INSTITUTE OF AGRICULTURAL RESEARCH

PRODUCTION NOTES FOR
HIGHLAND OIL CROPS

HOUG, RAPESEED, LINSEED

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Production Notes on Noug

Introduction

Noug is an oilseed crop which originated in Ethiopia. Largest production of Noug is in India where 630,000 ha are grown. Ethiopia has 150,000 ha of noug and is the second largest producer.

Noug is the most important oil crop in Ethiopia. Approximately 50% of total vegetable oil production is from noug. Gojjam, Gondar and Delega are the most important noug producing regions in Ethiopia. These 3 Administrative Regions account for 30% of the noug production in the country. It has been reported that noug is grown in East Africa, Zimbabwe, West Africa as well as Germany as a forage crop.

Adaptation

Altitude - Noug can be grown from 1400 meters up to 2500 meters, but grows best between 1800 and 2000 meters.

Temperature - Noug is a crop of the cooler parts of the tropics. The crop does not flower at high temperatures from 27° to 33°C.

Photoperiod - It is short day plant and will not flower if the day light period is longer than 14 hours. At shorter daylengths of 10-12 hours and with lower temperature of 15-21°C noug flowers readily. A soil temperature of 17-21°C has been found to be best for noug.
Rainfall - Noug will produce crop on less than 300 mm during the growing season. On heavy soils noug can be planted after the rains have stopped, a crop can be produced on the stored soil moisture. The crop is well adapted to areas where rainfall does not exceed 1000 mm per year. In India, the crop is grown in areas with very light rainfall.

Soils - In Ethiopia, the crop is often grown on heavy clay soils often poorly drained. This crop is very tolerant to water logging and has been found to produce equal yields on water logged soil compared with better drained soil. Noug in India is grown on light lateritic stoney and thin soils which will not grow any other crop.

Fertilizer - Fertilizer application causes a large increase in vegetative growth, but only a slight increase in seed yield. Therefore, this crop is not very responsive to fertilizer as far as seed yields are concerned. At Holetta, an application of the recommended amount of 23/23 kg/ha of N and P<sub>2</sub>O<sub>5</sub> produced a 21% yield increase. However, this was only an increase of 1.5 q/ha. In some cases, too much fertilizer may cause serious lodging and actually lower the yield.

Origin and Botany

Origin of Noug - Cultivated noug (Guizotia abyssinica) may have originated from the wild species Guizotia scabra due to selection by Ethiopian farmers several thousand years ago. Movement of the crop to India may have occurred soon after the crop was domesticated in Ethiopia.
Botany - Noug belongs to the family Compositae. Sunflower is another
crop belonging to the same family. The somatic cells of the plant have
30 chromosomes \(X = 15\). The plant height varies from 30cm to 250 cm.
The plant may become highly branched. Heads are borne on the ends
of the branches. Numbers of heads (Capitula) per plant varies from 35
to 170. Each capitulum has 2 types of flowers. On the outside are 8-9 ray
florets (female) with light yellow petals. On the inside are 25-60 disc
florets (both male and female) which do not have petals. The seeds are
small and black and shiny. They contain 30-45% oil.

Varieties - There is a large diversity of types of noug growing in
different areas of Ethiopia. There are two main groups. A fast maturing
group, which takes less than 120 days to mature and is found in lowland
area, and a taller, longer maturing group, taking about 160 days to mature
which is found growing in higher elevation areas. There is one recommended
variety called Sendafa which belongs to the longer maturing group.

There are wide range of noug types being tested, and higher yielding varieties
should be released in a few years, which are also responsive to fertilizer
and improved management.

Cropping Sequence

Noug is well known to be a good precursor for other crops as crops which are
planted after noug have a higher yield. Noug suppresses weeds very
effectively, and fields require less weeding in the following year. Noug
should not be planted after noug, as the yield will be reduced.
Cultural Practices

Seed-bed preparation - Often noug is planted on a poorly prepared seed bed, following a single plowing. This is true both in India and Ethiopia. However, the seed bed should be reasonably well prepared in order to insure proper germination.

Sowing - Noug is usually broadcasted, but does well in rows 25-30 cm apart. The depth of sowing should be shallow, only 1-2.5 cm deep. A rate of seeding between 5 and 20 kg per ha has little affect on seed yield, as plants under low rates of seeding will produce a higher number of heads. The recommended rate is 20 kg per ha broadcast and 10-20 kg/ha when planting in rows. A sowing date between June 25 and July 7 is considered the best time on reasonably well-drained soil. In water-logged soil, sowing can be delayed until the end of August, but yields will be lower.

Plant Protection

Weeds - During early stage of growth noug should receive at least one weeding. During later growth, the plants become very competitive and crowd out the weeds and other plants. Noug may produce a substance that is toxic to other plants and prevents their germination and growth.

Disease - Economic loss in noug due to diseases does not usually occur. The most prevalent diseases are:

1. Shot hole (Septoria spp) causes round rings with centres on the leaves starting at the bottom, and later becoming prevalent on the upper leaves.

2. Powdery mildew (Sphaerotheca spp.) white powdery spots can be observed on the leaves.

3. Leaf and stem nematodes (Anguina spp.) swellings or tumors on the stems and leaves.
Other diseases, usually of minor importance are: Rust (Puccinia guizotiae), damping off (Phizoctonia solani), downy mildew (Pasmoepara halstedii), stem lesions (Phoma spp).

**Parasitic Weeds** - In some areas, noug is badly affected by dodder (Cuscuta spp.) which has been found in Wolloga and Gondar, but not yet in Gojjam. In some cases the entire crop is destroyed by this weed. The dodder winds itself around the stem of the noug and removes the plant's nutrients. Orobanche or broom rape is also prevalent in some areas and can reduce yields. The Orobanche germinates close to the noug plant and fastens itself onto the roots. The thick pointed plants of Orobanche can be seen clustered around the noug plants. Both weeds should be pulled out before they set seed, and the plants should be burned.

**Insect Pests** - Plusia worms (Diachrysia orichalcea) are green or brown caterpillars which eat the leaves. They walk with a looping movement of the body.

The Noug Fly (Oioxyna sororcula) lays eggs in the flowers. The flowers will later dry up. If the florets are pulled apart, white worms up to 8mm. long can be seen feeding in the flower heads. Severe outbreaks of the noug fly have been reported in the Bako area. To control these pests, destroy wild host plants (Guizotia scabra) growing near the cultivated fields. Destroy crop residues at least 2 months before the next sowing is due. If pesticides are necessary, spray with a mixture of 15g 35% carbaryl w.p in 10 l of water against plusia worms, and spray with a mixture of 10 ml fenthine EC in10 l of water against noug fly.

**Harvesting**

Time of harvest is very important. Harvesting too early will cause the seeds to be shrivelled. Harvesting too late may cause heavy losses due
to seed shattering. The correct time for harvest is 3 weeks after the petals begin to drop from the flowers, and the top most leaves are just turning from green to yellow, while the bottom leaves are brown. Cut near the base of the plant and put into stooks. The stooks should be left in the field until fully dry, usually 3-5 days. The stooks can then be easily threshed, either by sticks, oxen or tractor, or with a threshing machine. Direct cutting of noug using a combine may lead to high losses by shattering.

Yields - Average seed yields of 3-5 q/ha are reported for Ethiopia. Under research conditions, yield of 3-10 quintals are common.

Utilization

Noug produces a high quality oil containing 70 to 50 percent linoleic acid, which is prized for cooking. Noug oil has excellent nutritional quality and stores well. Most noug is used for oil extraction, either in the home or in oil mills. A small proportion (about 2-3%) of total production is exported. Other uses of noug oil may be as lamp oil for lighting, as a lubricant, for soap and in paints. The oil cake remaining after the oil is extracted, is an excellent source of energy and protein for livestock. The oil cake can also be used as fertilizer.
Production Notes on Rapeseed
and Mustard

Introduction

Most rapeseed on the world market comes from two species of rapeseed, *Brassica napus* (known as true rape) and *B. campestris* (or turnip rape). These two species are grown in Northern Europe and North America. In India, oil is produced from Indian mustard, *B. juncea* as well as from *B. campestris*. World production of rapeseed has increased from 3.7 million tons in 1961 to 7.3 million tons in 1975. This increase has been due in part to the improved nutritional quality of oil produced by new varieties of rapeseed with low erucic acid. More recently, varieties with low glucosinolate content have been released. Glucosinolates are harmful compounds in the oil cake which may be toxic to animals that eat the oil cake. Glucosinolates also produce a pungent taste in the oil.

In Ethiopia, annual production is 6000 tons. This production comes almost entirely from *B. carinata*, known as Ethiopian mustard or gorenzer. This crop is often found growing near houses. The seeds are used for oil and the leaves made into wat.

Adaptation

Altitude - Rapeseed/mustard are grown at medium to high altitudes above 1650 meters. Best growth can be found between 1800 and 2600 meters.

Temperature - Rapeseed/mustard are cool season crop. Cool temperatures are especially important up to flowering but during grain filling, warmer temperatures can be tolerated. In India, a fast maturing rapeseed known
as Toria, can with stand high temperatures during germination and early
growth. Changes in temperature are not likely to affect the oil quality.
Rapeseed performs especially well when cool nights follow warm days.
Very high temperatures during seed development can reduce oil
content and yield.

Overnight frost can damage rapeseed during either the seedling or the
seed filling stages. During the late vegetative and flowering stages,
rapeseed is much more tolerant to frost.

Day length - Day length is not critical when rapeseed is grown during the
June to September season, when day length is more than 12 hours. Longer days
hasten maturity. Many types of rapeseed will not flower when the day length
is less than 12 hours.

Rainfall - The amount of rainfall required depends on the type and species
grown. Drought resistant types in India require as little as 120 to 400 mm
of annual rainfall, and others can produce a crop using only stored soil
moisture, with a tap root that grows 1.5 meters into the soil. In Canada
rapeseed grows well in areas where the annual rainfall is 400-500 mm.
Rapeseed requires more rainfall than mustard, and both rapeseed and mustard require
more rainfall than wheat. In Ethiopia, rapeseed will grow where the annual
rainfall is above 400mm. The rainfall should be evenly distributed during
the growing season, since yields can be reduced by either water logging, or
drought.

Soils - The soil should be relatively level, with good drainage, and be near
neutral in PH. Rapeseed/mustard perform best on loam soils. In Canada,
rapeseed yields more on heavier black soils compared with lighter brown
soils. Good drainage is essential for good yields. Water logging during
early growth was the most serious factor reducing yields in trials in different
rapeseed growing areas of Ethiopia during the past year. Rapeseed has been
found to be more tolerant of saline soil than wheat. The surface soil
structure is very important for proper emergence. Soil structure which is too fine may form a crust if a rain is followed by a dry spell, and prevent seedling emergence. Too coarse a seed bed will also reduce seedling emergence.

Fertilizer - Rapeseed is a heavy user of both nitrogen and phosphorus. The present fertilizer recommendation is 45/69 kg/ha of H/P₀₂. This amount will be supplied by 1q of Urea and 1.5q of TSP per ha. At Holetta, the application of recommended rates of fertilizer increased seed yields from 370 to 1837 kg/ha. Rapeseed requires more N and P than does wheat. Total nitrogen uptake is from 100 to 250 kg/ha, while phosphorus (P) uptake is 15 to 50 kg/ha, depending on crop growth (34 to 114 kg/ha of P₂O₅).

In some countries, especially where rainfall is heavy, part of the nitrogen fertilizer is applied at planting, and the remainder after 4-6 weeks. All of the phosphorus should be applied at or before planting.

In several countries, yields have been increased with the application of sulphur. Applications of 53.93 kg/ha of S have been found to be economic in France and Sweden, while in Canada, 22kg/ha is usually sufficient. Sulphur is best applied as a component of nitrogen fertilizer, such as Ammonium Sulphate.

Potassium (K) is sufficient in most soils in Ethiopia. Trials with rapeseed at Kulumsa did not show any response to K.

Deficiency Symptoms in Rapeseed

Nitrogen Deficiency - The leaves and stems have a light green colour. Older leaves may wither. Plants have short, thin main stems, and few branches. Flowering time is restricted, and the crop matures earlier.
Phosphorus Deficiency - The leaves are a dark green colour, sometimes with traces of purple. Stems become blue-green, purple or reddish. Older leaves may wither. Plants are spindly, with restricted branching. A slight deficiency tends to delay maturity.

Sulphur Deficiency - The leaves have a pale green colour. Just before flowering, there is interveinal chlorosis on the leaves (light areas between the leaf veins). Younger leaves are most affected. Flowers are paler yellow than normal. Flowering becomes indeterminate, so that ripe pods and flowers may be on the plant at the same time. Tips of the pods dry up and pods may have few, or no seeds. Stems are short and woody.

Origin, Breeding and Varieties

There are three species of rapeseed/mustard with potential as oil crops in Ethiopia.

1. Brassica carinata (Ethiopian mustard, or Oenanzer) originated in Ethiopia from the natural crossing of B. nigra (senafitch) and B. oleracea (tikil gomam). Approximately 15,000 ha are grown in Ethiopia. This species is widely grown only in Ethiopia. Very high seed yields up to 48q/ha have been obtained under experimental conditions. Most Ethiopians mustards are long maturing types, taking 150-180 days to mature. Some promising early maturing lines are now being tested.

The best of the recommended mustard varieties in last seasons trials were S71 and S 115, which are long maturing types, and S 67 which is a slightly faster maturing variety. Edela 1 (IAR/Dr 2) is another promising variety with uniform maturity and slightly earlier in maturity.
2. *Brassica napus* (true rapeseed or Argentine rapeseed) - This species was introduced into Ethiopia about 10 years ago on an experimental basis, from Northern Europe and Canada. Rapeseed is one week to 10 days earlier to mature than mustard, but yields are about 37% lower than mustard. Target is the only released rapeseed variety in Ethiopia. Target has high erucic acid and high glucosinolate levels, similar to those of mustard. Two new varieties called Tewer and Pura, have yields equal or better than Target, but have low erucic acid and glucosinolate levels. Rapeseed may be more adapted to mechanized farming, as it has thinner stems, and often matures more uniformly than mustard.

3. *Brassica campestris* (turnip rape). This is the earliest maturing of the three species, maturing in 90-120 days. It is more suitable for low rainfall areas. In higher rainfall areas, Alternaria leaf spot becomes a serious problem. Because of its short growing season, this species has the lowest potential yields. At the present time, there are no released varieties of *B. campestris* in Ethiopia.

### Recognition of Brassica Species

<table>
<thead>
<tr>
<th>Character</th>
<th>Carinata</th>
<th>Napus</th>
<th>Campestris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf colour</td>
<td>light green</td>
<td>dark blue/green</td>
<td>olive green</td>
</tr>
<tr>
<td>Leaf surface</td>
<td>smooth</td>
<td>smooth</td>
<td>rough</td>
</tr>
<tr>
<td>Leaf position</td>
<td>away from stem</td>
<td>touching stem</td>
<td>unfolding stem</td>
</tr>
<tr>
<td>Leaf lobes</td>
<td>deep lobes</td>
<td>no lobes</td>
<td>slight lobes</td>
</tr>
<tr>
<td>Stem</td>
<td>purple/pink</td>
<td>dark green</td>
<td>light green</td>
</tr>
<tr>
<td>Seed colour</td>
<td>light brown/yellow</td>
<td>black</td>
<td>black/yellow</td>
</tr>
<tr>
<td>Seed size</td>
<td>large</td>
<td>medium</td>
<td>small</td>
</tr>
<tr>
<td>Plant type</td>
<td>freely branching</td>
<td>moderately branched</td>
<td>least branched</td>
</tr>
</tbody>
</table>
Average performance of rapeseed and mustard across locations in 1981/82

<table>
<thead>
<tr>
<th>Variety</th>
<th>Days to Flower</th>
<th>Days to Maturity</th>
<th>Height (cm.)</th>
<th>Lodging (%)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>60</td>
<td>140</td>
<td>143</td>
<td>14</td>
<td>2213</td>
</tr>
<tr>
<td>Pura</td>
<td>68</td>
<td>140</td>
<td>150</td>
<td>11</td>
<td>2199</td>
</tr>
<tr>
<td>Tower</td>
<td>67</td>
<td>140</td>
<td>153</td>
<td>0.8</td>
<td>2192</td>
</tr>
</tbody>
</table>

**Mustard**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Days to Flower</th>
<th>Days to Maturity</th>
<th>Height (cm.)</th>
<th>Lodging (%)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.115</td>
<td>79</td>
<td>165</td>
<td>175</td>
<td>10</td>
<td>2804</td>
</tr>
<tr>
<td>Dodola</td>
<td>74</td>
<td>165</td>
<td>183</td>
<td>24</td>
<td>2655</td>
</tr>
<tr>
<td>S.67</td>
<td>76</td>
<td>164</td>
<td>183</td>
<td>24</td>
<td>2596</td>
</tr>
<tr>
<td>S.71</td>
<td>80</td>
<td>166</td>
<td>197</td>
<td>17</td>
<td>2640</td>
</tr>
</tbody>
</table>

New rapeseed varieties with low erucic acid and glucosinolate levels are being tested. A breeding program is expected to produce mustard varieties with low erucic acid and low glucosinolates in a few years.

**Cropping Sequence**

In Canada, it has been found that land seeded to rapeseed or mustard should not be seeded to these crops again for at least 2 years. This interval is required to break the cycle of pests and diseases. For the same reason, rapeseed and sunflower should not follow each other. Many growers have found that where the land is frequently cropped to rapeseed or mustard, the soil loses its structure and becomes powdery. In Canada, it has been found that cereals, oilseeds or other crops grown in rotation with rapeseed may suffer damage from a toxin found in the rapeseed straw. Some varieties of wheat and barley have been found which are resistant to this toxin. At Holetta, cropping sequence studies showed that wheat or barley following rapeseed produced good yields. However, rapeseed following rapeseed produced low yields.

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Cultural Practices

Seed-bed Preparation - Good seed bed preparation is very important for good emergence. Following plowing, the land should be disced to form a level surface, with clods up to 2.5 cm in diameter. There should be moisture not more than 2.5 cm from the soil surface. In North America, preplant incorporation with herbicides such as Cptam or Traflam are often applied at the time of final harrowing or discing.

Sowing Method - Two years results from Kulumsa indicate that higher yields were obtained from broadcasting than with drilling. Seed rate - A rate of 10 kg per ha. has been found to produce best yields both at Kulumsa and at Koletta. There was no increase in yield by using a higher seed rate.

Effect of Spacing in Mustard at Kulumsa

<table>
<thead>
<tr>
<th>Row Spacing (cm)</th>
<th>75</th>
<th>50</th>
<th>20</th>
<th>Broadcast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Yield (kg/ha)</td>
<td>2320</td>
<td>2440</td>
<td>2410</td>
<td>2790</td>
</tr>
</tbody>
</table>

In very weedy fields, where mechanization is available row planting may be preferable, so that cultivation between the rows can be carried out.

Date of Planting - Highest yields have usually been obtained from earlier planting. In high altitude, cool areas such as Bokaji, highest yields were obtained by planting the end of May. In general, the best time to plant is at the beginning of the main rains in June. Seeding delayed after the start of the main rains resulted in lower yields. Dry planting at Holetta, up to 2 weeks before the rains started did not affect yields.

Dept of Seeding - Shallow seeding of 1-3cm is best when sown into a firm moist seed bed. Seeding too deeply will result in delayed emergence and poor stand. A seed dressing using lindane insecticide has been found to increase yields at Kulumsa. Seed dressing is especially important with dry planting.
Fertilizer and rapeseed should not be drilled together. The fertilizer is best placed 2cm below the seed. This is especially important with phosphorus fertilizer. When broadcasting, the fertilizer and seed are not in close enough contact to cause any problem.

Weed control - Although several different herbicides are used to control specific weed species in other rapeseed growing countries of the world, no herbicide is recommended in Ethiopia for rapeseed/mustard.

In the early stages of growth, rapeseed is not a good competitor with weeds. The crop should have an early weeding at about 15 days after emergence, followed by a mid-season weeding. An early weeding is especially important. The mid-season weeding is usually carried and 40 days after planting.

Diseases

The importance of diseases in rapeseed/mustard, depend on the species and on the environment during growth. In general, mustard is more resistant, and turnip rape is more susceptible. Crops growing in a dry environment are likely to have less diseases than crops grown in high rainfall and high humidity environments. The main diseases are as follows:

1. Alternaria leaf spot (Alternaria spp.)

Description - Black or brown spots appear first on lower leaves, then appear on the upper leaves, and finally on the pods. The spots enlarge and may form concentric circles with white centres on the leaves. The entire leaf may die and drop off. On the pods, the black spots enlarge, and can cause up to 60% yield reduction in India.
Importance - This disease does not cause much damage in Ethiopian mustard. It is slightly more severe in rapeseed (B. napus) and can be most severe in turnip rape (B. campestris).

Disease cycle - Infection can be caused by wind borne spores or infected seed. Many weeds can carry the disease also. During the growing season, spores from initial infection can increase the disease.

Control - Seed should be cleaned to move shrunken and infected seed. There is no recommendation for seed treatment to control leaf spot. Rotation of crops, and removal of any cruciferous weeds or rapeseed/mustard volunteer plants should be practiced.

2. Downy Mildew/White Rust (Peronospora parasitica/Albugo candida)

Description - This disease produces swelling and strange shapes in the terminal parts of flower stalks. These stagheads are green, then become hard, dry and brown. Blisters may also occur on the stems and pods, and cream-coloured pustules on the under sides of infected leaves.

Importance - Turnip rape is most severely infected in Canada, while B. napus is reported to be immune. In Ethiopia, however, this disease has been found on B. napus.

Disease cycle - In Canada, the disease overwinters as cospores in the soil or in the seed. Infection in the crop occurs first on the under side of the leaves of seedlings, then later spreads to the stem and pod. At harvest, fragments of the "stagheads" and free cospores can contaminate both seed and soil.

Control - Remove any "volunteer" rapeseed plants, clean the seed to be planted, and practice rotation. There are no fungicides presently available that can control the disease.
3. **Sclerotinia Stem Rot (Sclerotinia sclerotiorum)**

**Description** - A soft, watery rot occurs on the stem. The plant later wilts and dies. The disease also causes premature ripening. Matured plants have a white colour on the stem. The diseased stem tissue tends to shred. Inside the stem, black bodies, called sclerotia can be found.

**Importance** - This disease is non specific and can infect sunflowers, white beans and clover as well as rapeseed/mustard. This disease has been indentified both on sunflower and rapeseed in Ethiopia. In Canada, yield losses of 28% in rapeseed have been reported.

**Disease cycle** - The sclerotia germinate in moist soil to produce either a mould, which can directly infect plants, or spores. The spores are carried by wind to the growing plants and cause infection. The infection usually starts in the leaf axil near the base of the plant. The infected plant produces sclerotia, which start the next cycle of the disease. The sclerotia either drop to the ground, or are harvested with the seed.

**Control** - Crop rotation to grasses or cereals for at least 4 years is recommended in infected fields. There are no resistant varieties.

**Insect Pests**

1. **Cabbage aphid - Brevicoryna brassicae** is an important sporadic pest of the Brassica spp., especially at young stage of growth.

**Recognition**

Masses of grey, mealy, soft-bodied insects on the heart and near the leaf bases.
1. Control

a) Cultural - Crop rotation
b) Chemical

   i) Dimethoate 40% E.C. 1 l/ha
   ii) Formothion 33% E.C. 1 l/ha
   iii) Epdcsulfan 39% E.C. 2 l/ha

2. Diamond-back moth - *Plutella xylostella* - An important pest of the *Brassica* spp.

   Recognition

   Light green caterpillars present up to 12mm long. Pupae may also be seen in grey silk cocoons on the leaves. Damaged leaves with shot holes or "windows".

   Control

   a) Cultural

   i) Crop rotation

   b) Chemical

   i) Carbaryl 85% WP 1.5 kg/ha
   ii) Fenitrothion 50% E.C. 1 l/ha
   iii) Trichlorfon 95% SP 1kg/ha
   iv) Diazipan 60% E.C. 0.75 l/ha

3. Cabbage white - *Pieris brassicoides* is also a sporadic insect pest of *Brassica* spp. in many areas of Ethiopia.

   Recognition

   Leaves eaten - Black, slightly hairy worms present & up to 4 cm long when fully grown. Each worm has a white stripe down the middle of the back and a yellow stripe on each side of the body.
Control

a) Cultural

i) Crop rotation

b) Chemical

   i) Carbaryl 85% WP 1.5 kg/ha
   ii) Malathion 50% E.C. 2 l/ha
   iii) Trichlorfon 95% SP 1 kg/ha

4. Cabbage flea beetle - Phyllotreta spp. is a serious pest of Brassica seedlings in many growing areas of the country.

Recognition

Small, black (or stiped) beetles present which jump like fleas when disturbed. Damaged leaves with shot holes.

Control

a) Cultural

   i) Plant as soon as the rains begin
   ii) Try to plant the whole crop in the area at the same time
   iii) Destroy wild host plants growing near the cultivated area

b) Chemical

   i) Carbaryl 85% WP 1.5 kg/ha
   ii) Malathion 50% E.C. 2 l/ha
   iii) Trichlorfon 95% SP 1 kg/ha
   iv) Fromophos 80% E.C. 1.5 l/ha

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5. **Plusia worms** e.g. *Chrysodeixis acuta* - These are serious sporadic pest of many crops in the country.

**Recognition**

Leaves eaten. Green or brown caterpillars present up to 4cm long. Worms have only 3 pairs of false legs and walk with a looping movement of the body.

**Control**

a) **Chemical**

i) Fomithrothion 50% E.C. 1.5-2 l/ha

ii) Carbaryl 85% WP 1.5 kg/ha

iii) Malathion 50% E.C. 2 l/ha

iv) DDT 25% E.C. 3-4 l/ha

Large caterpillars are very difficult to kill. Spray if possible when the caterpillars are small before serious damage occurs on the crop.

**Harvesting**

It is very important to correctly determine the right time to harvest. As rapeseed and mustard approach maturity, they may ripen quickly and shatter. Rapeseed may shatter more easily than mustard. In Canada, it was found that highest yields of seed and oil were obtained by harvesting the plants before they are fully ripe.

If the crop is uniformly mature, and free of weeds, it may be directly cut and threshed, using a combine. Direct combining also works well if the crop is short in height.
Rapeseed and mustard can be swathed when the seeds contain 35 and 25% moisture respectively. This is when the crop is greenish-brown in colour, and the seeds are firm with 25% of the seeds turning colour. When the seed in the swath has reached 10% moisture, or produces a hard, crunching sound when bitten with the teeth, the crop can be combined.

When combining rapeseed, and mustard, the cylinder speed should be reduced to about two thirds the speed used for cereals. The clearance for the concaves should be opened slightly so that the stems and pods are broken just enough to free the seeds. The fan speed should be reduced to prevent the small seeds from being blown out with the chaff.

In small farmers’ fields, mustard is often cut at about the same time as described for swathing. The bundles are allowed to dry in the field for several days. Threshing is carried out with a stick, or with oxen when the plants are fully dried.

Yields

Both mustard and rapeseed have high potential yields, if conditions during growth are optimum, and if correct management practices are followed. Research yields in Ethiopia of 48q/ha for mustard and about 30q/ha for rapeseed can be obtained. Optimum yields on production fields can generally be expected to be about 40% lower.

A summary of the conditions required to obtain high yields are:

1. Select land which is well-drained, and fertile.
2. Proper seed-bed preparation.
3. Plant sound seed of recommended variety and use the correct rate of both seed and fertilizer.

.../
4. Practice early weeding, correct weed control.
5. Watch the field during growth for insects and apply proper control.
6. Harvest at correct time, using correct methods.

Yields of rapeseed/mustard vary greatly from country to country. Some average national yields are reported.

<table>
<thead>
<tr>
<th>Country</th>
<th>1978 Average Yield (Q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>4.0</td>
</tr>
<tr>
<td>India</td>
<td>5.1</td>
</tr>
<tr>
<td>Canada</td>
<td>12.5</td>
</tr>
<tr>
<td>USA</td>
<td>13.3</td>
</tr>
<tr>
<td>USSR</td>
<td>10.0</td>
</tr>
<tr>
<td>West Germany</td>
<td>25.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>21.1</td>
</tr>
</tbody>
</table>

**Utilization**

In Ethiopia, mustard is used for many purposes. The uses reported by farmers in Welaga, Gijam and Gonder were as follows: For greasing the metad before enjera is baked, the leaves are boiled as gomen wat, the seeds are crushed, and oil is extracted by stirring, seeds used as a component in spices, used to make soup and used to soften leather.

In addition to the uses in the home, most farmers reported that they sold part of their crop, which went to the oil mills. A small amount of mustard seed is exported every year. In 1972, a maximum amount of 2,633q was exported which was 4.5% of the total crop.
Production Notes on Linseed

Introduction

Linseed Linum usitatissimum is grown both as a fiber crop, and as an oil crop. Production is in temperate countries in the Northern Hemisphere. In 1974/75 world production of linseed was 2,500,000 tons. The most important linseed growing countries are India, USSR, USA, Canada and Argentina. World production has declined slightly over the past 10 years. Ethiopia produces about 100,000 tons per year. This is produced by small farmers, and the oil seed is used for human consumption.

Linseed has several features that make it suitable for large scale cultivation. It is suitable in rotation with wheat, and can be grown under mechanization using the same equipment as used for wheat. In many countries, weeds are controlled by herbicides. The diseases that attack cereals do not attack linseed. Crops following linseed produce good yields.

Adaptation

Altitude - In Ethiopia, the crop is grown above 1800 meters, and performs best between 2300 and 2800 meters.

Temperature - Cool temperatures during growth produce highest yields. Highest mean temperatures range from 15°c to 31°c but the crop grows well at lower temperatures.

Linseed is more tolerant to frost than other crops. Plants at the seeling stage and during blossom to green boll stages are more susceptible and may be injured at -3.3°c and -1.1°c at each of these two stages of growth. Plants at the other stages of growth will withstand frost to -9.4°c or lower.
Length of Maturity: In Canada, linseed matures in 98 to 106 days, which is faster than bread wheat, and about the same time as durum wheat. In Ethiopia, days to maturity ranges from 90 days to 150 days, depending on variety and altitude.

Frost is a problem in higher altitudes in Ethiopia, especially if frost comes during the blossom to green boll stage. A number of experimental lines may possess some frost resistance. Sowing early in the season, or using fast maturing varieties is the most effective way of avoiding frost damage, so that the plants are no longer in a susceptible stage when the frost occurs.

Temperature has a marked effect on oil quality. High temperatures favour the development of saturated fatty acids or fatty acids with one double bond such as oleic acid. Low temperature increases the amount of unsaturated fatty acids such as linolenic and linoleic acid.

In Canada cooler weather during early flowering produced higher seed weight and higher yield and oil content. Higher temperatures hastened maturity, but reduced the number of seeds per boll and seed weight and as well as reduced oil content. Temperature changes more than 3 weeks after flowering did not affect seed weight, oil content or oil quality.

Day Length: Linseed is considered to be a long day plant. When photo-period was increased from 16 to 20 hours, maturity was hastened, but seed weight reduced. A short 8 hour photo period delayed maturity and also reduced seed weight. Oil content and the proportion of unsaturated fatty acids were highest with an 18 hour photo-period. Linseed grows well with a 12 to 18/hour photo-period.

Rainfall: Average annual rainfall above 450-500mm is required. The rain must be well distributed over the growing season. Linseed is very sensitive to drought, even for short periods, but can tolerate flooding for short periods better than other crops. Shortage of rainfall hastens maturity and reduces the number of seeds per boll.
Soils

Linseed grows well on any weed free soil that is suitable for cereals, but does better on loam soils that retain moisture well. Linseed possesses a limited root system, so that it cannot thrive well on sandy soil. On poorly drained, heavy clay soils, growth may be reduced, and susceptibility to disease increased.

Fertilizer

Linseed generally has lower fertilizer requirements than other crops. In Ethiopia, 23/23 kg/ha of N and P2O5 is recommended. In Canada, 22 to 67 kg/ha of N is generally recommended, but yield responses have been observed with up to 112 kg/ha of N. High levels of N may decrease oil content. Broadcasting of N fertilizer either just before or just after seeding is recommended in order to avoid fertilizer injury to the plants.

Although linseed has a high phosphorus content in the seed, the roots are not able to extract large amounts of phosphorus from the soil. Work in Canada has shown moderate to no response to applied phosphorus. The placement of phosphorus in relation to the seed is very important. Yield responses were found when the phosphorus fertilizer was placed just below the seed. Broadcasting of fertilizer phosphorus is often not effective.

Potassium (K) and Sulphur (S) are not generally required when fertilizing linseed. This appears to be true in Ethiopia, as well as in Canada.

High rates of fertilizer have been observed to cause lodging in Ethiopia. Lodging is a fairly serious problem in Ethiopia, and varieties with resistance to lodging are being selected.

Origin and Types

There are three types of linseed. A fiber type, a seed type and an intermediate types. The fiber types are tall and have very few branches, and are grown in cooler temperate regions, especially in USSR. Seed types are shorter.
with more branches. They are grown in warmer regions, in Argentina, Uruguay, India, USA, USSR, as well as in Ethiopia. The linseeds in Ethiopia are generally very short, and very highly branched and used for oil.

Ethiopia is considered to be a centre of diversity for linseed. It is thought (by Vavilov) that seed types originated in the South West Asian Centre (India Afghanistan and Turkestan) fibre types in the Mediterranean centre (Spain, Algeria, Greece and Egypt) and the intermediate types originated in Asia Minor.

Description of the Plant - Linseed has a tap root 1 to 1.2m long. Most types have a single stem, but more than one branch may arise from the cotyledon node in some seed types, or when planted at low density. In Ethiopia, plant height ranges from 10 to 115cm. Leaves are small, simple and in alternate pairs at the base of the plant, and in spirals near the top of the plant. Flowers are white, or blue or pink. Flowers open early in the morning, and petals are shed by noon of the same day. Linseed is usually self pollinated, with 0.2 to 2% outcrossing due to insects. Each flower has 5 petals, 5 stamens and 5 sepals. Two seeds are found in each locule and each ovary has 5 locules. The ovary develops into a boll. Seeds are yellow or brown. Yellow seeds have thinner seed coats and higher oil content, but the seed coat is easily damaged, and germination may be poor. Both endosperm and embryo are oil-bearing tissues, with 20% and 80% of the oil respectively. Oil content of linseed in Ethiopia varies from 20% to 45%.

Varieties

Victory and Concurrent are the presently recommended varieties. They are introductions with high oil content, and erect growth with few branches. In some locations these varieties were found to be susceptible to disease. New varieties with higher yields, and good disease resistance are being tested, and will soon be available to growers.
Cropping Sequence

At Holetta, linseed has been found to be an excellent precursor for many crops. High yields of wheat, barley, teff and rapeseed have been obtained following linseed. Linseed is often used in rotation in other countries to prevent disease build-up, as linseed is immune to diseases that attack cereals. However, linseed should not follow linseed, as yields are reduced and weeds may build up. Linseed should be grown following a cereal, rather than an oil crop.

Cultural Practices

Seed-bed preparation - In Ethiopia, linseed is often planted in poorly prepared seed beds, which results in low yields. Good seed bed preparation begins with plowing as soon as the previous crop has been harvested. Either another plowing, or discing, followed by harrowing and packing should be carried out just before planting. A seed bed should be firm, with small lumps, with the moisture not more than 2.5 cm below the soil surface. The seed-bed must be free of weeds.

Seeding - Linseed is fragile, and cracks in the seed coat are common. Therefore, a fungicide treatment on the seeds usually increases germination and yield.

Early sowing, as soon as the rains come is best. Later sowings may produce lower yields, and may suffer from frost damage.

A seed rate of 25-35 kg/ha is recommended for drilling, and 30-50 kg/ha for broadcasting. It has been found that seed rates above 25 kg/ha only produced marginal increases in yield in Canada.

Satisfactory yields of linseed can be obtained by broadcasting, but closely spaced rows (20 cm apart) are probably better.

.../
Linseed has a small seed, which should not be planted more than 2.5-4cm deep.

**Crop Protection**

**Weeds** - Linseed is a poor competitor with weeds, so proper weed control is essential for satisfactory yields. An early weeding 2 weeks after planting followed by a mid-season weeding is the minimum number of weedings necessary. It is often advisable to carry out a third, late weeding. At Holetta, an application of the herbicide potaran (Metabromuron) at 2kg ai/ha, followed by one hand weeding gave top yields and excellent control. In Canada, 2,4-D and MCPA and the most commonly applied herbicides. These herbicides are applied to the newly emerged crop, using high volumes of water to avoid herbicide injury to the crop.

A serious parasitic weed called dodder, can attack linseed in Ethiopia. Dodder should be pulled out and burned whenever it is seen in the crop. The presence of dodder should be reported to the weed control department at Holetta. Dodder has long tendrils which wrap themselves around the stems of the crop, and extract their nutrients. Dodder is usually a yellow colour, and does not possess green chlorophyll.

**Diseases** - Diseases in Ethiopia may be a serious where linseed is grown in high rainfall areas, or where the soil is poorly drained.

1. **Pasmo (Septoria linicola)** - Early infection appears as a brown spot on the leaves. Later the leaves die, and brown patches occur on the stems. Pasmo reduces yields and oil content, and may be the most prevalent disease in linseed in Ethiopia. The fungus is both seed and soil-borne. Spores from the infected crops are carried in the wind. Warm humid weather promotes the disease. **Control**. There are no varieties which have been identified as fully resistant, but some varieties are less susceptible than others. Concur has been found to be a susceptible variety. Crop rotation and burning of infected straw can help control the disease.
2. Wilt (*Fusarium oxysporum*) - The leaves turn yellow and apical leaves become thicker, the tip of the plant curls over. Growth stops and plants may die and become brown. The plant may be only stunted and re-growth may come from the basal branches. In Ethiopia, the later branches were found to be most affected. Wilt can occur at the seedling stage, or later during growth. And is more severe with high soil temperatures and low soil moisture. In many linseed areas, this disease is rarely seen because resistant varieties are now being grown.

3. Powdery Mildew (*Oidium spp.*) - Powdery superficial gray areas are seen on upper surfaces of the leaves near the top of the plants, and on floral structures. This disease is most prevalent in damp conditions. Good resistant varieties are now being tested, and should be released soon.

4. Seedling Blight (*Rhizoctonia spp.*) - This disease, sometimes associated with wilt, causes seedlings to wilt and die. The disease is promoted by warm, well worked soil. Best control is to plant when the soil is cool, practice rotation, and use clean seed which has been treated with a fungicide.

**Insects in Linseed**


   It is an important economic pest of linseed in many growing areas.

**Recognition**

Clean holes eaten in pods where seeds are forming including soft seed contents. Somewhat hairy green or brown caterpillars with undulating longitudinal light and dark stripes present. When fully grown, they reach up to 4 cm long.
A careful watch should be kept for eggs and young caterpillars as soon as flowering starts. Caterpillars feed by inserting their heads into the developing seed pods. Large caterpillars are very difficult to kill.

**Control**

a) **Chemical**

i) Endosulfan 39% E.C. 2 l/ha

ii) DDT 25% E.C. 3-4 l/ha

b) **Plusia worms E.G. Chrysodeixis acuta**

Discussed under rapeseed

**Harvesting**

Linseed is ripe when 90% of the bolls have turned brown. However, it has been found in Canada that yields are higher when flax is cut one week before that stage. Linseed is not prone to shattering of the seed, but delaying harvest can allow seeds to weather and germination is reduced. Also lodging is increased and harvesting is more difficult when delayed.

Small farmers in Ethiopia often uproot plants, and leave them lying in bunches in the field until dry. It is recommended to cut the plants rather than to pull them up. Once the bolls are dry, the seed can be readily threshed.

Linseed can be either directly combined, or swathed and allowed to dry before being combined. Swathing is better if weeds are a problem. A number of adjustments should be made to the combine before harvesting linseed. The gap between the concave and the cylinder should be only half as wide as for wheat. The cylinder speed should be slowed down to 1089 m/minute, in order to prevent cracking of the seed.
Yields

Maximum seed yields of linseed are lower than those of most other cereals such as wheat or barley, or oil crops such as sunflower or rapeseed. However, yields of 20 q/ha have been achieved under experimental conditions at Holetta. Low average yields may be mainly due to poor management practices.

Uses

In Ethiopia, linseed is used mainly for oil, and as a wet prepared from the crushed seeds. Linseed oil does not store well because of its high linolenic acid content.

On a world basis the oil from linseed has many industrial uses as a drying agent in paints, and varnishes, in soaps, printers ink, and linoleum tiles. The oil cake, remaining after the oil is extracted, makes an excellent animal feed. The straw is a good source of fibre and the fibre types are widely used for making linen.