - ix) 1 electric inspection lamp and grounded socket for portable humidifier  
(x) one 30 m. plastic tube for water distribution

1.3. **Air curing barns (N° 3 and N° 4 barns)**

(i) adjust the height of the highest tier  
(ii) omitted  
(iii) grounded wall sockets for portable humidifier  
(iv) hessian curtains  
(vi) modify top flue  
(vii) six small charcoal burners

1.4. **Tobacco Technology Laboratory**

(i) 6 more floor racks  
(ii) 50 harvesting crates made with tube  
(vi) one 4 m. grading table  
(vii) 12 wooden stalls  
(viii) one writing pedestal  
(viii) two shelves (Dexion) for grading room  
(ix - xvii) electrical installation  
(xx) curtains at windows  
(xxi) 16 sorting boards for graders.

**Remarks**:

1) **Light in the grading room**

- The light requirements for grading are 500-1,000 Lux in the grading room and 250 Lux in the baling room.

- A 1.5 m., 65 Watt fluorescent tube is recommended, 1.5 m. above the grading table (effective length: 2 m.), e.g. Philips tube, ref. 2D TCS, 229 465 C 220 L, with GM screen, type TL 65 day light.

2) **Problem of the flue-curing barn furnaces spoilt after first use**

As a result of the information collected, the following recommendations may be made:

(i) For the construction of furnaces ordinary bricks are perfectly satisfactory but ordinary cement is absolutely useless. It
has crack up with the first fire. High aluminium bauxite cement is essential if cement is used. Clay in place of high temperature cement is perfectly satisfactory.

(ii) Under tropical conditions, farmers sometimes use clay rich anthill soil. It is recommended to use this red soil thrown up by the termites in place of mortar. Do not mix this clay with cement or anything else, just add water to make it workable and use it as it is. When the furnace has been built in this way, put a thin layer of sand over it.

(iii) The best solution for using cracked furnaces already built is to encase the furnace with a layer of sand and hold it in place with metal sheeting.

2. **EQUIPMENT**

The equipment planned, for which addresses of suppliers and prices had been given, includes:

(i) one portable humidifier
(ii) two oil flue-curing units
(iii) one hand and one motorized tying machine
(iv) two mist blowers
(v) cotton thread for tying the leaves
(vi) six hand counters
(vii) rustic baling press (Morocco)
(xii) equipment to test combustibility
(xiii) ten maximum and ordinary thermometers
(xv) two sets of scales (5 and 20 kg/20 g)
(xvi) rubber water tank for trailer
(xvii) 20 hand dibbles (pattern provided).

3. **SHED**

It is preferable to provide the tobacco department with a shed for storing its light agricultural equipment, fertilizers and plant protection products. This building could be built economically against the side of the conventional flue curing barn.
The cost of the tobacco research to be carried out at Melka Werer had been estimated in 1970 by an FAO expert. The cost of the operation had been assessed as follows:

- Capital investment: 283,000 Eth.
- Recurrent expenses (2 years): 308,500 Eth.
- Total: 591,500 Eth.

When the medium-term programme was drawn up in February 1972, it had not been possible to know what financial resources would be available for the tobacco experiments.

The 1972-73 season has not been successfully completed due to the shortage of funds for the proper fitting out of the installations as planned.

It is essential to know what funds will be provided for the 1973-74 tobacco experiments at Melka Werer, so that an experiment programme corresponding to the funds available can be formulated.

As no information was available at the time of the consultant's visit, the 1973 programme has been drawn up on the basis of the objectives needing to be attained most urgently on which work had been started in 1972. This programme has already been described in this report.

The cost of the operations is detailed in the following paragraph.

Should the funds provided for the tobacco department not amount to the estimated budget, the 1973 programme should be reduced by eliminating some of the research operations according to the decreasing order of priority given below:
1. 1973 experimental trials
2. Monthly planting on flue cured tobacco
3. Monthly planting on dark air cured

This decision should logically be made before the initial programme has been started.

1. EQUIPMENT AND OPERATIONAL BUDGET FOR 1973

A. Capital Expenditure

- Fitting out the buildings 4,055
- Equipment 4,230
- Storage shed 500

= 8,785

B. Recurrent Expenditure

- Labour costs 18,700
  - 20 permanent workers/year
  - 15 extra workers/6 months
  - supervisors
- Products 4,200
- Miscellaneous 500

= 23,400

C. Total (A + B) 32,185 Eth.$
This last mission was carried out a month later than had previously been planned. Some difficulties encountered at the time of the mission might have been avoided or at least reduced, had the mission been undertaken at a more suitable moment.

It has been agreed, at the request of FAO/Rome, to undertake three short missions (2 weeks in the field) each year, instead of the two longer ones previously planned.

The next supporting mission could be quite usefully carried out in the first two weeks of September.
CHAPTER VI

ANNUAL REPORT ON TOBACCO OPERATIONS IN 1972

1. COMMENTS

It has been agreed that the descriptive report of the tobacco operations carried out on the Melka Werer Station will be drawn up by the tobacco consultant.

This report will consist of accounts of the cultural operations, observations, and weight and grading results.

In view of the delay in the working calendar, this information on the 1972-1973 season should reach the consultant in late April 1973. Under these conditions, it will be possible to prepare the analytical report during the following month and send it to the I.A.R. in early June 1973.

Chemical analyses of trial samples have been planned. Under the present circumstances, these results are unlikely to be ready in time to be included in the annual tobacco operations report for the year.

2. DATA TO BE SUPPLIED BY THE COUNTERPART

The counterpart will supply a full report on each of the coded trials, giving clear separate accounts, without any unnecessary words but with constructive comments, of the information that has been recorded during the crop season in the following note-books:

1. Climatic records book
2. Seed introduction register
3. Seedbed note-book
4. Trial and field observations note-book
5. Harvesting and barn note-book
6. Grading record cards
7. Monthly reports
The following lay-out may be used for each trial:

1. Objective of the trial
2. Description of the treatments
3. Plan of the plot lay-out, theoretical number of plants/plot,...
4. Varieties used with I or G numbers
6. Plot counts
   - replacements
   - number of plants harvested
   - measurements
7. Weight results:
   - plot yields in dg.
8. Grading results:
   - copies of the grading cards for each elementary plot
9. Plant protection observations: pest and disease attacks, dates, treatments applied
10. Comments.
ANNEX 1

CLIMATOLOGICAL RECORDS

MELKA WERER RESEARCH STATION

Lat. 9° 16’ N; Long. 40° 9’; Alt. 750 m (approx.)

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<td>10.4</td>
<td>10.9</td>
<td>9.4</td>
<td>5.1</td>
<td>-</td>
<td>-</td>
<td>9.9</td>
<td>8.2</td>
<td>?</td>
</tr>
<tr>
<td>1967</td>
<td>8.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.8</td>
<td>7.9</td>
<td>5.4</td>
<td>6.2</td>
<td>?</td>
</tr>
<tr>
<td>1968</td>
<td>7.5</td>
<td>6.1</td>
<td>7.6</td>
<td>6.5</td>
<td>6.7</td>
<td>10.1</td>
<td>6.3</td>
<td>6.0</td>
<td>7.6</td>
<td>9.3</td>
<td>7.5</td>
<td>6.7</td>
<td>7.5</td>
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<tr>
<td>1971</td>
<td>6.35</td>
<td>7.56</td>
<td>9.15</td>
<td>8.37</td>
<td>8.82</td>
<td>11.35</td>
<td>8.76</td>
<td>6.38</td>
<td>7.42</td>
<td>8.17</td>
<td>5.64</td>
<td>5.39</td>
<td>7.8</td>
</tr>
<tr>
<td>Mean</td>
<td>7.55</td>
<td>7.70</td>
<td>6.29</td>
<td>7.72</td>
<td>8.31</td>
<td>11.08</td>
<td>8.64</td>
<td>6.67</td>
<td>7.81</td>
<td>8.35</td>
<td>7.38</td>
<td>6.86</td>
<td>7.9</td>
</tr>
</tbody>
</table>
### 1.6. MEAN MONTHLY SUNSHINE (hours)/DAY

<table>
<thead>
<tr>
<th>YEAR</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>G</th>
<th>N</th>
<th>D</th>
<th>Annual mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>7.6</td>
<td>6.5</td>
<td>7.6</td>
<td>7.2</td>
<td>8.0</td>
<td>7.4</td>
<td>6.1</td>
<td>6.8</td>
<td>7.5</td>
<td>9.8</td>
<td>9.8</td>
<td>10.0</td>
<td>7.9</td>
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<tr>
<td>1970</td>
<td>6.9</td>
<td>9.3</td>
<td>7.3</td>
<td>9.1</td>
<td>9.3</td>
<td>9.0</td>
<td>7.2</td>
<td>7.4</td>
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<td>9.5</td>
<td>10.3</td>
<td>9.5</td>
<td>8.6</td>
</tr>
<tr>
<td>1971</td>
<td>8.2</td>
<td>9.4</td>
<td>6.4</td>
<td>8.7</td>
<td>8.2</td>
<td>9.3</td>
<td>7.4</td>
<td>7.8</td>
<td>8.3</td>
<td>9.2</td>
<td>9.2</td>
<td>8.8</td>
<td>8.6</td>
</tr>
<tr>
<td>1972</td>
<td>9.1</td>
<td>7.3</td>
<td>9.2</td>
<td>8.4</td>
<td>9.7</td>
<td>8.5</td>
<td>7.2</td>
<td>8.3</td>
<td>7.5</td>
<td>9.2</td>
<td>9.6</td>
<td>9.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Mean</td>
<td>7.95</td>
<td>8.13</td>
<td>8.13</td>
<td>8.35</td>
<td>8.80</td>
<td>8.55</td>
<td>6.98</td>
<td>7.58</td>
<td>7.88</td>
<td>9.43</td>
<td>9.73</td>
<td>9.35</td>
<td>8.4</td>
</tr>
</tbody>
</table>
1) Books


- Tobacco Diseases and Decay - F. WOLF - Univ. Press, Box 6697, College Station, Durham N.C. (396 pp.), 1957.


2) Leaflets and technical bulletins


- The culture of Maryland tobacco - Maryland Tob. Improvement Foundation, INC, Box 2005, Lago Road, Upper Marlboro, Maryland 20670, march 1971.


Ann. 2/2


. Fertilizing Burley Tobacco - Ch. BORTNER - Univ. of Ky., Agric. Extension Service, Lexington, Circ. 545, 4-1957.


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ANNEX 3

TOBACCO GLOSSARY

BODY: The thickness and density of leaf or weight per unit of surface (chaffy, thin, medium, medium-heavy, heavy).

BULK GRAINED: Abnormal development of the leaf, resulting in a tight or close structure of cells and fibres, and a flat surface.

COLOUR: A subdivision of a group based on the relative colour shades and brilliances common to the group and on certain elements of quality, such as body and maturity, which are closely related to colour.

CONDITION: The state of tobacco with regard to its moisture content.

CROSSING: Cancelling the sale of a bale by drawing a cross on the bale ticket.

CRUDE: Any immature leaf of which one-fifth or more of its surface has a hard green colour: or any tobacco containing more than 25 per cent. of crude leaves.

CUTTERS ("C"): A group of tobacco originating from the lower middle portion of the plant which is spready and very thin to medium in body, over 16 in. long and having characteristics as defined in the specification.

DAMAGED: The effect of mould, rot, or other fungus or bacterial diseases which attack tobacco in its cured state, including tobacco having the smell of mould, or rot.

DECAYED: Any tobacco which is damaged to the extent of 20 per cent or more.

FINISH: The stage of finality in the cured leaf, depending on the type of leaf and the effects of injury, disease, cultural practices and of curing and handling after curing, which might impair the natural lustre and perfection of the leaf.
FOREIGN MATTER: Any substance or material extraneous to tobacco, including dirt, sand, stalks, suckers, grass, string, oil, grease, etc.

FUNKED: Tobacco which, while appearing to be sound, has an aroma indicating that the tobacco has been or is about to become mouldy.

GRADE: A sub-division of tobacco according to group, quality, colour and, where it is of sufficient importance to be applicable, special factor.

GRAIN: The structure and arrangement of the cells and fibres of the tobacco leaf and resulting weave or texture.

GREEN ("G"): (1) Any leaf of which one-fifth or more of its surface is predominantly green in colour; or (2) Any lot of tobacco containing 20 per cent. or more of green leaves; or (3) Any lot of tobacco which is not crude but which contains 20 per cent. of green and crude combined.

GREENISH ("V"): (1) Any leaf of which one-fifth or more of its surface has a decided greenish tinge or cast; or (2) Any lot of tobacco containing 25 per cent. or more greenish leaves; or (3) Any lot of tobacco which is not green but which contains 25 per cent. of green and greenish leaves combined.

HIGH MATURITY ("F"): A special factor applicable to tobaccos in the leaf, cutter, lug and priming group which display a superior degree of maturity to the standard grade. Tobaccos qualifying for this special factor shall be thin to medium in body, fairly soft to slightly rough, fairly oily to fairly low in oil, ripe to mellow and open-grained, with a natural to fairly natural colour and finish. Grades bearing this special factor may carry a material amount of injury associated with an advanced degree of maturity.

IMMATURE: Not fully ripe, not fully developed and close-grained.

INJURY: Hurt or impairment from any cause except damage. Injured tobacco shall include dead, burnt, hail-cut, or ragged tobacco; or tobacco that has been sun-burned, or scalded, scorched or bulk-burnt, pole-burnt, bleached or bruised; or tobacco damaged by insects.

LEAF: A group of tobacco from the middle and upper portion of the plant, and having characteristics as defined in the specifications.

LEMON: Tobacco which is chiefly yellow in colour and which is not crude, green, variegated or mixed.
LOOSE LEAF: Leaves which are presented for sale in the unstemmed form but not tied in hands.

LOT: A bale or other definite unit.

LUGS ("X") : A group of tobacco consisting of leaves from the lower portion of the plant and having characteristics as defined in the specifications.

MAHOGANY DARK ("S") : Tobacco which is chiefly of a dark red or mahogany colour and which is not crude, green or mixed.

MAHOGANY LIGHT ("R") : Tobacco which is chiefly of a light red or light mahogany colour and which is not crude, green, variegated or mixed.

NATURE: Fully ripe, open-grained.

MIXED ("M") : A lot of tobacco which contains 20 per cent. or more leaves of a distinctly different group, quality or colour from the major run of the lot. Mixed bales may be sold if declared "MIXED".

NESTING: Packing into bales so as to deceive the buyer about the nature and quality of the contents of the bale.

NONDESCRIPT ("N") : Except as may be designated by a special factor, Nondescript shall include: (a) Any tobacco which does not meet the minimum specifications of the lowest grade of any other group; (b) Any wet, semi-cured, or unsound tobacco; (c) Any tobacco which has wasted or contains waste to the extent of 40 per cent. or more; or (d) Any tobacco defined as crude, decayed or off-type.

OFF-TYPE: Any tobacco which cannot be properly classified in any other grade of the type normally sold on the market due to its distinctly different characteristics. It shall include any tobacco having an aroma distinctly foreign to the type.

OPEN-GRAINED: Normal development of the leaf resulting in an open structure of cells and fibres and a crinkly surface of the leaf.

ORANGE ("O") : Tobacco which is chiefly orange in colour, and which is not crude, green, variegated or mixed.

PRIMINGS ("P") : A sub-group of lugs originating from the bottom of the plant, composed of very thin leaves which tend to be paler in colour, rather smooth, low in oil, dull in finish, and which may have a material amount of injury and an earthy aroma characteristic of leaves grown near the ground.

QUALITY: A division of group, forming the second factor of a grade, based upon the relative degree of one or more of the elements of quality in tobacco.
SCORCHED: Abnormal reddish brown colour caused by excessive heat in curing process.

SCRAP: A by-product from handling tobacco in both the unstemmed and stemmed forms, consisting chiefly of portions of the lamina.

SEMI-CURED: Tobacco in the process of being cured, or tobacco which is partially, but not thoroughly cured, including mid-ribs which have not been thoroughly dried in the curing process.

SHORT-LEAF ("T"): A special factor applicable to the Leaf group, denoting any lot of tobacco which contains 25 per cent., or more of leaves which are under 12in. long.

SIDE: Any distinct characteristic of tobacco, or certain aspect of quality, colour or length as compared with some other aspect of quality, colour or length.

SLATELY: Very close-grained and immature leaves having a very smooth, flat surface, and which are distinctly grey in colour.

SLICK: Very close-grained and immature leaves having a very smooth, flat surface, and which may have a starchy nature and a pale or fleshy appearance.

SMOKING LEAF ("H"): A sub-group of Leaf; composed of thin to medium, non elastic, mellow and very open-grained leaves, being rather low in oil, and characterized by a mellower colour than the corresponding colours of the Leaf group. Some of the lower grades of Smoking Leaf have a considerable amount of injury of the kind often found in very grainy or over-ripe tobacco.

SPECIAL FACTOR: A symbol or term authorized for use with specified grades to designate a certain side or characteristic of importance varying from or not covered by the specifications of the standard grades.

SPONGED: Leaf of a dull, greyish colour or greyish and brownish blotches on leaf surface, caused by allowing leaf to become over-ripe or not removing moisture fast enough when curing.

SPLIT BALES: Bales in which there are not more than two grades (four grades for Burley) of tobacco clearly separated by a sheet of paper may be offered for sale declared "SPLIT".

STEMMED: A form of tobacco which the stems or midribs have been removed.

STRIPS: A tobacco leaf from which the lower two-thirds of the stem has been removed; or a lot of tobacco composed of strips.
SUB-GRADE: Any grade modified by a special factor.

SUB-GROUP: A group formed by the substitution of a different group symbol to denote a modification of the specifications or to indicate a certain side or characteristic of the tobacco.

SWEATED: The condition of tobacco which has passed through one or more fermentations natural to tobacco.

TWO FACED: A difference in colour shade between the front and the back of a leaf. The back being a lighter colour.

UNIFORMITY: One of the elements of quality in tobacco having reference to the consistency of a lot, as ordinarily sorted and prepared for market.

VARIEGATED ("K") : Having a diversity of contrasting colours or tints, other than green, within a leaf; or leaves which are in part distinctly grey, or which can be described as slately or slick; or leaves which do not blend with the normal colours of lemon, orange and mahogany established for the type. Tobacco containing 25 per cent. or more of such leaves may be classified "variegated".

VARIEGATED RED ("KR") : Leaves which are in part distinctly red mottled, or stained or badly discoloured in the curing or handling process by scalding, scorching or bulk-burning.

WALNUT ("D"): Tobacco which is chiefly composed of leaves having a dull or dingy finish and a very dusky or dark shade of brown colour and which is not crude, green or mixed.

WASTE: That portion or portions of the lamina of tobacco which has been lost or rendered unserviceable for use in tobacco products, including: - (a) portions which have decomposed or largely decomposed by field diseases, sun-scorch, pole-burn, barn-scorch or bulk-burn, and (b) portions which are dead, lifeless, and do not have sufficient strength or stability to hold together in the normal manufacturing process due to excessive injury of any kind.

WOODY: Harsh.

WRAPPERS: A group of tobacco normally originating from the middle of the plant, and having characteristics as defined in the specifications.
Grading the tobacco is simply the sorting of leaves into uniform lots according to body, colour and degree of damage or spotting.

In countries where tobacco is produced under contract or for a specific market, the buyer usually stipulates, in the form of a detailed specification, the grades he requires and the tolerances in each.

When produce is to be sold on the international market, without any specific buyer, the detailed classification of a well-known tobacco-growing country should be followed.

If the official American classification is taken, it is found to contain 172 grades for flue cured tobacco, which are formed by the following factorial combinations:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Qualities</th>
<th>Colours</th>
<th>Special Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>wrappers</td>
<td>choice</td>
<td>lemon</td>
<td>greenish</td>
</tr>
<tr>
<td>leaf</td>
<td>fine</td>
<td>orange</td>
<td>dappled</td>
</tr>
<tr>
<td>smoking leaf</td>
<td>good</td>
<td>red</td>
<td>light green</td>
</tr>
<tr>
<td>cutters</td>
<td>fair</td>
<td>mahogany</td>
<td>medium green</td>
</tr>
<tr>
<td>lugs</td>
<td>low</td>
<td>walnut</td>
<td>dark green</td>
</tr>
<tr>
<td>primings</td>
<td>poor</td>
<td>variegated</td>
<td>unsafe keeping</td>
</tr>
<tr>
<td>nondescript</td>
<td></td>
<td>mixed</td>
<td>green</td>
</tr>
</tbody>
</table>

At the beginning of the experimental tobacco programme undertaken in Ethiopia, it was thought advisable and wise to begin grading with a simple classification, so that it is possible to differentiate the essential characteristics of the first experimental tobaccos and also gradually train the staff and workers in this very special operation.

In 1973, the flue cured Virginia, light air cured Burley and dark air cured 1972 tobaccos will be graded according to the following criteria:
### 4.1. FLUE CURED

<table>
<thead>
<tr>
<th>Primings</th>
<th>P_1</th>
<th>≤ 37 cm</th>
<th></th>
<th>P_2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>round tips</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>normally tissued to very thin bodied</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bright color</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>earthy aroma</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>may have material amount of injury or disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lugs</td>
<td>L_1</td>
<td>&gt; 37 cm</td>
<td></td>
<td>L_2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>good maturity, well cured</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>thin body to tissued</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>more pronounced tip than primings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bright color - to slightly orange</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a few disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutters</td>
<td>C_1</td>
<td>&gt; 37 cm</td>
<td></td>
<td>C_2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>thin to medium in body</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>good elasticity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>light color to orange</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a few disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf</td>
<td>B_1</td>
<td>&gt; 37 cm</td>
<td></td>
<td>B_2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>heavier normally narrower body</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>less elasticity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>prominent midrib, more pointed tip</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>orange to mahogany</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tips</td>
<td>T_1</td>
<td>≤ 37 cm</td>
<td></td>
<td>T_2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(subdivision of B group)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>heavy body</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>any lot containing 25% or more &lt; 30 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>poor texture</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>darkish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refusal</td>
<td></td>
<td></td>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>

(P_2 = P_1 with one or two lacks)
(L_2 = L_1 with one or two lacks)
(C_2 = C_1 with one or two lacks)
(B_2 = B_1 with one or two lacks)
(T_2 = T_1 with one or two lacks)
### 4.2. BURLEY

- **Well cured**
- **good lustre**
- **very few blemish**
- **lost of lustre**
- **limited pale barn**
- **blemish**
- **greenish**
- **(non descript USA)**

<table>
<thead>
<tr>
<th>Component</th>
<th>Symbol</th>
<th>Length limit</th>
<th>Shape/Color</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F. Flyings</strong></td>
<td>$F_1$</td>
<td>$\leq 37$ cm</td>
<td>thin body, with rounded tip, yellow, cinnamon or mahogany, some degree of injury or disease</td>
<td>$(F_2 = F_1$ with one or two lacks)</td>
</tr>
<tr>
<td><strong>X. Lugs</strong> (or $F$ long)</td>
<td>$X_1$</td>
<td>$&gt; 37$ cm</td>
<td>larger than $F$, more tipped, sounder in body, light in color</td>
<td>$(X_2 = X_1$ with one or two lacks)</td>
</tr>
<tr>
<td><strong>C. Cutters</strong></td>
<td>$C_1$</td>
<td>$&gt; 37$ cm</td>
<td>as wide as long, heavy body, cinnamon to red color</td>
<td>$(C_2 = C_1$ with one or two lacks)</td>
</tr>
<tr>
<td><strong>B. Leaf</strong></td>
<td>$B_1$</td>
<td>$&gt; 37$ cm</td>
<td>same heavy body, darker color</td>
<td>$(B_2 = B_1$ with one or two lacks)</td>
</tr>
<tr>
<td><strong>T (Tips)</strong></td>
<td>$T_1$</td>
<td>$\leq 37$ cm</td>
<td>darker and thicker</td>
<td>$(T_2 = T_1$ with one or two lacks)</td>
</tr>
<tr>
<td><strong>R</strong></td>
<td></td>
<td></td>
<td>Refusal</td>
<td></td>
</tr>
</tbody>
</table>

*Ref: L. Burrell, 1961*
4.3. DARK AIR CURED

1st grade
- more than 40 cm
- well cured
- no heavy body
- sound tissue
- warm maroon (chestnut) red color

2nd grade
- more than 40 cm
- no heavy body
- light color a little yellowish
- warm to fairly warm tint
- tissue with sufficient holding and fairly sound

3rd grade
- all lengths more than 32 cm
- sound tissue more or less coarse
- reddish or yellowish color, fairly warm

4th grade
- all lengths more than 30 cm
- material amount of injury concerning integrity and body
- dark color, brown more or less greenish
- too thick and rough tissue

R - Refusal
4.4. GRADING PROCEDURE FOR THE EXPERIMENTAL TOBACCOS

General remark: Each time the batches are handled, they must be treated with care so as to avoid losses and damage to the leaf which would be detrimental to the validity of the experiment results.

1. The tobacco hung in the barn is allowed to absorb moisture by taking advantage of the night humidity or supplemental moistening by leaving the doors and ventilators open at night.

2. The tobacco is unloading, by labelled harvest in each elementary plot, early in the morning before it is dry.

3. Each batch is made up into bundles tied with thread and joined to form a rope which is marked at each end with the two labels already used for the harvest and tying.

4. Each batch is weighed and the number of bundles marked.

5. The leaves are put in temporary bulks in the fermentation room in a compact mass formed by two rows of bundles with the bundleheads towards the centre.

6. The relative humidity in the fermentation room is kept at 75 %

7. For light air cured and dark air cured tobaccos, active fermentation bulks are made as soon as there is enough leaf in the right condition in the temporary bulks to form a mass of at least 2 m. x 3 m. x 1.5 m. These tobaccos will be graded when the internal temperature becomes stable.

8. The flue cured tobaccos are sorted into grades after 2 to 3 weeks' storage in temporary bulks.

9. The amount of tobacco to be sorted is prepared the day before by spreading out the batches in the grading room where the relative humidity will be kept at 80-85 %.

10. The grading of each batch begins by checking the weight. If a rope of bundles breaks, the number of bundles recorded in the barn note-book is checked. If necessary, the whole batch is reconstituted.

11. Each separate batch is graded by one worker who sorts it according to the criteria selected for the season and the type of tobacco.
12. The graders must be supervised continually by a grading supervisor.

13. As soon as the batch has been graded on the sorting board, the grades are weighed and records kept on the cards provided by a supervisor with experience in this type of work.

14. Samples are taken for valuation and/or chemical analysis according to the procedure chosen for the trials.

15. The tobacco is kept in bulk by grade in the baling room where the relative humidity is kept at 40-50%.

16. As soon as there is enough tobacco in a specific grade, it is baled.

17. The bales are labelled with their origin (1), year of production (2), type of tobacco (3), weight (4), grade (5) and bale number (6); e.g.

```
  7(6)   80(4)
     IAR 72 (1) (2)  
      FC   X2   (3) (5)
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18. The tobacco to be valued and analysed will be baled separately.

19. A bale register will be kept.
After curing, tobacco is not yet a raw material fit for direct use by the manufacturing industry. The leaf must undergo fermentation treatment which is mainly designed to develop its particular qualities and make it easier to store.

The tobacco is fermented and baled either by the grower himself, or by growers' co-operatives, or by middle men between the grower and the manufacturer, or directly by the state or private manufacturer.

1. **GENERAL REMARKS**

There are several fermentation methods (in bulk, bales, crates or hogsheads) which vary mainly according to the types of tobacco. These methods determine the nature of the process, the changes in the tobacco and the conditions to be provided so as to obtain the best results.

The various methods of fermentation, in the widest sense of the term, can be divided into 3 types:

- **Active fermentation**, whose main feature is a significant rise in temperature. It is used for all cigar tobaccos and nearly all dark tobaccos.

- **Moderate fermentation**, used for aromatic tobaccos.

- **Slow fermentation or rather aging**, in which the tobacco does not undergo any conspicuous heating. This is used for flue-cured Virginia, for example.
2. **CHANGES IN THE TOBACCO DURING FERMENTATION**

The changes in the tobacco generally follow the same lines, but they occur to a lesser or greater extent according to the fermentation method used.

### 2.1. Taste and physical quality changes

During fermentation, the colour of the tobacco becomes more uniform, but darker and slightly duller. The green shades disappear. The body of the leaf becomes less rubbery and if it is over-fermented the leaf may lose some of its resistance and elasticity. Lastly, the leaf loses water and its hygroscopic properties are reduced.

Freshly cured tobacco leaf is unfit for use because of its pungent and irritating smoke. By the process of fermentation or aging, the leaf delivers mild and aromatic smoke.

The extent of these changes depends upon the degree of fermentation, that it is to say the temperature produced in the tobacco and the length of the process. If fermentation is too intense or too long, the leaf may lose the advantages obtained from normal treatment.

### 2.2. Weight loss

A general feature of fermentation is weight loss, resulting from losses of water and dry matter.

The initial water content of dark air cured leaf fermented in bulk averages 22 to 27%. After baling, the moisture rate is 15 to 18%. This drop results partly from heating which leads to evaporation, and partly from the chemical changes, especially in the albuminoid substances, which lose their water retention capacity. The weight loss is from 3-4% to 10-12% for air cured tobacco and 1-2% for flue-cured.

### 2.3. Chemical changes

During fermentation, the water soluble components of the leaves, amounting to 2-4% of the weight of the tobacco, become water soluble. This effect is caused by:

(i) the formation of calcium phosphate, calcium oxalate and other water insoluble calcium compounds,

(ii) the shift of some of the water soluble nitrogen compounds into water insoluble fractions,

(iii) the insolubilisation of some unidentified non-nitrogenous organic leaf components.
2.3.1. Carbohydrates

For flue-cured tobacco, the carbohydrate content, especially sugars, is very high. The drop varies, but is generally low because fermentation is not very active.

In dark air cured tobacco, carbohydrates only occur in small amounts. The starch has already been eliminated by proper drying. If any sugars remain, they may partly disappear during fermentation.

2.3.2. Nitrogenous substances

The various nitrogenous substances are modified to varying degrees according to the type of tobacco and fermentation process. The protein content, however, never drops very much.

With dark air cured tobacco, a slight increase in insoluble nitrogen is found to occur, probably as a result of some amino-acids combining with the sugars or polyphenols. The simple forms of nitrogen change the most, especially the amino-acids which diminish and ammonia which increases.

2.3.3. Gas emission

Apart from the elimination of water vapour, the most important phenomenon is the emission of carbonic gas.

Other substances (etheral oils, methyl alcohol, ammonia, etc.) are emitted, with characteristic odours with can indicate how the changes are occurring. The smell must always be natural. At the beginning it is similar to the smell of fresh bread. A smell of ammonia, when it is not too strong, is quite normal during the fermentation of dark air cured leaf.

On the other hand, leaf which is subject to decay gives off a really offensive smell (rotten fish) due to certain volatile amines.

3. FACTORS INFLUENCING FERMENTATION

3.1. Types of tobacco and nature of the leaves

Fermentation varies according to the type of tobacco and nature of the leaves, which in turn depend upon growing and drying conditions, degree of ripeness, position on the stalk, etc. For these reasons, leaves grown during wet weather heat more readily than leaves produced under dry conditions. The higher leaves ferment more actively than the lower leaves. These observations show that the leaves must be sorted beforehand for the tobacco to be fermented in uniform batches.
As fermentation is essentially an oxydisation process, catalyzed by enzymes, it requires oxygen and environmental conditions suitable for enzyme activity.

3.2. Oxygen

Oxygen is essential for fermentation. The bundles must therefore be aired, by shaking them before laying them in rows when making the bulks.

3.3. Environmental conditions

To be effective, the diastases require a certain degree of humidity and a suitable temperature. Under dry conditions they have no effect.

The effect produced by the initial moisture content of the tobacco is of prime importance. The higher it is, the more intense fermentation is. Although it is not negligible the effect of the weight of the batch is not so significant.

The recommended initial moisture content for dark tobacco is 25% (which can be checked in a drier) with an ambient temperature of between 20 and 70°C and a relative humidity rate of 80%.

Finally, apart from the amount and compactness of the tobacco, which have indirect effects, the most important factors are:

(i) the initial moisture content of the tobacco
(ii) the ambient temperature
(iii) relative humidity of the air.

In view of some unfavourable environmental conditions, methods have been sought, in various countries, to create suitable conditions artificially.

4. NATURAL FERMENTATION

4.1. Active fermentation of light and dark air cured tobacco

This treatment, whose main feature is fairly high temperatures, is generally used for cigar tobacco and dark tobacco. It is often completed by maturing after baling. It is also used for light air cured tobacco when no redrying artificial fermentation equipment is available.
4.1.1. Bulking

The tobacco should normally be sorted into uniform batches, particularly as regards to body. As for the initial moisture content, it may be necessary to prepare the tobacco in temporary bulks to give it the proper moisture content.

The bulks, which are built on the floor of a properly ventilated building, vary in size. They are parallelepiped in shape, with the sides quite vertical up to the top. For normal healthy tobacco, they may be 1.60 m. to 2.50 m. wide and 1.80 m. to 2 m. high, with the length depending upon the size of the room.

The piles are formed by successive layers of bundles laid with the tips towards the middle. The rows are begun simultaneously on opposite sides of the bulk, with the successive rows in the same course laid in the same direction so as to cover about a third of the bundles in the row below. On this first course a second is laid perpendicularly, and the process is continued until the desired height is reached.

When the bulk is being built, a wooden tube is laid horizontally, half way up, with its end in the middle of the bulk. A maximum thermometer is placed in it to measure the temperature of the tobacco.

The temperature is checked twice a day, making sure that the thermometer is whirled at each reading and the result recorded on a diagram.

4.1.2. Fermentation control – Turning

Under normal conditions, fermentation begins shortly after the tobacco has been bulked. The temperature gradually rises to a certain level and then tends to drop.

The rate at which the temperature rises and the level it reaches depend upon the factors mentioned above. On average, the maximum temperature varies from 44 to 55° C, and is reached after 10 to 25 days.

If the tobacco was left, the temperature would fall and gradually drop to the ambient temperature. But the tobacco would be likely to deteriorate through anaerobic fermentation and the leaf on the outside would not have fermented enough.

This is one reason why the bulks are turned, by breaking them up and rebuilding them to one side, taking care to put the leaf that was on the outside in the centre, and vice versa. This must be done as soon as the temperature begins to drop.
Overheating consists of an abnormally high and rapid rise in temperature in some places in the bulk where the tobacco
is too damp. An external sign of overheating is when the bulk sinks. The leaf turns black and loses its elasticity. To limit the damage, the bulk must be turned so as to lower the temperature.

(iv) Condensation

The rise in temperature in the middle of the bulk leads to a considerable amount of water vapour being given off. If the temperature in the room is low, the outside parts of the bulk act as a cold surface and the water vapour condenses.

4.1.4. Baling

The end of fermentation is shown by the drop in temperature and also by the characteristics of the tobacco (colour, smell, etc.).

The tobacco is pressed and baled at humidity rates depending of the type of 13-18% in hemp sacking, in bales measuring 80 x 80 x 40 cm and weighing 100 kg on average, depending on the nature and compressibility of the produce. The bales are stored in piles 2, 3 or 4 bales high. The tobacco then matures. The temperature should be checked, since it sometimes tends to rise a little too high, especially if the humidity rate is too high.

4.2. Slow Fermentation - Aging in hogsheads

Flue-cured Virginia and Maryland tobaccos only undergo aging in hogsheads. The same applies to some dark tobaccos such as flue cured.

4.2.1. Flue-cured Virginia

After the tobacco has been piled up for a few days after being untied, it is graded.

It is then packed for maturing, which is a sort of aging in hogsheads. For this, it must be packed at a relatively low moisture content rate of 10 to 12%. When the water content is too high, the leaf becomes dark and deteriorates.

After packing, the wooden hogsheads are laid on their sides and stacked in a well ventilated place where they are exposed to the temperature and humidity variations. Maturing is slow and takes 18 months to 2 years on average. The colour becomes slightly darker and duller and the aroma develops.
To pack these tobaccos under proper conditions, they are first of all treated in special machines which make it possible to pack them rapidly by a redrying process to bring the moisture content down to 10-12% for flue-cured.

4.2.2. Burley

Burley tobacco also only undergoes slow maturing and the redrying process is also used for packing it with a low moisture content (7 to 10%).

Without this equipment, this type of tobacco can be put in active fermentation, like dark air cured tobacco, by placing bundles with high moisture contents in bulks. The bulk should be turned when the daily temperature check shows that the temperature has reached 45-48°C.

5. ARTIFICIAL FERMENTATION

Natural fermentation takes rather a long time (several months) and requires a lot of room and costly handling. It does not protect the tobacco from the accidents that are likely to occur. To avoid these drawbacks, methods have for a long time been sought to ferment tobacco under artificial conditions which shorten the length of treatment considerably and make it possible to operate at any season of the year.

5.1. Dark air cured tobacco

(i) in fermentation rooms

The tobacco is fermented in special rooms in which certain conditions must be combined (temperatures of up to 70°C and relative humidity of up to 90%).

Fermentation lasts from 6 to 12 days.

(ii) pre-accelerated fermentation

Apart from controlling temperature and relative humidity, a chemical process has been formulated to stimulate the action of the enzymes.

The starter used is ethylene oxide and a vacuum of 700 mm Hg is necessary.

5.2. Other special processes (electrofermentation, infra-red, ultra-violet, high frequency and ionizing ray treatments) are still in the experimental stage for various types of tobacco.
Some factors that have to be considered to answer the question: "would it be worth while to provide supplementary irrigation for tobacco?" are discussed here. They include the effects of water-stress on the plant, its response to applied water, the probability of drought and the likely profitability of irrigation.

1 - THE TOBACCO PLANT AND WATER

The ideal weather for tobacco production has been described (Neas, 1953) as: "... occasional rains during the first six weeks or so of growth, followed by adequate moisture during the pre-blooming and final stage of growth". The life of the plant must be divided into three phases: the seedbed phase, the development phase from transplanting to about topping time, and the maturation phase during which the leaves ripen and are harvested.

2 - THE SEEDBED PHASE

The supply of water is controlled for most, if not all of this phase and adequate water is applied to ensure complete germination of the seed and subsequent rapid growth of the seedling.

However, in the final stages prior to transplanting a period of moisture stress is necessary to prepare the plant for the hot, dry transplanting conditions and to provide it with a mechanism of drought resistance during the development phase.

Plants hardened in this way in the seedling phase withstand a mid-season drought better than those that are not stressed in the seedbeds and also grow faster when the stress.
is relieved. The type of mid-season drought referred to is fairly common and even occurs under irrigation when the air is very dry and the irrigation cycle is seven or more days in the case of furrow irrigation.

3 - THE DEVELOPMENT PHASE

Rain or irrigation during the first two to three weeks after transplanting leaches mobile nutrients such as nitrogen and potassium beyond the root system and restricts root development.

To some extent the nutrients can be replaced by top dressing but the restricted root system severely limits subsequent growth.

At about topping time the plant has maximum leaf area and loses considerable amounts of water in hot, dry weather.

If the root system is small and shallow and water in the root zone is depleted, the plant wilts severely.

In an experiment conducted in tropical wet season, seedlings were planting into a soil at field capacity, some were not watered again for three and others for five weeks. After three weeks only the surface soil had dried appreciably, while after five weeks the upper 30 cm of soil had dried to 50 per cent of field capacity. Root development and subsequent yield in the drier soil was much the larger. The final yield of cured leaf was 709 kg/ha more where post-planting irrigation was delayed for five weeks.

<table>
<thead>
<tr>
<th>Date of planting</th>
<th>Irrigation</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>preplanting</td>
<td>supplementary</td>
</tr>
<tr>
<td>Day 0</td>
<td>- 5</td>
<td>+ 18</td>
</tr>
<tr>
<td>Day 0</td>
<td>- 5</td>
<td>+ 35</td>
</tr>
</tbody>
</table>

Leaf expansion and dry matter accumulation slow down during the stress but this is usually compensated for by accelerated growth where stress is relieved.

Prolonged stress, however, usually results in scorched leaves of decreased value, and a marked setback in growth.

Recovery after rain or irrigation, nevertheless, is usually remarkable and yield is decreased only in the most extreme circumstances.
3 - THE MATURATION PHASE

When leaves are no longer expanding rapidly drought has little effect on leaf size. However, leaves become heavier because dry matter accumulates even plants wilt during part of the day, and the rate of ripening usually decreases. As a result, the cured product is usually dark coloured and coarse textured and is high in nicotine. Leaf scorch after topping occurs only in extreme droughts and this lead to a marked drop in quality.

Wet conditions, particularly when they are associated with overcast during this phase result in faster ripening and an increased incidence of diseases such as white mould, alternaria, wildfire and hollow-stalk.

4 - RAINFALL PROBABILITY AND DATE OF PLANTING

It is difficult to decide on supplementary irrigation for a crop planted at the normal time in the rainy season. In some years irrigation would be an advantage and in others this expensive investment would be idle. The need of a drought probability survey is essential, but depends on the available records. This type of information will indicate whether there is sufficient probability of drought in a particular area to make irrigation of crops, such as tobacco, worth while when they are planted at the normal time of the year.

Irrigation should also be considered as a mean of establishing a crop well before the start of the rains and then supplementing rainfall when necessary during the rainy season.

Without irrigation the earliest date of planting is governed by the expected start of rains. The usual recommendation is to begin planting about two weeks before the date on which there is an 80 per cent probability of effective rain.

One of the difficulties of this planting date is the occasional shift of the rainy season that results in wet conditions too early in growth and a consequent loss of yield.

There is a much better chance of dry weather early in the development phase if the crop is planted earlier than normal with irrigation. This technique has a further advantage in that the crop will be growing under the most favourable climatic conditions.

(From H.D. Papenfus, TRB, 1972)