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**Field Operations  
Trial Management  
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and  
Compilation  
in  
Mustard and Rapeseed  
Research**

Edited by  
Nigussie Alemayehu  
Bayeh Mulatu

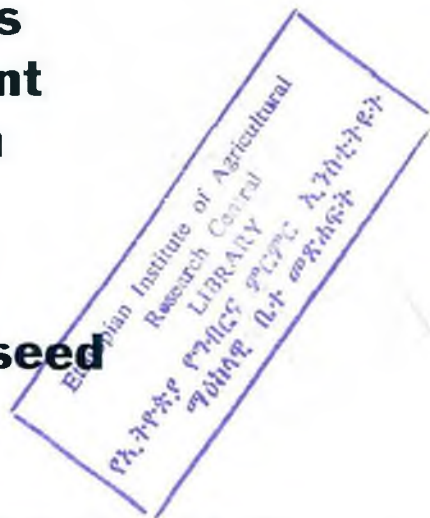
**Technical Manual No 16**

Ethiopian Agricultural Research Organization



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2003

# Field Operations Trial Management Data Collection and Compilation in Mustard and Rapeseed Research



Technical Manual No 16

## Contributors

Nigussie Alemayehu  
Adefris Teklewold  
Agaje Tesfaye  
Alemayehu Refera  
Awgichew Kidane  
Bayeh Mulatu  
Bulcha Weyesa  
Elias Zerfu  
Getachew Mohammed

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Copyediting and design: Abebe Kirub

Page layout: Kidanemariam Hagos

Printing: Abesolom Kassa

Binding and collation: Woudnesh Mamo and Miftah Argeta

Distribution: Akililu Woube, Enanu Dagne and Bogalech Abebe

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## **Preface**

The vegetable oils, which are also called fatty or fixed oils are of paramount importance in human diet. Among other things, they are concentrated source of caloric energy, supply the body with the essential fatty acids, and maintain cell structure and membrane functions and many others. Above all, fats and oils play a key role to offset the existing gloomy-effects of protein-poor nutrition in developing countries in general and in our country in particular. In the face of ever increasing rural population and limited resources coupled with the unwarranted physical environment, the need for crop diversification, development of value-added products and the provision of products for industrial uses are not only pertinent to the agricultural policy of the country but are also crucial to the very survival of the rural livelihood. In such a situation of utmost urge for the development of rural economy, oil crops, as has been proved in many countries, play a special role to fill up the gap.

It has been said, time and again, that Ethiopia is endowed with an enormous wealth of genetic potential for oil crops as bounteous as it is for cereals, pulses, medicinal plants, spices, forest genetic resources, etc. Of all the oilseed crops cultivated in the country, the oilseed brassicas occupy a special place. They are among the oldest crops to have been domesticated by the Ethiopian farmers many centuries back. They have been used for an array of purposes ranging from for food, feed, beverages and medicines to abortive concoctions.

Under Ethiopian conditions, as attractive for edible oil production as these crops may be, they are threatened by a long-list of biotic as well as abiotic factors, which instigate the need for undertaking research on them. Research on the oilseed brassicas in Ethiopia commenced during the late 1960's and over the last several decades, quite encouraging results, in terms of improved varieties and production technologies, has been compiled. These research experiences of our predecessors and contemporary colleagues together with our own involvement in the research for over 15 years have been the impetus for us to prepare this guide. It is our conviction that this manual will be of great help especially to young scientists who will join the oilseed brassica research arena of the various research teams in the different research centers.

*Editors*



## Introduction

In Ethiopia, a considerable number and diversity of plant species are known to bear fixed or volatile types oils. They are found in a state of either cultivation, wild or semi-wild forms. Despite such a prominence of diversity, however, only very few crop species, which include the oilseed brassicas are being used as a source of edible oil in the country. The genus *Brassica* of the family Cruciferae (old taxonomic name Brassicaceae) includes some 37 species of great agricultural importance. They are valued for their edible roots, stems, leaves, buds, flowers and seed oils. Cultivation of *B. carinata* in Ethiopia is an ancient practice dating back to the 4–5<sup>th</sup> millennia BC (Simmonds, 1979). *B. napus* is a very recently introduced species probably not more than 30 years.

Several species are implicated within the general trivial name “mustard and rapeseed”. These include: the Ethiopian/Abyssinian mustard (*Brassica carinata* A. Braun), Indian/Brown/Oriental mustard (*B. juncea* L.), the turnip/bird rape (*B. campestris* L.), the true rapeseed (*B. napus* L.), black mustard (*B. nigra* Koch.) and white mustard (*Sinapis alba*) which is also known as yellow mustard (*B. hirta*). The term “mustard” is derived from the use of the seed as condiment: the sweet “must” or “mustam ardens” for the purpose of which *B. nigra*, locally known as “senafich”, is popular. Excluding *B. nigra* and *Sinapis alba* the other four species are all together termed, in the world literature, as the “oilseed brassicas” and the Amharic name “gomenzer” generally equates the latter although traditionally represents only *B. carinata*. In Ethiopia, only two of the oilseed brassicas, namely *B. carinata* and *B. napus* are being cultivated for the production of edible oil.

## Evolution

Cytotaxonomic evidences have long shown that both *B. carinata* and *B. napus* are amphidiploids (Allotetraploids) derived by natural hybridization between their respective diploid ancestors. The Japanese Scientist Nicolas U (1935) has illustrated the evolutionary relationships of the oilseed brassicas in an arrangement of a triangle named after his name, the U – triangle (Fig. 1).

*Brassica carinata* with genomic formula BBCC = 34 is a result of a natural hybridization between the diploids *B. nigra* and *B. oleracea* followed by chromosome doubling in the highlands of Ethiopia where both the ancestors were sympatric. Similarly, *B. napus*, (AACC = 38) is an allotetraploid derived from *B. campestris* and *B. oleracea*.



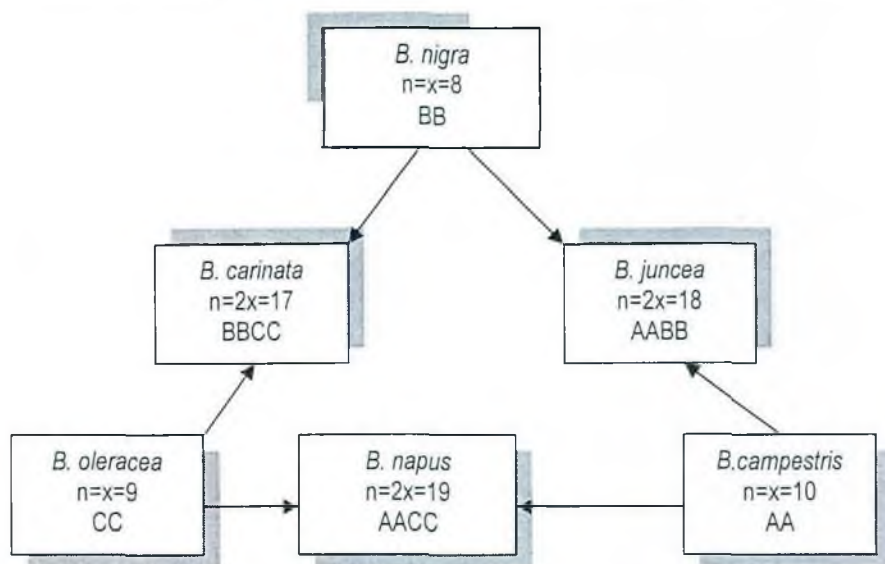


Fig.1 Genomic relationships of the major oilseed *Brassica* spp. (after U, 1935)

## Morphology

Both *B. carinata* and *B. napus* have a substantially elongated taproot (reaching up to one meter or more) with numerous laterals. The two species can be distinguished in the field once the stems elongate and leaves develop. In *B. napus*, the lower leaves (except the first few true leaves) partially clasp the stem while in *B. carinata* leaves are petiolated and do not clasp the stem.

The inflorescence is an elongated raceme, borne terminally on the main stem and branches. The flowers are typically bright – yellow although flower color varies from orange to creamy white. It is also possible to distinguish the two species by looking at the position of open flowers in relation to younger (non-open) pods on the terminus of same branch. While in *B. napus* open flowers hang above the younger pods, the reverse holds true in *B. carinata*.

The fruit is a long narrow pod which is botanically a silique (pl = siliqua) consisting of two carpels separated by a false septum (false, because it does not develop from the ovarian tissue) which upon maturity, the two carpels split along the septum and thus causing shattering of seeds in *B. napus* but not in *B. carinata*.

The seeds are mainly embryonic and are often small. They have a characteristic feature of epigeal germination, whereby the cotyledons emerge above the ground and thus, are photo-synthetically active to offset the negative consequences of insufficiency of the reserve food, which in turn emanates from the size of the seeds.

## Adaptation and Importance

For oilseed production in Ethiopia, *B. carinata* is of prime importance between the two species. Since recently *B. carinata* is being cultivated also in Spain following the development of varieties with oil of edible quality and efforts are underway to develop suitable varieties of *B. carinata* for the Australian and Canadian conditions. *B. napus* is a widely distributed oilseed crop of Europe, Canada, India and China. Both winter and spring forms of *B. napus* are grown in Europe while only the spring type is grown in Canada. In Ethiopia both species are best adapted to the highlands ranging from 2000 – 2600 m.a. s.l. *B. carinata* is traditionally used for different purposes including: for greasing the traditional bread-baking clay pan, the “Mitad”, treating certain ailments and stomach upset and preparing beverages. Boiled leaves of young plants are consumed as vegetable relish. The oil, very often adulterated with oils from niger seed (noug) or linseed, is the most important product. An additional advantage of oilseed brassicas in the farming systems as potential break-crops for cereals is certainly immense.

## II

# Trial Management

Trial management includes both pre- and post-treatment operations. It involves also observance and handling of both experimental and non-experimental variables. Experimental variables are those variables, which are associated with the planned treatments for the experiment and non-experimental variables are those operations and other constants, which are uniformly applicable to all experimental units.

## Site Selection

Adjacent plots receiving different treatments are supposed to be as uniform as possible. The major causes of differences are soil heterogeneity, cropping history and management and the principal features that intensify local heterogeneity and thus which require due attention include.

### Field history

Areas that were sown to different crops with different fertilizer levels, various management practices, fallow areas, alleys etc, are sources of variation; and thus, these differences should be recognized in selecting experimental sites.

### Graded areas

To reduce the unevenness in the field or to layout the field for proper drainage and enable uniform irrigation, field grading is done. Removing the topsoil from elevated areas to the lower areas of the field can do the grading. This will also result in uneven depth of surface soil and at times exposes the sub soil, which again can be a source of experimental error.

### Presence of large trees, buildings and other structures

These influence the experiment by shading the neighboring plots, and root competition by trees. These situations, if possible, should be avoided and in case it is not possible to avoid them, the treatments in a block should be laid out in such a way that they will all be exposed uniformly.

### Slopes

Observance of the degree and direction of slopes is crucial. This is so because soil fertility gradients are more pronounced in sloping areas. Since soil nutrients are soluble in water, they can easily be washed off from higher ground level and deposited at the lower areas. Differences in slopes within the block can be source of variability in hydrology. When there is higher water supply from rain or irrigation, while plots at the upper part of the slope will have better aeration and favorable water absorption, plots at lower areas will have excess water and retarded absorption of both water and nutrients.



### **Unproductive site**

A field with very poor or problematic soils in patches should be avoided unless the experiment is designed specifically to evaluate such conditions.

## **Seedbed Preparation**

This is often an operation to be established and carried out as a routine practice in research centers or sub-centers usually by the Farm Management Units. Deviations occur when needs arise to use newly cropped/fallow lands, on-farm fields and the like. Choice of tillage method, the timing of tillage and previous cropping histories are of extreme importance for a good seedbed. A good seedbed, in the context of oilseed brassicas, is a smooth and firm seedbed without large soil lumps, and seedlings or remnants of weeds. Such a seedbed ensures a uniform seeding depth and thus an even emergence of the crop thereof; and a condition under which the seedlings will grow free of weed competition at the stage when they would otherwise be most sensitive. Unless otherwise it is meant for tillage experiments, a single primary plowing with a moldboard plow and twice harrowing with a disc harrow is sufficient for a field, which previously was under cropping. The primary tillage and the first harrowing shall be done during the period of the small rain (March – April) and the second harrowing a week or two before the time of seeding. If the plowing operation has to be done with animal-drawn implement, the “Maresha”, three – plowings are in order. The first two tillage operations are to be done during the short rain (March – April) and the third just before planting in June.

For pot experiments in the lath-/green/glass/poly – house, different pot types could be used. Pots large enough for single plants only (10cm diameter and 10 cm depth) or enough for three-four strong plants (20 cm diameter and 20 cm depth) are being used in research centers. Seeds could also be germinated in Petri dishes and when the radical is 3-4 cm long, they can be transplanted into multi-top growing trays where the young seedlings will grow until their second true leaf stage and will have to then be transplanted into permanent pots. Since both mustard and rapeseed are sensitive to standing water, the pots have to be porous from the bottom for proper drainage. Watering can is done twice a day depending on the rate of evapotranspiration. In all cases, pots have to be filled with soils mixed in a 3:1:1 proportion of field – soil (red, Nitosols for example), sand and compost.

## **Field Layout**

Before doing the actual field layout, one has to assess the general situation and suitability of the field for the experiment intended. These include such considerations as for example the size of the field in comparison with the area required for a particular experiment, absence of the factors and features leading to soil heterogeneity, etc. As much as possible, it will be prudent if the whole set of an experiment falls in a rectangular block of field. Once the field is assessed, it is always useful to put the sketch of the whole experimental plan including details of plot dimensions and benchmarks on to the paper. During field layout, the most commonly committed error is in measuring plot dimensions. It is thus, always important to double check whether the actual plot



measurements made in the field are consistent with plot dimensions sketched on the plan.

In order to construct the field layout, the guiding principle is the famous Pythagoras theorem on the algebraic relationship between the sides of a right angle triangle; whereby the square of the hypotenuse (the largest side of a triangle) is equal to the sum of the squares of the base and its height. Symbolically this could be represented as  $h^2 = b^2 + l^2$  where  $h$  = hypotenuse;  $b$  = base and  $l$  = height of the triangle as is exemplified in Fig 2. Point "c" of the figure is the benchmark from where the experimental block is assumed to start.

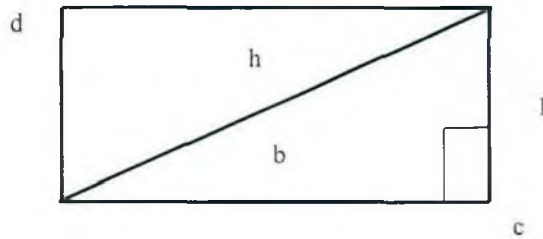


Fig. 2 The guiding principle of a right angle triangle to construct an experimental field layout

The step-by-step procedure of the layout include

- (i) Drive a wooden peg into the soil at point "C";
- (ii) Stretch a string from the peg at point "C" along the "b" or "l" direction desired to be the border-line between the experiment and the field. A tip is to fix the borderline along the longer side of the field. Extend the string in this direction up to a point some meters beyond the length of the plot dimension required for the experiment;
- (iii) drive another peg at the point marked to be the end and tie the string onto it very tightly;
- (iv) stretch out another string from the same peg at the origin (point "C") to the direction opposite to the border-line (along the line "b" or "l" as the case may be);
- (v) In order to make this string form a right angle at point "C" with the border-line, it has to pass through a definite point to be determined using the above equation. For practical purposes, this reference point can be determined by measuring a distance of 4m from "C" along the border-line ("l" – for example) and 3m along the base, "b"; now by definition "h" would be 5m and mark the point of junction on the tape by joining the "o" and 12m ( $3 + 4 + 5$ ). For a bigger block of experimental field, a 6+8+10 analogue of measurement can give a more precise layout. Marking can be done by setting a thin but straight piece of stick exactly at the juncture;
- (vi) Once the point of reference is determined, adjust the direction of the string along the base by stretching it well as far as required so that it can only just touch the reference stick (from the outer side of the experimental plot);
- (vii) At the end of the required distance from the origin, drive a peg into the soil and tie the string tightly;
- (viii) Determine the diagonal opposite corner of the origin (point "d") either by directly measuring both the vertical and horizontal sides or by the same 3, 4, 5-principle. Drive a peg into the soil at this point and extend the strings

- from the pegs at the ends of the border-line and the base and tie both strings tightly onto the peg;
- (ix) Once the four corners of the experimental field are in place, plots and blocks can be delineated using pegs according to the plan drafted on the paper.

## Seeding and Fertilizer Application

Mustard and rapeseed are very sensitive to sowing dates but are much less sensitive to a wide range of seed rates and also to sowing methods. Determination and observance of suitable sowing date for a given area are extremely critical and has to be established before anything else. For most of the growing areas in Ethiopia, it is one or two weeks after the onset of steady rains. A range of seed rate from 5-25 kg ha<sup>-1</sup> had only slightly affected seed yields of both species. Unless it is a seed rate trial, for standard practices, 12kg ha<sup>-1</sup> is found practical for row sowing while 15kg ha<sup>-1</sup> is apt for broadcasting. For each plot, an appropriate amount of seed has to be weighed, labeled and packed in a moisture-tight condition. When planting is done in rows, the seeds can either be drilled or placed in hills of regular intervals. With the latter case, 2-3 seeds have to be placed in each hill in order to ensure the development of at least a single viable seedling. In case if all the seeds in a hill succeed to develop, the excess seedlings have to be thinned out later while weeding. After sowing is done, the seeds will then have to be covered with a thin layer of soil (2-3cm depth) so that they will not be picked up by birds or washed away by the rain.

Traditionally, mustard is grown on humus-rich soils often around homestead and application of inorganic fertilizers is unfamiliar. As field crops, however, both mustard and rapeseed require a substantial amount of nitrogen and phosphorus fertilizers. The actual amount of fertilizer to be applied could of course vary depending on the native fertility status of the soil in a given area. But long-term experiences show that a blanket-rate of 46/69 kg ha<sup>-1</sup> of N/P<sub>2</sub>O<sub>5</sub> was found to be optimum for both species in almost all of the growing areas of Ethiopia. An exception is at Dembi/ Debre Zeit area where the crops can perform equally well under no-fertilizer conditions as they do with fertilizer application. For pot experiments, one has to calculate the amount of fertilizer required based on the weight of the soil filled in each pot. For practical purposes, a hectare of land represents 2\*10<sup>6</sup> kg of plow-layer soil.

Thus, for a pot with 2kg of such a soil, the fertilizer required would be

$$\frac{2 * 46 * 10^6}{2 * 10^6} = 46\text{mg of N and } \frac{2 * 69 * 10^6}{2 * 10^6} = 69\text{mg P}_2\text{O}_5.$$

Like the seed, the fertilizer required for the experiment should also be prepared on plot-basis well ahead of time. If seeding is done in rows, the amount of fertilizer has to be first determined for each row and has to be drilled and covered by a thin layer of soil by dragging a peg before sowing. Similarly, for pot experiments, the fertilizer has to be thoroughly mixed with the soil before putting into the pots. This is done in order to avoid a direct contact between the seed and the fertilizer thereby hindering possible osmotic-damages in the

former. If planting is done by broadcasting, the chance of such damage to occur is so slim that pre-sowing covering of fertilizers can be omitted. Under both sowing methods, the whole fertilizer should be applied at planting.

## Crop Management

### Drainage

As has been said earlier, newly sown seeds are covered only very thinly and thus can easily be washed away by flooding if it occurs soon after planting. Equally sensitive to either flooding or standing water are both the seedling and adult plants of mustard and rapeseed. It is therefore crucial that flooding is checked by constructing and maintaining ditches and water-ways from day one to the end of the growing period. Drainage ditches are better if constructed along experimental blocks and separate one replication from the other.

### Weed control

Since recent years, the parasitic weed, broomrape (*Orobanche ramosa*) has become a serious threat to both species of the oilseed brassicas. In addition to this, a very long list of annual as well as perennial weed species has been recorded. Yield losses as much as 60% could result from aggressive weed competition during the most critical stages (early establishment to budding). Hence, the crop has to receive two hand-weeding during these critical stages.

### Disease control

For leaf and pod spot, spray with Bayleton or Mistral. For the Blackleg, use disease free seeds or treat the seeds with hot water 25-30 minutes at 50°C or 0.2% suspension of Benomyl and Thiabendazole for 24hr.

### Insect pest control

For cabbage flea beetle (see part V for details), use Carbaryl 85% WP (1kg/ha) for effective protection of seedling damage. For the true cabbage aphid, apply the organophosphate, Pirimiphos-methyl 50(25) % depending on the availability (1 and 2l/ha, respectively) or the aphicide, Pirimicarb 50%WP (500g/ha). For the diamond back moth, spray the synthetic pyrethroid, Cypermethrin 25%EC (200ml/ha) or the organophosphate Malathion 50%EC (2l/ha).

### Harvesting and threshing

At maturity, plants have to be harvested from the net-area of each plot and put into a sack that doesn't let seeds to fall out. The sack has to be clearly labeled and in each sack, a copy of the label should be put. Threshing can be done either on a threshing ground or on a large canvas by beating the harvested crop with a stick while it is still in the sack. Care has to be taken not to lose or interchange the tag. The labels should at least contain the name of the trial, year, plot number, trial location and/or site and other pertinent information as deemed necessary.



## Controlling Non-Experimental Variables

It is impractical to consider all researchable factors seemingly affecting the output of an experiment simultaneously. The rule of the game is thus only few, no matter how much influence they might have, factors are investigated with an underlying assumption of "*ceteris paribus*" meaning that the influences of all other factors will remain constant. Though it is well known that there is always a G x E – interaction, the investigator keeps, as much as possible, the non-experimental variables constant. Experimental variables are the variables, which are associated with the planned treatments for the experiment and non-experimental variables are those operations and other constraints, which are uniformly applicable to all experimental units. The researcher should not for example irrigate a particular multi-location trial in one/or another location just because it is unusually affected by drought while at all the other locations, the experiment is conducted under rain-fed conditions. Such management practices as for example weeding should be applied to all experimental units (treatments) in one replication all in the same manner and /or day.

With on-farm experiments, it is customary to keep the levels of non-experimental variables at the average farmers' practices. For on-station experiments, on the other hand, non-experimental variables are kept at levels, which the researcher thinks will be favorable for maximum performance of the experimental variable.

### III

## Data Collection and Record Keeping

When planning the experiment, you should be able to clearly identify observations. Since the whole purpose of doing the research is to generate reliable data, the data collection part of the research process is critical. In order to facilitate the collection, the researcher should always have a well prepared field book and observation notes.

Recording of data is usually done using pre-planned and prepared record- or field- books and the field book should be so designed that all data are entered directly by a pencil. To properly assess experimental data, chronological notes should be recorded in the field book. The field book should also contain the field plan. The data/observations to be recorded, of course, depend on the effects of the treatments to be evaluated. The plan should contain a schedule for data collection, which ensures timely and unbiased evaluation of each and every observation to be recorded.

In the oilseed brassica, more than 30 types of agro-morphological, biochemical and physiological data as well as data related to the reactions of the crops to diseases, insects and other pests are recorded. The data could be categorized as those associated with date (which are called temporal data), seed yield and yield components, disease, insect, other vertebrate pests; oil quality, other biochemical, and agronomic considerations. A brief account of each follows.

### Temporal Data

These are data associated with time and they should all be entered in Gregorian calendar. For each of the events, the number of days has to be calculated, as deemed necessary, taking date of sowing as a reference.

#### Date of sowing

It is essential that the date, month and year be recorded in the field book for each experiment immediately after sowing.

## **Date of emergence**

In its strict sense, emergence is quite different from germination. A seed to emerge has to certainly germinate, but germination alone doesn't warrant emergence. Emergence for the oilseed brassica is the outburst of the cotyledons (epigeal type of emergence) from the soil and become visible just above the ground. The date of emergence is the date at which ca. 50% of the seedlings expected in a plot (experimental unit) emerge.

## **Date of commencement of flowering**

The first flower appears in a plot at this date. It is probably the simplest to collect for the fact that only the appearance or absence of a single open flower will be sufficient to determine the parameter.

## **Date of flowering**

The oilseed brassicas in general are characteristically indeterminate. As long as water is not the limiting factor, new branches continue to be born and these in turn set new flowers. Therefore, flowering date is the most difficult parameter to objectively establish in mustard and rapeseed. However, the date at which ca. 50% of the plants in a plot show blooming on ca. 50% of their flower buds is taken to be the date of flowering.

## **Date of maturity**

Plots are ready for harvesting at this date. As opposed to physiological maturity, harvest maturity in mustard and rapeseed can very well be recognized in the field. The pods and stems turn creamy-white, pods become rustling when plants are shaken and seeds will be hard when felt between the thumb and forefinger or crash when broken with teeth. As data, which is arithmetically derived from two or more observations, grain-filling period can be determined from the difference between maturity and flowering dates. But such a data should not be used for certain type of analyses like for example Principal Component analysis.

## **Yield Components**

Yield is a product, which is influenced by morphological parts of plants. These morphological parts of plants with functional bearing on yield are generally called yield-components. Some of these components influence yield positively and thus will have positive correlation coefficients, while others may have negative influences and thus negative coefficients thereof. Empirical correlation coefficients, however, do not always disclose the true relationship how a given component might affect the yield recorded at a particular point in time and space. Yield could increase or decrease as a result of increasing or decreasing magnitude of a given component independent of any other component part; in which case the influence/effect of that particular component under question is said to be its "direct effect". On the other hand, the influence of a given component could be positive or negative depending on functional relationships it might have with other components; and this type of influence is called "indirect effect" of the particular component on yield *via* the other



components. One very important point of worth mentioning is the fact that these various types of relationships are not constant or peculiar to a given species or even populations at all. There are statistical techniques useful to discriminate the magnitude of such general relationships between dependent and independent variables into specific direct and indirect effects. In the Ethiopian mustard and rapeseed, quite a number of such yield components are known. But before discussing every yield component it is important to point out that both species are partially allogamous although are often bred with similar methods as self-pollinating crops. Therefore, the number of sample-plants to be taken to determine yield components varies, apart from the size of course, with the degree of homogeneity of the population under study. For such relatively heterogeneous populations as new collections, still segregating populations, designated farmers' varieties, materials at early evaluation stages, etc., 10 – individual plants may need to be randomly sampled from the net-plot area, while for more homogeneous populations (materials, which are at later evaluation stages, lines, varieties, etc), five plants sampled from the net-area may suffice to represent the population.

Once it is decided how many sample-plants should randomly be selected, the samples have to be permanently labeled with colorful and conspicuous tags so that these same samples would be used to determine the following yield components.

In order to make the data on yield components amenable for multi-variant analyses, it is important that the data should be determined independently and should not be mathematically derived from one another.

### **Number of primary branches**

The total number of primary branches (branches born on the main stem) which give rise to other seed-bearing branches of higher order or which bear seeds for themselves (hereafter productive branches) counted from all of the sample-plants and then averaged over the latter. Counting can be done at the time when flowering becomes completely over and the siliqua are still green but old enough to judge that they will bear seeds.

### **Number of secondary branches**

The total number of secondary branches (branches born on the primary branches), which give rise to higher order productive branches or which they themselves produce seeds, averaged over the sample-plants marked and used to determine the data on primary branches. Counting of secondary branches should be done well before branches become brittle or plants are ready for harvesting.

### **Number of tertiary branches**

Under the prevalence of long and conducive growing conditions like in Bekoji (2700m altitude, 1300mm annual rainfall and June-January cropping duration), especially Ethiopian mustard grows so strongly and luxuriously to make use of the full season. Under such circumstances of noted ramification, third or more order of branches may develop. Since it is seldom that the crop continues developing such productive branches of higher order, it is often tedious, and confusing to identify their order properly, they are often considered all together

as tertiary branches. Like the number of branches discussed above, tertiary branches are also determined by averaging the total number of branches other than primary or secondary branches counted from the same sample-plants used to determine the latter.

### **Number of siliqua**

This has to be determined as an average number of pods counted from all the sample-plants labeled for the determination of productive branches. Counting should be done before the pods become brittle, preferably at the same time when branches are counted.

### **Number of seeds**

This is the average number of seeds per individual plant. This too has to be obtained by counting all the seeds born by the same sample-plants used to determine the above components. However, since the multiplication rate of both mustard and rapeseed is very large (1: 1000-5000), counting the total number of seeds manually from all sample-plants will certainly be cumbersome and time consuming. The use of automatic or semi-automatic seed counters seems necessary.

### **Number of seeds per siliqua**

If one wants to avoid unduly inflation of covariance and correlation coefficients, due to ipsative measurements, this is probably the most difficult parameter to determine. Because one needs to separately thresh every single pod from each of the sample-plants and count the seeds born therein. This is, however, practically very difficult, if not impossible; for one thing the pod may split along the false septum (as in rapeseed) and discharge the seeds; and for another the pods may easily break off when they become dry, which in fact it is by the time seeds have to be counted, and thus the seeds may get lost all together before they are counted or it will be impossible to match the seeds with specific pods. Therefore, the most practical way is to divide the average number of seeds per plant by siliqua per plant but the data may not be valid for certain forms of analyses such as Principal Component Analysis.

### **Seed weight**

This is an average fresh weight of the seeds obtained from all the sample-plants used to determine the above yield components. In order to avoid confusions, the weight should be given in grams. For more precision, the weight could be adjusted to a constant moisture level (7%) as is always done for yield per unit area to be discussed later.

### **Thousand seed weight**

Seed size is an important trait in oilseed brassicas. It is also a trait, which shows high degree of polymorphism. Bold-seeded (big-seeded) cultivars generally yield more oil than small seeded cultivars. Obviously seed size is essentially one of the yield components and has to be determined by counting and weighing 1000-seeds from the bulk-sample of seeds harvested from all sample-plants used to determine the other yield components. Thousand seed weight has to be entered in grams and to two digits of mantissa.



## Plant height

Plant height could be measured in different fashions and at various stages of the growing crop: (at the beginning of flowering, mid – or end of flowering or at maturity) or at different levels of the growing plant (from the ground to the first or last branches, etc) depending on the purpose of the investigation. For the usual breeding experiments plant height is taken at maturity just before or at harvesting. It is determined as the average height in centimeters of all sample-plants measured from the crown (ground level) to the tip of the terminal pod on the main stem.

## Other Agronomic Data

### Uniformity

Polymorphisms in such phenotypic traits as petal, stem, leaf and seed colors; leaf and stem hairiness; general appearance and stature of plants; synchrony of flowering or maturity; plant height, etc are immensely abundant in both mustard and rapeseed. Since both species are partially allogamous coupled with indeterminate type of flowering habit, the kind of uniformity one expects with highly/strictly self-pollinating species is not usually the case in these crops. Thus, one has to have a good note of heterogeneity by inspecting each trait and defining the variation either in words or figures as is exemplified hereunder in Table 1.

Table 1 Examples of uniformity traits and their scores encountered in mustard and rapeseed

Trait	Scale/score	Remark/Definition
Petal color	1	Yellow
	2	Cream
Leaf – surface	1	Hairy
	2	Glabrous
Seed color	1	Black
	2	Yellow
	3	Reddish
	4	Brown
Synchrony of flowering	1	Synchronized
	2	Otherwise

### Stand

The stand could generally be defined as the proportion of plants actually counted to the number of plants theoretically expected. The expectation is based on the number of seeds sown and of course their germination rate. Much has been said of the latter under the heading seeding but suffices to say that an assumption is made that every single seed sown will develop into a successful plant. This is not, however, usually true. In fact in both species <75% is the usual figure we record under normal weather and soil conditions. The theoretical number could be determined in two ways. The first and probably most reliable is counting all the seeds just before seeding. This is obviously impractical for it is tedious and time consuming. The second and more prudent way is to determine the number from the index of seed size (= 1000–seed



weight) and the weight of seed sown in an experimental unit (plot or pot) as could be worked out using the following relationship.

$$N = \frac{W_s}{W_t} * 1000 \quad \text{-----} \quad 1$$

Where N is the theoretical (expected) number of plants,  $W_s$  is the weight in grams of the seed sown and  $W_t$ , thousand seed weight in grams.

From this theoretical figure will thus be determined the stand as:

$$S = \frac{C}{N} * 100 \quad \text{-----} \quad 2$$

Where S = stand in % and C, the actual plant counts.

At times, it may be required to take sample of an area rather than considering the whole plot in order to estimate stand and thus the formula need to be adjusted accordingly. Stand is normally taken twice, the first during rosette stage to monitor the degree of crop establishment and the second at maturity.

### Seed shattering

As was said earlier, *B. carinata* is immune to shattering while in *B. napus*, shattering is a serious problem. Thus when conditions do not permit timely harvesting of rapeseed some loss of seed will be inevitable and has to be quantified as percent of shattering. Shattering is estimated as the proportion of productive pods (well developed and bearing seeds), which get naturally split along their false septum.

### Lodging

Lodging is any inclination of plant to the ground by a magnitude of an angle more than half from its up right position. For crops whose normal up right position is perpendicular to the ground ( $90^\circ$ ), inclinations from less than  $45^\circ$  to  $0^\circ$  (when plants lay flat) are all considered as lodging. In order to distinguish the latter from all others, root-lodging is coined to the situation whereby plants fall completely on the ground and stem-lodging, otherwise. Lodging in both species is estimated as proportion, in percent, of lodged plants to actual total population count in an experimental unit.

### Sterility

Sterility is a measure of barrenness of pods, which can result from either environmental stress or genetic limitations. When the day temperatures become too high, for example, the pollen grains fail to germinate through the style and thus will there be no fertilization at all or the embryo may abort under conditions of scorching heat if they prevail. No matter what might cause the emptiness the fact is sterility is measured as the proportion of pods on individual plants that fail to bear seeds. Estimation is made by considering all plants to be harvested from the net area.

## Seed, Oil and other Biochemical Analyses

### Seed yield

In order to determine the seed yield per hectare, the yield obtained from the net unit area (plot) has to be converted by a factor and the resulting figure will be an unadjusted seed yield per hectare. But because at harvest maturity, the moisture content of seeds considerably varies from plot to plot, the yield has to be readjusted to a constant moisture level of 7%. The stepwise readjustment procedure can be outlined as follows

- (i) Determine the moisture content of the seed from each unit. To determine the moisture content, weigh 100g of seed samples of each of the seed lots from every unit (plot) and put it in an oven set at 78°C. Wait until the samples reach a constant weight by repeatedly weighing and putting the seeds back into the oven, which often takes not more than two days. Weigh the oven-dried samples to get the dry-matter weight (DM) of the seeds;
- (ii) Determine the moisture content in percentage by subtracting DM from 100;
- (iii) Once the moisture content is determined, it is possible to find a conversion (adjustment) factor by the following relationship:

$$CF = \frac{100}{100 - (M_d - M_a)} \quad \text{-----} \quad 3$$

Where CF= correction factor,  $M_d$  = moisture content desired (7% in our case) and  $M_a$  = actual moisture content of the fresh weight (FW).

Table 2 gives some examples of the CF for some selected levels of moisture. Note that as moisture level in the fresh weight increases will correspondingly decrease the correction factor.

Table 2            Some examples of correction factors (CF) used to adjust seed yield for selected moisture levels of oilseed brassica seeds

Moisture (%)	Correction Factor (CF)	Moisture (%)	Correction Factor	Moisture (%)	Correction Factor (CF)
5.0	1.020	7.0	1.000	9.0	0.980
5.5	1.015	7.5	0.995	9.5	0.976
6.0	1.010	8.0	0.990	10.0	0.971
6.5	1.005	8.5	0.985	10.5	0.966

- (iv) Adjusted seed yield ( $Y_p$ ) in grams per plot (unit) will be the product of FW and CF (v) and finally seed yield in kilograms per hectare ( $Y_h$ ) can be calculated as:

$$Y_h = \frac{Y_p}{A_n} * 10 \quad \text{-----} \quad 4$$

Where,  $A_n$  = net area ( $m^2$ ) of the plot (unit).



## Oil content

Oil content ( $C_o$  in %) is generally measured as percentage of fat in the seed. Different laboratories employ different methods to measure oil content depending on the facilities they have access to and also on the purpose of the analyses. The earlier and conventional method of measurement includes the so-called "Soxhlet" method whereby ground seeds are continuously washed with organic solvents such as, Diethyl ether, until the oil is completely extracted out of the meal. This method, however, has a lot of drawbacks to be used for research. It is costly in terms of time and finance because requires chemicals, is destructive, i.e., samples cannot be reused for planting and requires relatively larger samples to run the analysis. In modern labs, there are other methods of oil determination. The Nuclear Magnetic Resonance Spectrometry (NMRS) and the Near Infrared Reflectance Spectrometry (NIRS) are nowadays very widely used by crop research and food science laboratories. Once acquired, they are less expensive (no chemicals needed), very fast, require small amount of samples otherwise they are non-destructive.

## Oil yield

Oil yield is the measure of the amount of fat harvestable from a unit of area. It is empirically determined as the product of adjusted seed yield per hectare and oil content using the following formula:

$$Y_o (\text{kg / ha}) = \frac{Y_h * C_o (\%)}{1000} \quad \text{-----} \quad 5$$

Where,  $Y_o$  = oil yield in kg/ha,  $Y_h$  is as given in equation 4 and  $C_o$  = oil content in %.

## Other Biochemical Constituents

The fatty acid compositions of the oil and protein and glucosinolate contents of the meal are the most important characteristics in brassica crops. The nutritional and industrial value of a vegetable oil is largely determined by the presence and proportion of the individual fatty acids in the seed. The oil from *B. carinata* is very often shunned because of its high content of the monoenoic long chain fatty acid, erucic acid (C22:1), which is associated with cardiac and vascular disorders. It is, therefore, of prime importance that erucic acid is bred-out from varieties of the oilseed brassicas produced for the production of edible oils. Erucic acid on the other hand has a very important industrial value in plastic industries. In all cases, though the amount of erucic acid in the seed has to be precisely determined. There are a number of techniques developed for this purpose. The earliest and perhaps relatively cheaper method of analysis is the paper chromatographic technique. The more advanced method of analyses includes the gas chromatography, gas-liquid chromatography, high-pressure liquid chromatography and other versions of modern chromatographic techniques. Chromatographic analyses of fatty acids have one very special advantage that it is possible to do the analysis from half of the cotyledon, while the other half can still be grown into a full plant. In modern laboratories, the use of NIRS has simplified the analyses of fatty acids even to a greater extent.



Like the fatty acid analyses, the analyses of glucosinolates have gone through several paradigms of innovations ranging from the "Testape" techniques to the use of NIRS. Unlike fatty acids, however, whereby the genotype of the embryo determines the genotype of the following generation, the inheritance of glucosinolates is more complicated and the seed can only tell that of the maternal plant and not that of the following progeny. The "Testape" technique is a fast technique for screening a large number of breeding materials based on the color change of the test-stick like in clinical urine test for sugar level. Since glucose is one of the breakdown products of glucosinolates, it is possible to tell materials devoid of glucosinolates from those, which are laden with. In addition to the chromatographic techniques used for the analyses of fatty acids, glucosinolates can be analyzed by "Palladium-test", a method, which allows a fast determination of the contents of glucosinolates in cruciferous seeds based on the reaction between the latter and tetrachloropalladate II. This is a method, which also allows quantitative measurement of glucosinolates in the samples. The results, however, are not as accurate as gas chromatographic techniques. With all its advantages pointed out above, the NIRS is the modern technique of determining glucosinolates in plant breeding.

The meal remaining after oil extraction is rich in protein of balanced amino acids. Protein content as high as 30% is very common in the meal of *B. carinata*. But because of the anti-nutritional effects of glucosinolates, the meal is often used for fuel, which is in fact a waste of a very expensive resource that could otherwise be fed to livestock or even as a good source of N-fertilizer and organic matter to the soil. The protein content can be analyzed by both the conventional method of Kjeldal procedure whereby the proteinaceous contents in the seed are first acid-digested followed by measuring the total N-content by titration. The amount of N determined then would be multiplied by a factor of 6.2 in order to estimate the protein content. Another method of protein determination, like the contents of oil or glucosinolates, is by using the NIRS.

# IV

## Important Diseases

### Introduction

Fifteen diseases have been reported on mustard and rapeseed in Ethiopia: twelve fungal, one bacterial, one viral and one nematode (Table 1). Based on their distribution, amount of damage they cause on the crops and frequency of their occurrence over years, three diseases namely leaf and pod spot, black leg and white rust are identified as the most important in mustard and rapeseed production in Ethiopia. Important aspects of these diseases (the major ones) including importance and distribution, the causal organism, disease cycle and control options are presented in some detail. For better understanding of the content, it was found important to define some technical terms.

*Disease:* It refers to a particular destructive process in an organism with a specific cause and characteristic symptoms. In practice, a plant is usually only considered diseased when symptoms (visible manifestation of the disease), by means of which the disease may be recognized, are present.

*Pathogen:* The primary agent responsible for causing a disease that could be infectious (transmissible from diseased to healthy plant) or non-infectious (non-transmissible from diseased to healthy plant).

*Leaf curl:* leaves are arched, twisted and distorted due to growth in tissues in localized areas of leaves.

*Spots:* cells are killed in limited areas and the dead tissues become brownish. The shape of the spots may be rounding, angular or irregular.

*Lesions:* localized area of diseased tissue of a host plant

*Damping off:* a condition in which the seedling stem is attacked near the soil surface, becomes constricted, weak, and results in toppling and death of seedlings.

*Pycnidium (pl. Pycnidia):* An asexual, spherical or flask shaped fruiting body producing conidia.

*Perithecium (pl. Perithecia):* sexual, flask shaped fruiting body producing sexual spores.

*Haustorium (pl., Haustoria):* a simple or branched projection of hyphae into host cell that serves as absorbing organ

*Canker:* sunken necrosis and subsequent drying that involves mainly the primary phloem and related parenchyma tissue.

Table 1. Mustard and rapeseed diseases in Ethiopia

Pathogen	Disease	Importance
<i>Alternaria brassicae</i>	Leaf and pod spot	Major
<i>Leptosphaeria maculans</i>	Black leg	Major
<i>Albugo candida</i>	White rust	Major
<i>Alternaria tenuissima</i>	Leaf spot	Minor
<i>Cercospora albomaculans</i>	White leaf spot	Minor
<i>Mycosphaerella brassicicola</i>	Ring spot	Minor
<i>Oidium</i> sp.	Powdery mildew	Minor
<i>Peronospora parasitica</i>	Downy mildew	Minor
<i>Phyllosticta brassicae</i>	Leaf spot	Minor
<i>Rhizopus stolonifer</i>	Seed mold	Minor
<i>Sclerotinia sclerotiorum</i>	Stem rot	Minor
<i>Trichothecium roseum</i>	White cover on inflorescence	Minor
<i>Xanthomonas campestris</i>	Black rot/leaf blight	Minor
<i>Meloidogyne</i> sp.	Root knot	Minor
Virus	Leaf curl	Minor

## Key Diseases

### Leaf and pod spot

#### Causative agent: *Alternaria brassicae*

Individual conidia of the fungus are large and can be plainly seen under a x20 binocular dissecting microscope. Conidiophores arise in groups of 2-10 or more from the hyphae, emerging through stomata, up to 170 $\mu$  long and 6-10 $\mu$  thick, bearing one to several small but distinct conidial scars. Conidia are solitary but occasionally found in chains of up to 4, with 16-19 (usually 11-15) transverse septa and 0-8 (usually 0-3) longitudinal or oblique septa. They are pale or very pale olive or grayish olive, 75-350 $\mu$  long and usually 20-30 $\mu$  (sometimes up to 40 $\mu$ ) thick in the broadest part, and the beak about a third or one half the lengths of the conidia and about 5-9 $\mu$  thick.

#### Importance and distribution

The disease is distributed almost worldwide. In Ethiopia, it has been reported from Arsi, Shewa, Sidamo, Kefa, Wellega, Bale and Gojam. Under favorable conditions, the disease causes up to 14% yield loss.

#### Symptoms

Initially, circular, zonate, light brown to grayish or dark brown spots appear on leaves measuring from less than 0.5 to 12 mm in diameter, sometimes coalescing. On the mid ribs of the leaves, the spots are oblong or linear and sunken. Under favorable conditions, the spots enlarge to form gray, circular spots containing concentric rings with purple or black boarder. On stems and pods, spots enlarge into lesions that are either entirely black or black with grey center. Pods with infected pedicels fail to develop and often drop off the plant prematurely. Severely infected pods contain shrunken, infected seeds.

#### Disease cycle

The fungus is primarily seed-born. It also survives as mycelium on infected plant debris. Spores are produced abundantly during heavy dews and frequent rains, and are blown in from mycelium growing on debris or on infected plants and weeds. Infected seeds may cause pre- or post emergence damping off. The



disease becomes most severe under humid and warm conditions that occur during the season.

### **Black Leg**

**Causative agent:** *Leptosphaeria maculans* (anamorph *Phoma lingam*)

Also known as canker or dry rot, it is important mainly on *Brassica oleracea*, *Brassica napus* and *Brassica napobrassicae*. Ascocarps of the fungus could be found on stems and leaves, immersed, becoming erumpent, globose, black, globose with protruding ostioles, 300-500 $\mu$  in diameter. Asci are cylindrical to clavate, sessile or short stipitate, 8 spored, 80-125 x 15-22 $\mu$ . Ascospores are cylindrical or mostly ellipsoidal, ends mostly rounded, yellow brown, slightly or not constricted at the central septum, 35-70 x 5-8 $\mu$ . Pycnidia are usually found on stems and leaves. They could be globose or variable in shape, black and 200-600 $\mu$  in diameter. Conidia are hyaline, shortly cylindrical, mostly straight; some curved, guttulate, with one guttulate at each end of the conidium, unicellular, 3-5 x 1.5-2 $\mu$ .

### **Importance and distribution**

Wide spread but mostly in temperate regions. In the tropics, it is important only at higher altitudes. In Ethiopia, it has been reported as one of the most widely distributed diseases on mustard and rapeseed that could cause yield losses as high as 62% under favorable conditions.

### **Symptom**

Lesions on leaves, stems and roots become gray, white in color, irregular in shape and spotted with pycnidia, which appear as small black specks. The disease is most conspicuous on lower stem parts on which poorly defined, white to gray or black lesions appear that commonly develop near the soil line. Often, these lesions have purplish borders. Pycnidia frequently form in stem lesions, commonly on lower stem portion and exude pinkish exudates during wet weather containing spores. Severely infected stems may have cankers. Lesions may extend to the root system where black cankers are formed. Infected roots disintegrate, further weakening plants.

### **Disease cycle**

The fungus survives as perithecia and pycnidia on or in infected plant debris and as mycelium in seeds. During wet weather, ascospores are produced in perithecia and are wind borne that can infect new crop. During the season, conidia are produced repeatedly and dispersed by rain splash or wind to neighboring healthy plants. High soil moisture and high relative humidity in the air favor the disease.

### **White Rust**

**Causative agent:** *Albugo candida*

The fungus is an obligate parasite. Mycelium in host tissue is intercellular with small globose to knob like haustoria. Sporangiophores are hyaline, clavate thick walled, especially towards the base, 30-45 x 15-18 $\mu$ . Sporangia are globose to oval, hyaline with uniform thin wall arranged in basipetal chain, up to 12-18 $\mu$  in

diameter. Oospores are chocolate brown, 30-55 $\mu$ , and often confluent and irregularly branched, sometimes seemingly smooth.

### Importance and distribution

The disease is distributed world wide wherever its hosts are present. In Ethiopia, It has been reported as one of the most widely distributed diseases on the Ethiopian mustard and rapeseed. Dry weight decreases in infected plants due to decreased photosynthesis and increased respiration rates.

### Symptom

The most obvious symptom is swelling and deformation of the terminal parts of flower stalks resulting in the spiny stag heads. At first, the stag heads are green but become brown as they dry up. Portion of individual flowers may also become distorted. Sometimes petals, stamens and carpels become enlarged and green color owing to the formation of chloroplasts. White or cream colored pustules occur on the underside of infected leaves. Attacked parts often show marked hypertrophy.

### Disease cycle

Primary infection is by zoospores from germinating oospores left in the soil or plant debris from a previous crop. Oospores germinate to produce a short exit tube that terminates in a vesicle. Zoospores are released from the vesicle and swim to host tissue, where they encyst and germinate, infecting the tissue. *Albugo candida* is usually associated with the downy mildew *Peronospora parasitica* and may cause considerable injury from combined attacks.



Black crown cranker



Blackleg lesions



Fungal fruiting bodies



Black crown cranker



## Disease Research Methods

### Assessment of black leg

Disease infection on the Ethiopian mustard and rapeseed should be evaluated using simple, quick, reliable and objective methods in order to determine the reaction of the crops to their major diseases. The procedures that should be followed are described below

In trial plots, one score can be given per plot. In large fields, select at least three sample areas, but preferably five sample areas (each area should be ten meters radius) evenly distributed throughout the field, or at random along the diagonal. Use the disease assessment key given below for each sample area. The average scores give an indication on severity of the disease. The assessment key for black leg is described below (5 point scale)

- 0 = no symptom
- 1 = small individual spots on leaves
- 2 = small lesions on lower stem; lesions on leaves spotted with pycnidia
- 3 = extended black lesions on lower stems
- 4 = girdling of lower stem and retarded growth of plants
- 5 = severe stem girdling with cankers and death of plant

### Developing blackleg resistant cultivars

The first step is to develop sick plot. The procedures to be followed:

1. Collect samples of the fungus in all the accessible production locations and multiply them on artificial media in the laboratory.
2. Mass-produce propagules (mainly spores) of the fungus should be worked into the soil by shallow plowing or racking.
3. Grow susceptible genotypes to fasten the sick plot development. Sowing such susceptible genotypes should be repeated for successive seasons until 95-100% plant mortality is observed.

The next step is to evaluate genotypes on the sick plot. The possible sources of resistance for Brassica include commercial cultivars, land races and related species. Follow the screening stages as put.

#### 1. Preliminary screening

- Take maximum number of genotypes and grow them on the sick plot. The genotypes could be collections/introductions or segregating materials from crossing block.
- Evaluate the disease situation using the disease assessment key described above.
- Select single plants and lines with scores of 0 to 3 and advance them to the next stage.

#### 2. Advanced screening

- Lines and single plants selected during preliminary screening should be further tested on same sick plot.
- Evaluated for disease reaction using the 0-5 disease assessment score. At this stage, select genotypes highly resistant (0-2) to the disease. Also measure yields and yield components. Depending on their performance for other agronomic traits, the selected lines should either be transferred for crossing



with outstanding cultivars or be tested in multiple locations for possible release.

### **3. Multi-location tests**

Best materials for disease resistance and other agronomic traits should be grown at various locations, under natural infection. During the process, occurring isolates of the fungus should be collected and stored. Collecting the isolate will help enrich the sick plot.

## **Assessment of leaf and pod spot**

The above procedure applies to leaf and pod spot in mustard and rapeseed. But, the disease assessment key (5 point scale) for leaf and pod spot disease is the following:

- 0 = no symptom
- 1 = a few, small spots (less than 5 mm in diameter) on leaves.
- 2 = large (5-10 mm in diameter) spots on leaves, spots not coalescing
- 3 = spots appear on pods and stems; spots on lower leaves coalescing.
- 4 = lower half of leaves yellow, necrotic or dropped; necrotic spots on upper leaves and spots on stems and pods coalescing.
- 5 = pods drop off and severely infected; seeds infected and shrunken.

*NB. The above scoring scale was modified from Arina Van Bruggen and Almaz Yilma (1980) "Disease assessment methods on horticultural crops" Nazret, IAR.*

## **Developing resistant cultivars**

Methods of disease sample collection and sources of resistance could be similar to black leg. Once representative disease samples and possible sources of resistance are made available, the step-by-step procedure to develop resistant cultivars is as follows

### **1. Preliminary screening**

- Grow maximum number of genotypes as possible. Include spreader rows either after defined number of test genotypes or at the perimeter of the experimental block. The genotypes could be collections/introductions or segregating materials from crossing block.
- Create more uniform disease pressure across the field by artificial inoculation.
- Evaluate the disease situation using the disease assessment key described above.
- Select single plants and lines with scores of 0 to 3 and advance them to the next stage.

### **2. Advanced screening**

Materials selected in the previous stage should be further tested in disease nursery in the field to select well-developed resistant genotypes (0-2). Here also, best materials can be included in crossing blocks or promoted for multi-location testing, if the genotypes show agronomic merits.

### **3. Multi-location tests**

Best materials for disease resistance and other agronomic traits should be grown at various locations, under natural infection. During the process, occurring isolates of the fungus should be collected and stored. Collecting the isolate will help enrich the disease collection.

## **Cultural disease control**

### ***Crop rotation and sanitation***

These will apply to both diseases described above. Crop rotation and sanitation are appropriate cultural methods that could be used to reduce amount of inoculum of key pathogens in Ethiopian mustard and rapeseed.

### ***Crop rotation***

1. Determine the host range and survival of the fungus in/on soil to identify rotation crop and rotation time. Host range is defined by testing for the pathogenicity of the fungi on as many plants species as possible (cultivated and uncultivated).
2. Identify break crops that showed lower disease infection and determine the potential of the fungus to survive over time. Survival is determined by measuring the viability of propagules of the fungi in/on soil and plant debris.

## **Chemical disease control**

### ***Screening potential fungicides***

There is an active Pesticide Research Committee (PRC) in EARO, which has a national mandate to direct research on efficacy data generation for national registration of useful pesticides based on their safety, to human and the environment, cost and availability. Therefore, any pesticide screening for the control of key Brassica diseases should follow the rules the committee has set for the conduct of research on pesticides. Both seed and foliar applied fungicides are appropriate for the control of the major diseases of the Ethiopian mustard and rapeseed. Selection of appropriate fungicides for future use should be done following the procedure described below.

1. Collect commercially available fungicides with potential for the control of the targeted Brassica diseases. Include recommended fungicides as checks;
2. Plant susceptible cultivars in common use in plots of 4x3m.
3. Both for blackleg and leaf and pod spot start scoring right after the disease appears on leaves and continue the scoring every week until the crops mature;
4. Measure seed yield and yield components;
5. Analyze the data following the planting design. Select the best fungicides and determine their rates of application. Verify the best rate on-farm and recommend for use.

# V

## Important Insect Pests

Numerous insects attack both crops. The first reported case of pest incidence on the Ethiopian mustard and rapeseed was in 1978/79-crop season. Then the true *Brassica* aphid (*Brevicoryne brassicae* L.) was reported to have infested rapeseed and Ethiopian mustard very heavily. However, the observed pest pressure did not result in significant crop yield reduction (Anon, 1981). In 1982, a number of insect pests were recorded on rapeseed, which included the African bollworm (*Helicoverpa armigera* (Hubn)), diamond back moth (*Plutella xylostela* L.), and *Plusia* sp. Later systematic surveys had been conducted and the major pests of the two crops in the country were identified. The results are described below. Abundance in a given area, distributions over many places, and presence in an area over years measured the level of importance of an herbivorous insect as a pest of the two crops. Based on these, there were identified through the extended field surveys two minor, four major, and two sporadic pests both on rapeseed and the Ethiopian mustard in where the crops were growing (Kemal and Tadesse, 1987) (Table 4).

Table 4. Important insect pests of Ethiopian mustard and rapeseed recorded in Ethiopia

Scientific name	Common name	Pest status
<i>Athalia s. shweinfurthi</i> Konow	cabbage saw fly	minor
<i>Liromyza brassicae</i> (Riley)	cabbage leaf miner	minor
<i>Brevicoryne brassicae</i> (L.)	true cabbage aphid	major
<i>Phyllotreta masonana</i> Jacob	cabbage flea beetle	major
<i>P. Weisei</i> Jacob	cabbage flea beetle	major
<i>Plutella xylostela</i> (L.)	diamond back moth	major
<i>Pieris brassicoides</i> (L.)	cabbage white	sporadic
<i>Trichoplusia orichalcea</i> (Fabricus)	golden plusia	sporadic

Source: Kemal Ali and Tadesse Gebremedhin, 1987

### Key Insect Pests

#### Cabbage flea beetles (*Phyllotreta* spp, Coleoptera: Chrysomelidae)

Flea beetles are general feeders and are frequently found on the foliage of vegetable crops where they chew small holes through the leaves from the underside, producing a shot hole on sieve like appearance. The larvae of many species feed on the underground parts of their host plant. These chrysomelids are called flea beetles because they are provided with well-developed hind legs with greatly developed leaping powers and when disturbed, jump in a manner resembling fleas (Davidson and Lyon, 1979). Members of the genus *Phyllotreta* share this behavior and as pests, they are exceedingly destructive to cruciferae (Richard and Davis, 1977). The two species in the genus *Phyllotreta* mentioned in Table 1 are major pests of the Ethiopian mustard and rapeseed especially at early seedling growth period. Damage by flea beetles reduces the available total leaf area per unit of land, hence, decrease the amount of solar



radiation, which could otherwise be intercepted and used for photosynthesis. Though not confirmed experimentally, as observed, the reduction in leaf area especially at early seedling growth stage has been causing retarded seedling growth. When infestation comes much earlier, i.e., on the primordial leaves, it has been observed to reduce the total plant stand which is worse than when the infestation occurs at later growth stages (Bayeh unpublished data). The following are what should be done to develop management methods for flea beetles.



Fig 1. Cabbage flea beetle (*Phyllotreta* spp) a cosmopolitan pest of *Brassica* species and other *Cruciferae*. Courtesy of Sumitomo Chemical Co., Ltd., Osaka Japan, Pest control guide, Plant Protection Division-International.

### Monitoring cabbage flea beetles

This helps one understand the dynamics of the pest within and between years on *Brassica* cultivars under production. Flea beetle monitoring should be done as follows:

1. On row planted *Brassica* crops, count healthy and damaged seedlings within 25cm segment of a 1m row (NB. The total number of samples will depend on both the length and number of rows per plot).
2. On broadcast planted *Brassica* crops, count healthy and damaged seedlings within a quadrat of 50cmX50cm. The number of sample quadrates will depend on the size of the plot/field. It is advisable to take at least 15 such samples in an area of ca. 250m<sup>2</sup>.
3. Repeat the counting for two more weeks in a row.
4. Summarize the data for row/broadcast planted on per plot/field and genotype bases, for the three sampling weeks separately.
5. Count productive stands after the crop is removed on the rootstalks.

NB. For data collected from experimental plots, follow the design used to plant the crops whereas for data collected from production fields, make use of each field as a replication and analyze the data.

### Screening insecticides for the control of cabbage flea beetles

Follow the stages of screening described in the guideline for the testing of insecticides in EARO. Take note of the following: the most appropriate insecticide formulations to use for the control of cabbage flea beetles on *Brassica* seedlings are granular and spray forms. To evaluate such insecticides follow the procedure described below.

1. Plant a *Brassica* cultivar in common use on plots of 2mX3m in RCBD with four replications.
2. For granular forms furrow apply them together with the seeds. For spray forms, apply them at the chosen rates right after 50% emergence of seedlings.
3. Count as described earlier healthy and damaged seedlings on weekly intervals for three weeks.
4. In the subsequent vegetative and reproductive growth phases, count damaged leaves per plant on fortnightly base. It could be enough to do this on five randomly selected plants per plot.

5. Count productive plants after the crop is harvested by counting rootstalks.
6. Summarize the data on per plot bases and run ANOVA and correlation (between seedling damage and productive plant stand at harvest) analyses.

## **Screening Brassica genotypes for cabbage flea beetle resistance**

### ***Preliminary screening***

1. Consider the maximum number of genotypes, which you can manage to screen at one go.
2. Plant each genotype in two rows of 50cm long. Plant repeated checks after every, e.g., 10 genotype (NB. The checks should be cultivars in wider use).
3. Count all the healthy and damaged seedlings for several weeks in a row.
4. In subsequent vegetative and reproductive growth phases, count damaged leaves per plant on fortnightly base. Five randomly selected plants per genotype could be enough.
5. Measure the number of branches per plant and the seed yield per genotype per plot.
6. Summarize the data for the different parameters measured and rank the genotypes based on their reaction to the pest. Select the best 5-10 genotypes for advanced stage of screening.

### ***Advanced screening***

1. Row-plant the selected genotypes in plots of 2X3m in split-plot design with four replications. Put the genotypes in the main plots and chemical insecticide treatment in the sub-plots.
2. Count healthy and damaged seedlings within 25cm segment of a 1m row.
3. In the subsequent vegetative and reproductive growth phases, count damaged leaves per plant on fortnightly base.
4. Record the number of branches per plant and the seed yield per genotype per plot. Carryout this study, for two consecutive seasons.
5. Summarize the data for the different parameters measured and select the best three genotypes based on their reaction to the pest. On the best genotypes, the possible mechanism of resistance could be investigated. This is done if found a necessity.

The selected genotypes could either stand on their own, as potential cultivars for release, or passed to breeders for the crossing programs of Brassica.

## **True cabbage aphid (*Brevicoryne brassicae* L. Homoptera: Aphididae)**

The aphid is a green species with a considerable amount of gray, waxy-bloom on the surface, which gives heavily infested plants a whitish appearance (Davidson and Lyon, 1979). This is a specialist aphid and because of its close association with the *Brassica* crops, it is called the true cabbage aphid (Singh and Bakhetia, 1987). The aphid is capable of dealing with the allelochemicals embodied within the leaf tissue profile of a cruciferous plant. It has an enzyme in its tissue called glucosinolase, which is capable of detoxifying sinigrin, which are abundant in cruciferous plants (Dixon, 1987). It is an important pest of *Brassica* crops worldwide. In Ethiopia, particularly on Ethiopian mustard and rapeseed, the pest incidence occurs after pod setting in September-October, but because rapeseed matures much earlier than the Ethiopian mustard, the infestation was not found to cause significant reduction in the crop yield. A very high infestation of the true cabbage aphid occurred first in the 1978/79-



crop season, but as mentioned earlier, even then, the infestation occurred after pod setting and no significant yield reduction was recorded (Anon, 1981). To date there was no a single cropping season when spraying was required particularly at Holetta to control the pest. For such a pest, what is important to do is to carryout once every few years a monitoring work both in experimental plots and production fields.



Fig 2. Cabbage aphid, *Brevicoryne brassicae* a cosmopolitan pest of *Brassica* species (Courtesy of Sumitomo Chemical Co., Ltd., Osaka Japan, Pest control guide, Plant Protection Division-International)

### Monitoring cabbage aphid in Brassica crops

1. On row planted Brassica crops, count aphids per plant on 15 plants in a plot.
2. On broadcast planted Brassica crops, count aphids per plant by crisscrossing the field. Take at most 25 plants per field.
3. Take the counts at early vegetative, 50% flowering and 50% pod setting stages.
4. Summarize the data for row/broadcast planted on per plot/field bases.

If the data are collected from experimental plots, follow the design used to plant the crops whereas for data collected from production fields, make use of each field as a replication and analyze the data.

### Diamond-back moth (*Plutella xylostella*, Lepidoptera: Noctuidae)

This moth when it is in its normal resting position is about 8mm long and the light colored areas that show as anal margins of the forewings fit together to form diamond-shaped spots, which is the basis for the common name. It lays its tiny eggs on leaves of cabbage and related hosts. Upon hatching the pale green larvae chew small cavities and holes in the leaves feeding mainly on the underside. In about two wks, they become fully developed; spin a loose mesh-silken cocoon and change to pupae, the moths emerging a week or more later. Brassicae of all species as well a wide range of wild and cultivated Crucifereae host diamond-back moth strictly.



Fig 3. The larva and adult of the Diamond back moth, *Plutella xylostella*, a cosmopolitan pest of *Brassica* species. Courtesy of Sumitomo Chemical Co., Ltd., Osaka Japan Pest control guide, Plant Protection Division-International.

It is a wide spread pest of mainly cabbage and severe attacks sometimes occur, especially in hot dry weather (Hill, 1975). But, in the highlands of Arsi and Bale where the Ethiopian mustard



and rapeseed have been produced extensively by the state farms, diamond back moth has never been recorded as a major threat to the production of the crops. It might have been important pest of Brassica crops, at the times earlier to the works of Kemal and Tadesse (1987) but later it has not been reported as a major pest of the crop. So far, it has not been reported that there has been a time when pesticides were required to control diamond-back moth on Ethiopian mustard and rapeseed. For such a pest, what is important to do is to carryout once every few years a monitoring works both in experimental plots and production fields.

**Monitoring diamond back moth in Brassica crops**

1. On row planted Brassica crops, count larvae and damaged leaves per plant on 15 plants in a plot.
2. On broadcast planted Brassica crops, count larvae and damaged leaves per plant by crisscrossing the field. Take at most 25 plants per field.
3. Take the counts at early vegetative, 50% flowering and 50% pod setting stages.
4. Summarize the data for row/broadcast planted on per plot/field bases.

If the data are collected from experimental plots, follow the design used to plant the crops whereas for data collected from production fields, make use of each field as a replication and analyze the data.

# VI

## Collecting Socio-Economic Data

In order to generate appropriate technologies for the farmers and other beneficiaries, collection of socio-economic data is crucial. Information on socio-economic aspects could be obtained in three main stages: Secondary data collection, exploratory (informal survey) and formal survey.

### Secondary Data Collection Stage

Secondary data on the target location are assembled from diverse sources. This provides useful background on the region for beginning exploratory survey. Secondary data can be obtained from various published and unpublished sources, such as maps, regular and ad hoc reports, and censuses and from other sources such as reports of a research organization. The advantage of obtaining secondary information is that it results in a quicker and general understanding of farm household systems, and the environments in which they operate. It also avoids duplication of work and makes it easier to contact local people. Farmers judge outsiders, from the first moment, on the basis of their behavior and questions. Irrelevant questions can result in distrust. Hence, reviewing secondary information helps to avoid such expected problems during entry into the social systems for study. Some of the examples of secondary data types include agro-climatic data, topographic data, soils data, population data, production data, price and market data and research data.

### Exploratory (informal) Survey Stage

Exploratory (informal) survey is the second stage of collecting socio-economic data. The objective of exploratory survey is to quickly gather detailed information through informal interviews with many people, particularly with farmers, in order to arrive at a tentative description of farmer practices as well as an understanding of why, in light of their particular circumstances, farmers follow those practices. This information is useful in refining recommendation domains and identifying potentially improved technologies to overcome major factors limiting production and incomes. Moreover, its output consists of information related to the present situation, the constraints and development potentials of farm-household systems in the study area. The exploratory survey is also used to help design a well-focused formal survey. Further, the exploratory survey is used to collect important information that may be too sensitive or complicated to include in a formal survey. It is a gradual process of assembling information on farmer circumstances using a checklist. Field observations complemented by questions to farmers are very useful in the exploratory survey. Exploratory survey is best done when the target crop is in

the field so that problems can be observed in the field. The amount of time spent on the exploratory survey will vary depending on the size and complexity of the study area and the previous local knowledge of the researchers. The techniques employed in exploratory survey mainly include direct observations and informal interviews (with key informants, group interviews with farmers and interviews with individual farmers). All agricultural development workers can also use participatory rural appraisal (PRA) techniques to collect qualitative information. Different techniques can be selected and adapted to suit different stages of extension, research or general development programs. Some of the important PRA tools include participatory mapping and modeling, participatory transect walks, seasonal calendars, activity profiles and daily routines, semi-structured interviewing, time lines, participatory diagramming, wealth rankings direct matrix and pair wise ranking and scoring, seed counts and proportional pilling. A checklist is the most important tool during individual and group interviews with farmers.

## **Formal Survey Stage**

The purpose of formal survey is to verify and quantify information and test hypotheses formulated in the exploratory survey. Variations in farmer practices in the region can be quantified and hypotheses or reasons for the use of these practices can be more formally tested. The essential characteristic of formal survey is that a uniform set of data is obtained from a relatively large number of farmers that as a whole are representative of the region. This is achieved using a structured questionnaire and a random sample of farmers. The questionnaire is developed on the basis of the exploratory survey. There is no standard questionnaire for this type of survey, but rather the questionnaire is specific to a given region and set of research objectives. The questions included in the questionnaire arise from focusing the exploratory survey onto the important information needed for planning experiments.

### **Rules of developing a questionnaire**

#### **Organizing the questionnaire**

Questions should be included in a sequence that begins with specific questions on crop practices, which the farmer will find easy to answer and proceeds to more sensitive and difficult questionnaire. The questions should be organized into sections of the questionnaire in such a way that the questionnaire has a logical flow.

#### **Language of the questionnaire**

It is common to find that the language spoken by farmers differs from the *official language of the country or region*. If this is the case, the questionnaire should be asked in the local language by an interviewer whose native tongue is that language. The questionnaire should be written in the common written language and translated by the interviewer during the interview. In particular, questions that solicit opinions have to be very carefully translated to ensure that the meaning of the questions is correctly conveyed.



### **Length of the questionnaire**

The length of the questionnaire depends on the objectives of the survey and the complexity of the farming system in the area of study. As a rule, the questionnaire should be completed in less than 90 minutes to avoid fatigue on the part of the farmer. A thorough exploratory survey enables the design of a questionnaire that can be completed in about one hour.

### **Sampling for the formal survey**

Before beginning a survey, a basic decision must be reached about the population of farmers of interest. If the target group is Ethiopian mustard (*Brassica carinata*) and rapeseed (*B. napus*), the population of interest is all those farmers who could grow these crops. Because it is not possible to interview all farmers in the target group, we interview a part or a sample of the farmers and use the information obtained from this sample of farmers to make statements or inferences about all farmers in the population. Hence, the purpose of sampling is to select, at reasonable cost, a group of farmers, which are roughly representative of farmers in the population. A representative sample must be selected at random - that is, where each unit in the population or subgroup of the population has an equal chance of being selected. Some of the most important practical sampling methods include the following:

#### **Stratification**

Stratification of the population is the process of dividing the population into relatively homogenous subgroups called strata, and then taking separate samples from each group of strata. It is convenient to stratify the population by recommendation domains delineated during exploratory survey prior to sampling. A recommendation domain is a group of farmers with similar agro-climatic and socio-economic circumstances for which the same technologies can be recommended.

#### **Random sampling**

Random sampling is a selection procedure, which ensures that every unit of the population or strata of the population have an equal chance of being selected. Random sampling is best done with a table of random numbers.

#### **Sample size**

A representative sample must not only be random but must also be large enough to reflect all farmers in the region. Consideration of the variability within the study area is important in determining sample size. In an area where there is much variability within the recommendation domains, the sample size should be increased. It should be noted that the sample size depends on the variability within the population and not on the size of the population. The sample size must conform to the time and cost constraints of the survey. The marginal cost of including additional farmers in the sample is relatively low. For this reason, increasing the sample size is favored when there is doubt about the adequacy of the sample size for representing some variables.

### **Implementing the formal survey**

The questionnaire has to be pre-tested before implementation for its consistency, logical flow and length. After the pre-testing, the questionnaire has

to be corrected and finalized for implementation. With a questionnaire developed and pre-tested, and a sample drawn, the formal survey is ready for implementation. Successful implementation requires a team of capable interviewers, the farmers' cooperation, correct completion of the questionnaire and close supervision by the researchers of these activities. The following important aspects have to be taken into consideration during the implementation of the study.

### ***The interviewer***

The interviewer is the middleman between the researchers and the farmers. The quality of the interviewer is one of the most important factors in conducting a successful survey. Researchers should personally recruit the interviewers. The following characteristics are important in selecting interviewers

- Motivation to work hard and honestly;
- Ability to fill the questionnaire correctly (usually determined by some minimum level of schooling and intelligence);
- Ability to communicate with the farmers in the local language; and
- Knowledge of local agriculture and respect for farmers and rural people.

Some of these characteristics could be evaluated during recruitment of interviews and in training; while others depend on personal assessments by trusted acquaintances.

### ***Gaining farmers' cooperation***

Farmers' cooperation is essential to the success of the survey. This cooperation is gained at the following levels

- Through support of local leaders, particularly in societies in which these leaders enjoy considerable respect; and
- By correctly introducing the survey to the farmer.

It is best to interview the farmer when and where it is convenient for him. For this reason, the survey should be planned for implementation in a relatively slack time in the agricultural calendar. Above all, the farmers should be treated with respect.

### ***The interview***

Interviews should be conducted with the household head or the primary decision maker of the target crop. The interviewing should be as relaxed and informal as possible. The interviewer should ensure that the farmer understands the question but should not inject his own opinion. Before terminating the interview, the questionnaire should be reviewed to ensure that all information is complete.

### ***Supervision***

Constant and effective supervision is critical to the success of a survey. The researcher(s) must be in the area during the period of the survey acting as field supervisor throughout. The supervisor should edit the questionnaire on a daily basis for legibility, completeness and consistency.

## Resource Base

- Farm size, plot sizes, soils
- Fragmentation of holding
- Water resources
- Land tenure
- Labor availability
- Capital assets, irrigation facilities
- Cash
- Skills and knowledge

## Resource Utilization

- Crops grown, areas, seasons
  - Cropping systems, rotations, intercropping
  - Cultivation practices, level of technology
  - Material input use, fertilizers, chemicals, pest management
  - Power use
  - Labor use, intensity
  - Capital use, intensity
  - Output, prices, cash income
- Livestock
  - type, numbers
  - purpose of keeping
  - husbandry, level of technology
  - output, prices, cash income, on-farm consumption
- On-farm processing
- Storage

## Household

- Family composition
- Age structure
- Education
- Labor/activity division
- Off-farm activities, cash income; non-farm activities, cash income
- Food processing
- Cottage industry
- Schooling

## Household Objectives and Preferences

- Food, nutrition, other consumptive needs
- Shelter, Health, Wealth, Leisure
- Risk, security
- Social status and acceptance
- Aspirations

## Community

- Social obligations/restrictions
- Social behavior and customs
- Communal resources and organization
- Decision-making, participation in planning and implementation of community works



## **Institutional Support**

- Marketing, cooperatives, merchants, etc
- Credit and financing, savings
- Input supply
- Extension services

# VII

## Transfer of Production Technologies

### Technology Transfer

There are two components in technology transfer: knowledge and inputs. Input transfer involves planning and management of technology multiplication, manufacturing, distribution and sales. Knowledge transfer involves planning and management of message development, training and backstopping, delivery strategy and dissemination. Technology transfer in general involves evaluating and adapting research outputs for users and then widely disseminating the knowledge and inputs to different target adopters: farmers of different categories, private and state owned companies. This part of the manual focus mainly on the how of transfer of knowledge through various means

### Situation Analysis

**I. Identify “Weredas” growing Brassica crops and categories based upon their growing potential as major, medium, marginal.**

**II. Analyze the potential access to resources based on the following issues:**

**Land**-size of holding: small, medium, large; type of tenure: owner operated, family land, rent-share-cropper

**Water**-irrigated, none irrigated

**Labor**- family, hired (cost and availability)

**Inputs**-Availability of improved seeds, agricultural chemicals, fertilizers

**Market**-Location, availability of storage and transport, accessibility to road, oil mills, etc

**Capital**-sources and cost of credit, type of collateral needed, and ease of obtaining credit

**Information**-appropriateness of technology, availability of extension service (worker to farmer ratio)

**Influence** -ability to affect technology development, transfer to be appropriate to user needs such as user control, claim-making capacity

**III. Assess growing conditions and agro-ecological zones**

In identifying and transferring appropriate technology for extension, clientele's it is important to map areas a priori into agro-ecological zones. Mapping allows for the identification of agronomic variables such as soil type, rainfall,

lope and altitude, which will influence the development of location-specific technologies.

#### **IV. Farming practices followed in the different areas and conditions**

Have a clear picture and understanding about the following: Plowing, Sowing (time, amount of seed and fertilizer), weeding time and frequency, harvesting

#### **V. Inventory of technologies**

**Variety:** Available varieties, characteristics of the varieties, areas wherein the varieties were tested and the potential yield special characters of varieties and recommended agronomic practices.

**Other technologies:** Available technologies, description of technologies, areas where the technologies were tested and their potential yields.

## **Execution of Extension Work**

### **Clientele selection**

Extension Clientele (*Weredas* and Farmers) has to be defined within the context of an agricultural policy framework. This framework should provide the boundaries for selecting from among the border user categories, the specific groups that are to be targeted. The current national agricultural policy gives more emphasis for market oriented research and extension. The following are the steps to be followed to execute extension work:

#### **1. Select "weredas"**

Select one to two "*weredas*", which could represent adjoining ones. It is better to consider "*weredas*" with better access to roads and/or oil mill.

#### **2. Select farmers**

Select farmers having representative topographies and soil types, which are mainly covered by oil crops in the area. Avoid waterlogged fields because they may not be representative. If the dominant practice is to plant Rapeseed on "Kosi" land, we need to locate demonstration plots on "kosi" land. In planting the rapeseed, follow farmers' and the improved management practices.

#### **3. Designing the demonstrations**

##### **Plot size**

Plot size can be decided based on the area where the demonstration is to be conducted. However, it is good to plan for large plot size. The 2500m<sup>2</sup> plot, which has been in use for most extension purposes, was found to have the following advantages: increased seed multiplication, manageable size and easy to observe. It can also be increased whenever there possible, as there is a grater demand for the supply of more improved seeds.

##### **Treatment types**

From Holetta Agricultural Research Center recent experience, the following three treatments

- Farmer variety + farmers practice;



- Improved verity + Improved practice; and
- Improved variety + Farmers practice are preferable. This is because they allow potential adopters of technologies to make better comparison and see the advantages that could be obtained from the demonstrated technology.

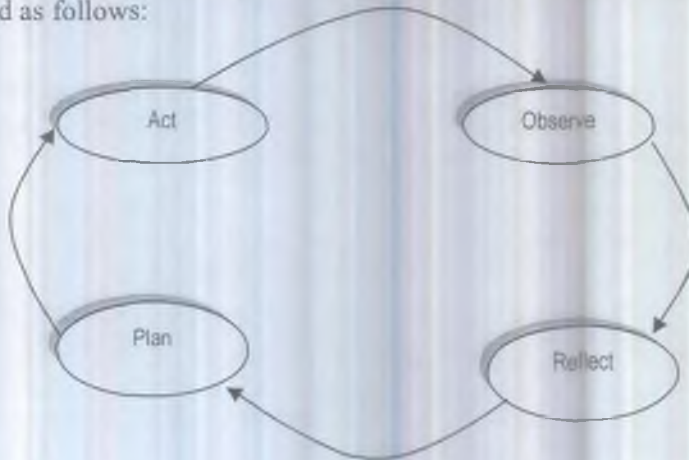
## Forming Farmer Learning or Extension Groups

Holetta research center has accumulated a lot of experience in this regard. Forming, supporting and guiding farmer learning/extension groups (FLG/FEG) by the Holetta Research center have proven that such an approach is a good one for effective transfer of technologies.

Process in-group formation can be as follows:

- Need and awareness creation
- Adopting the formulation process of local institutions (rules, regulations, etc)
- Mobilization
- Observing the process
- Developing memorandum of agreement
- Developing action plan (type of activities, frequency of visits etc)

A series of cycles with increasing knowledge as the FLG/FEG continues can be demonstrated as follows:



## Monitoring and Evaluation

### Major elements in evaluation

There are at least five major elements in most evaluations:

1. Focus questions
2. Objects or events to be evaluated
3. Data or evidence
4. Analysis and interpretation using judgment perspectives
5. Judgment, conclusion or findings

### Steps in Monitoring and Evaluation

1. **Process Monitoring and Evaluations** - this can include observing attendance, topic of discussion, interest development, and leadership development in the

group, efficiency and effectiveness of communication among the group members.

2. **Result evaluation** – we can apply the principle of single loop, double loop or/and triple loop techniques.
3. **Agronomic evaluation (include example from existing report)** -Mean, Standard deviation, T-test, % increase.
4. **Economic evaluation** -Partial budget analysis can be utilized
5. **Farmer evaluation** -Use strength-weakness approach or SWOT analysis. e.g. improved variety of Rapeseeds.

Strength	Why?	Weakness	Why?

6. **Evaluation of the process of FEG/FLG** -should be done by farmers. Perform the same strength and weakness analysis or you can use SWOT analysis.

## Information dissemination outside demonstration farmers

Using the following techniques, information can be disseminated for non-participant farmers: by arranging field days, through training, arranging group visit to demonstration fields preferably in the presence of participant farmers, offering seminars, using the Research Extension Advisory Council (REAC) forums, by creating and using Farmers Research Groups (FRG) for non-participants and other groups, and using the traditional farmers' information exchange system.

## Conducting field days and utilizing them successfully

- Make all the necessary preparations
- Giving opportunity for demonstration hosting farmers to invite any number of farmers (relatives or peers)
- Invite media
- Keep attendance disaggregated by gender

## Evaluation

Three important elements of evaluation process

1. Observations or collecting some information
2. Applying some standards or criteria to our observation
3. Finally, forming some judgment, drawing some conclusions or making some decisions are essential. There are different degrees of evaluation and one of the following can be used:
  - a. Casual every-day evaluations
  - b. Self-checking evaluations
  - c. Do-it-yourself evaluations
  - d. Extension studies
  - e. Scientific research

As a general guideline, one can follow the following steps to evaluate:

- i. Asking sample farmers to evaluate the demonstrated technology;
- ii. Asking and recording number and addresses of farmers willing to test on their own farm the following year.



## Preparation of publication

Preparing publication is one of the most important components; this can be in the form of leaflet. Effectively demonstrated technologies are prepared in leaflets so that more people can be made aware of promising technologies. Make sure that every potential technology user "wereda" gets a copy of the leaflet for future reference.

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