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Introduction

Sesame (*Sesamum indicum*) is grown in areas with annual rainfall of 625-1100mm and temperature of >27°C. The crop is tolerant to drought, but not to water logging and excessive rainfall. Sesame is well adapted to a wide range of soils, but requires deep, well-drained, fertile sandy loams. In Ethiopia, sesame grows well in the semiarid areas of Amhara, Tigray, Benshangul Gumuz, and Somali Regions. Lowlands of Oromiya and Southern Nations nationalities and Peoples Regions also grow a significant amount.

Despite the increasing demand and price of sesame in the world market, its productivity is declining from 8 to 3 q/ha in most parts of the country. The major reasons are the lack of knowledge and skill in land preparation and agronomic practices, weather uncertainties and pest outbreaks. It is thus, anticipated that availing information on improved agronomic practices, weed and pest management will undoubtedly increase sesame production and productivity.

Therefore, this production manual is prepared to equip growers with the state to art production techniques, knowledge, skill, and information. It enables to provide farmers with practical guides and alternatives to increase production and productivity of sesame. The recommendations are safer, more affordable, and easy to
Crop Description

Sesame is a broadleaf plant that grows to a height of 1.5 to 2 meters, depending on the variety and growing conditions. It considerably differs in size, form/shape, growth habit, color of flowers, seed size and color and composition. It is erect, branched, mostly annual, or long season plant with well-developed root system. It is a warm season annual crop and is considered drought tolerant, but needs good soil moisture for establishment and for high yield. Soil type and moisture influence growth and productivity of varieties. Sesame grown under irrigation often becomes much greater and yield higher than rain-grown crops.

Stem

The stem is erect and square in cross-section with definite longitudinal furrows, in certain cases rectangular, and rarely wide flat. The stem can be smooth, and hairy. Stem color ranges from light green to purple, dominantly darkish-green. The extent, type, and height of branching vary from one variety to another.
Roots
Sesame has a deep thin taproot of about 1m long with a well-distributed secondary root system for maximum exploitation of soil moisture.

Growth Habit
Sesame has an indeterminate growth, development and flowering continues for a long time if environmental conditions are favorable. Nevertheless, most of the currently cultivated varieties are determinate with uniform and short flowering and capsule ripening periods.

Leaf Shape and Size
Lower leaves are broad and sometimes lobed, margins/edges prominently with outward directed teethes. Leaves are entire, lanceolate, and sometimes slightly serrate. Upper leaves are narrower and lanceolate in order to permit maximum sunlight penetration. Leaf arrangement vary with variety, alternate or opposite or opposite below and alternate above. Leaf size varies from 3 to 17.5 cm in length and 1 to 1.7 cm in width, and with the petiole length of 1 to 5 cm.

Leaf Color
Leaf color is mostly dull, darkish-green or light green with a yellowish tint. Leaves are mucilaginous and hairy. Abscission is early and complete at maturity.
to 45 days after planting and continues for 75 to 85 days for early types and with some varieties lasting 150 days even to mature. Multiple flowers arise 20 to 30cm from the soil surface in the leaf axils of the upper portion of the stem and branches while singly on the lower axils. Flowers are born on very short peduncles with white, pale pink to almost purple, five lobed corollas. The inner surface of the corolla might have red or black spots with purple or yellow blotches.

**Pollination**
Sesame is normally self-pollinated crop, although cross-pollination by insects is common. Up to 50% out crossing was reported due to insect pollination. Flowers open early in the morning and shed in the evening. Anthers open and release pollen shortly after flower opening, which remain viable for 24 hours only. The stigma remains receptive one day prior to flower opening to another one day after flower opening.

**Fruiting structure (capsule/pod)**
The fruiting structure is a capsule or pod, starts forming about 20 to 30cm above ground surface for most commercial cultivars, rectangular and deeply grooved with a short triangular beak. Capsule size is modified by environmental factors and within the basic flat sided, cylindrical shape or several forms may occur within the same plant. Capsule lengths vary from 2.5 to 8 cm, with a
Capsules are attached to the stem at upright angle, usually hairy and contain about 50-90 small oleaginous seeds, ovule abortion within the pod is uncommon. Number of capsules per plant is directly related to number of flowers but climatic conditions can affect the percentage of fertilized flowers. Plant population also directly influences the number of capsules per plant, high population or close spacing in the row tends to reduce both the number of capsules and number of seeds per capsule.

Capsule dehisces (open) by splitting along septa from top to bottom. Lower capsules ripen first and those nearest the tip last. Physiological maturity normally occurs 95-110 days after planting for early types and up to 150 days for late types. Physiological maturity is when 75% of the capsules on the main stem have mature seeds or when three-fourth of the stem turns yellow. Sesame normally dries down in about 150 days. Thus, do not allow matured plants to stand in the field for long time as seeds may lose through shattering.

**Seed retention**
There are two types of sesame with regard to pod opening behavior, shattering and non-shattering (dehiscent). Almost all sesame cultivars in Ethiopia are shattering type, which open by cracking of pods from top to bottom and releasing all seeds to fall on ground. The dehiscent varieties have effective seed retention mechanisms which...
strong placental attachments, which retain the seed within the capsule until it could be harvested or threshed. Nonetheless, varieties with such character do not exist in Ethiopia.

**Seed size and color**
The economic part of the plant is the seed and is directly related to number of branches and the total number of capsules per plant. Sesame seeds are very small ovate, slightly flattened and somewhat thinner at the hilum than at the opposite end. Depending on variety, thousand seeds could be large, medium, or small. On average 1000 seeds weight is between 2 and 4 g. According to varietal differences, the seed color varies—white, yellow, reddish brown or grey, dark grey, olive green, very dark brown and black. The seed coat is rough, but easily removed by dry decortications.

**Nutritional Value**
The seed is consumed whole in bakeries or pressed for oil extraction. Light colored seeds are considered to yield better quality oil than dark. However, dark colored varieties have high oil content than light colored seed. White-seeded varieties are preferred when roasted and eaten. They also command the market premium over the dark seeds.

Nutritionally, whole seed and seed cake contain 22-25% and 22-35% protein; 43-50% and 9% oil; 11 and 23% carbohydrates.
Sesame oil is yellow in color and used in shortenings, salad oil, margarine, and similar food products. The oil content of the seed varies between 40 and 60% depending on varieties and growing environments. It is rich source of energy providing 582 and 884 kilo calories, and fat 53.4 and 49.1gm for whole and hulled seeds, respectively. The oil from sesame seeds contain high amount of protein 15-25% and has 103-116 iodine, 188-196 safonification and <6% acid values. Its specific gravity is 0.916-0.921 @ 25°C, with solidification range of 20° to 25° and heavy metals <0.001%.

Sesame seed is rich in calcium oxalate and fatty acids. The oil is high in Vitamin A, Vitamin B, Vitamin E, calcium, magnesium and phosphorous; but, low in total free fatty acid content (<1.5%).

Sesame oil is a stable product because of a natural antioxidants sesamol and sesamolinol that reduce the rate of oxidation. This character makes it preferable vegetable oil. The major fatty acids contained in the seed and oil, chemical structure and carbon: bond ratio is described in Table 1.
<table>
<thead>
<tr>
<th>Common name</th>
<th>Chemical structure</th>
<th>Carbon to bond ratio (C: D)</th>
<th>Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myristic acid</td>
<td>CH₃(CH₂)₁₂COOH</td>
<td>C14:0</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>CH₃(CH₂)₁₄COOH</td>
<td>C16:0</td>
<td>7-12</td>
</tr>
<tr>
<td>Palmitoleic acid</td>
<td>CH₃(CH₂)₁₄CO₂H</td>
<td>C16:1</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>CH₃(CH₂)₁₆COOH</td>
<td>C18:0</td>
<td>3.5-5.5</td>
</tr>
<tr>
<td>Oleic acid (ω-9)</td>
<td>CH₃(CH₂)₇CH=CH(CH₂)₇COOH</td>
<td>C18:1</td>
<td>32-54</td>
</tr>
<tr>
<td>Linoleic acid (ω-6)</td>
<td>CH₃(CH₂)₄CH=CHCH₂CH=CH(CH₂)₇CO₂H</td>
<td>C18:2</td>
<td>35-59</td>
</tr>
<tr>
<td>Linolenic acid (ω-3)</td>
<td>CH₃CH₂CH=CHCH₂CH=CHCH₂CH=C(CH₂)₂CO₂H</td>
<td>C18:3</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Arachidic acid</td>
<td>CH₃(CH₂)₁₈COOH</td>
<td>C20:0</td>
<td>0.4-1.0</td>
</tr>
<tr>
<td>Eicosenoic acid</td>
<td></td>
<td>C20:1</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Behenic acid</td>
<td>CH₃(CH₂)₂₀COOH</td>
<td>C22:0</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Total FFA</td>
<td></td>
<td></td>
<td>1.5-2</td>
</tr>
</tbody>
</table>

**Favorable Growing Conditions**

**Agro-ecology**

Sesame grows well in Hot to warm semi-arid plains (SA1-1) of the western Tigray (mainly Humera) areas, ranging from 500 to 1600 meters above sea level. These areas have mean annual temperature ranging from 21 to 28°C and with 300-800mm mean annual rainfall. The second major sesame growing agro-ecology is characterized as Hot to warm sub-moist plains (SM1-1) that includes northwestern part of the Amhara Region; particularly around Metema. Altitude ranges from 400 to 1400 meters above sea level; mean annual temperature is higher than 21°C and mean annual rainfall varies from 200-1000mm. The third major AEZ is Hot to warm sub-humid plains.
mean annual temperature 16-28°C and rainfall varying from 700 in the western part of the sub-zone to 1000mm in the eastern part. Hot to warm arid plains (A1-1) of the Afar National Regional State and the Ogaden area of the Somalia National Regional State where mean annual temperature is >27°C and rainfall is <400mm is the forth potential AEZ in which sesame can successfully be grown under irrigation. Other minor sesame growing AEZs include Hot to warm sub-humid gorges (SH1-4) of both the Oromiya National Regional State (ONRS) and the Southern Ethiopia Nations and Nationalities Peoples Regional State (SENNPRS), specifically located in the gorges of Gibe, Gojeb and Omo rivers and Hot to warm sub-moist lakes and rift valleys (SM1-2) identified around Humbo (SNNRS).

**Altitude**

Because of increased export value of this crop, its production area has been extending to places previously not known in sesame production. Therefore, nowadays sesame is cultivated from lowland to mid altitudes (300-1700m). Nevertheless, it grows and yields well in altitudes ranging from 650 to 1250ml. For optimum growth, sesame requires frost free and warm areas.

**Temperature Requirement**

Sesame requires hot conditions during growth to produce maximum yields. For optimum development and yield, sesame requires 25 to 37°C temperature throughout its growth period.
Temperature below 20°C for any length of time inhibits germination or delay, and a temperature of less than 18°C after emergence will severely retard growth of seedlings. The seeds will not germinate at all at temperature below 11°C. Low temperature at flowering can result in the production of sterile pollen, or premature flower fall. Conversely, period of high temperatures, 40°C or over, at flowering will seriously affect fertilization and the number of capsule set will be low. Thus, do not plant sesame in areas with frost history or low night temperatures.

**Soil Requirement**
Sesame is adaptable to many soil types but it thrives best on well-drained and medium-textured fertile soil with 5 to 8 soil pH. The best soil for sesame growth in Ethiopia is light alluvial and chromic Vertisols. It does not grow well on heavy clay, salty and waterlogged soils. Do not plant sesame on heavy clay soils especially on low spots where water cannot be drained off, as the plant is extremely susceptible to even short periods of water logging at any stage of growth.

**Water Requirement**
Sesame is a drought-resistant crop, but this does not mean that good growth and yields can be obtained on a very low total rainfall. It does indicate that, once established, sesame is capable of withstanding a higher degree of water stress than any other cultivated plants. Nevertheless, the seedling stage is extremely susceptible to moisture.
800 mm per season is necessary for reasonable yields. However, optimum yields are obtained in areas with 500-650 mm rainfall per annum well distributed over the 3-4 months growing period. Sesame needs water during the seedling, flowering, and grain filling stages. Heavy rain at flowering will drastically reduce yield, and if cloudy weather persists for any period at this time, severe bacterial blight infection will occur resulting in exiguous yield. In irrigated lowlands where rainfall is erratic and does not support crop growth, application of 75 mm water every 15 days interval until 120 days is recommended, especially for the middle and Lower Awash River basin.

### Agronomic Practices

#### Land Preparation
Sesame requires a warm, moist, weed-free seedbed and a high temperature for germination. During the land preparation, choose the tillage practices that will ensure to keep the soil in its best physical condition for a favorable crop’s growth and development. First plow the soil to a depth of 20 to 25 cm which will physically support the plant and allow the use of sufficient moisture and nutrients; sufficient enough to control weeds; and then harrow at planting to leave the soil surface roughly level.

#### Seed Requirement
to assist even distribution. Use clean seeds for planting. In broadcast sowing a 1:3 mixture of seed and dry sand or earth is commonly used. However, as latest field observations indicate 1kg seed to 5kg soil (1:5) was found optimum and gives good stand establishment. Research recommended seed rate is 5-7 kg for row and 7-10 kg for broadcast planting depending on the efficiency of a person to distribute uniformly. Nevertheless, the rate is mostly determined by environmental conditions where the crop is planted. Even under broadcast planting, in areas like Metema, farmers prefer to sow 3-4 kg seed per hectare because of the high rainfall (>650mm) that induce bacterial blight infection and to avoid thinning. In Humera, where rainfall is in the range of 450 to 600mm 4-5kg seed is used. Generally, more emphasis has to be given to distribute evenly seeds over the required area. Increase seed rate if seeds are planted deep—covered by oxen plow, highly termite infested, soil moisture is limited, and the soil is compacted, cloddy, or trashy. Decrease the planting rate if the soil is well prepared and have adequate moisture. Maintain a population of more than 250,000 plants per hectare.

**Variety Selection**

Because of environmental variations, there is great diversity within varieties of sesame grown in Ethiopia. The agroecological diversity required development of varieties that fit to specific environments; hence, there is no variety that grows well across locations. Therefore,
If it is meant for oil purpose varieties with darker seed color can be grown. Nevertheless, for export market white seed color, medium to large seed size is preferred. In Ethiopia, both the improved and local cultivars are branching types. Nevertheless, this character is most influenced by moisture regimes. Generally, for drier areas where rainfall is low and erratic using early maturing varieties is recommendable. Branched types are recommended under irrigated or rainfall of more than 600mm.

Methods of Sowing
Sesame is sown or planted manually by hand or mechanically by hand-operated seeder or animal-drown or tractor-operated drills. In hand planting, seeds are either broadcasted or drilled in row on ridges. In ridge planting, two methods are practiced: in one known as broadcast, seed is spread thinly over flat surface and subsequently ridges are formed in recommended row spacing, usually 40cm. In the other, known as ridge sowing, seed is drilled after ridges are developed in the desired row width by hand. Nowadays sesame can be seeded with a row crop planter mounted on tractors and equipped with vegetable planter boxes. Planting less seed usually ends up in missing plants. In most situations, sesame plant adjusts to the population density in a given area. If the population is too high, it will self-thin itself, wherein in a low population, it will develop more branches to fill the
## Table 2: Adaptation area and characteristics of registered sesame varieties in Ethiopia

**Note:** 1 quintal (qt) = 100kg; **Source:** MoARD, crop variety register book, 1990-2010, *Ir* = Irrigation

<table>
<thead>
<tr>
<th>Name</th>
<th>Adaptation Area</th>
<th>Altitude (m)</th>
<th>Rainfall (mm)</th>
<th>Seed color</th>
<th>Yield (qt/ha)</th>
<th>Oil content (%)</th>
<th>Days to maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adi</td>
<td>Irrigated valley (Awash and Shebelle), and low rainfall areas</td>
<td>300-750</td>
<td>Ir</td>
<td>White</td>
<td>16-20</td>
<td>42-48</td>
<td>85-90</td>
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<tr>
<td>Abasena</td>
<td>High rainfall (Wellega and Benshangul Gumuz)</td>
<td>500-1200</td>
<td>&gt;700</td>
<td>Gray</td>
<td>12-14</td>
<td>44-48</td>
<td>110-120</td>
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<td>Kelafo-74</td>
<td>Irrigated valleys</td>
<td>&lt;500</td>
<td>Ir</td>
<td>Blackish</td>
<td>10-12</td>
<td>42-46</td>
<td>110-120</td>
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<tr>
<td>Mehado-80</td>
<td>Irrigated valleys</td>
<td>300-750</td>
<td>Ir</td>
<td>Gray</td>
<td>15-22</td>
<td>41-44</td>
<td>100-110</td>
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<tr>
<td>Argege</td>
<td>Irrigated valleys</td>
<td>350-750</td>
<td>Ir</td>
<td>Deep gray</td>
<td>15-18</td>
<td>-</td>
<td>90-100</td>
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<tr>
<td>Serkamo</td>
<td>Irrigated valleys</td>
<td>360-750</td>
<td>Ir</td>
<td>White-brown</td>
<td>15-18</td>
<td>-</td>
<td>90-100</td>
</tr>
<tr>
<td>E</td>
<td>High RF (Like Dedesa areas)</td>
<td>300-750</td>
<td>&gt;700</td>
<td>Dull white</td>
<td>12-14</td>
<td>42-47</td>
<td>90-100</td>
</tr>
<tr>
<td>S</td>
<td>High RF (Like Dedesa areas)</td>
<td>300-750</td>
<td>&gt;700</td>
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<td>12-16</td>
<td>40-46</td>
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<td>T-85</td>
<td>Humera</td>
<td>400-650</td>
<td>400-650</td>
<td>Dull white</td>
<td>8-10</td>
<td>42-45</td>
<td>100-115</td>
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<td>Tate</td>
<td>Haraghe and Southern Region</td>
<td>600-1200</td>
<td>600-800</td>
<td>Dull white</td>
<td>15-18</td>
<td>47-49</td>
<td>110-120</td>
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<td>Ahadu</td>
<td>Moisture stress areas of Wello</td>
<td>1400-1600</td>
<td>750-950</td>
<td>Brown</td>
<td>-</td>
<td>49-51</td>
<td>105-115</td>
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<tr>
<td>Borkena</td>
<td>Moisture stress areas of Wello</td>
<td>1400-1600</td>
<td>750-950</td>
<td>Brown</td>
<td>-</td>
<td>47-48</td>
<td>105-120</td>
</tr>
<tr>
<td>Obsa</td>
<td>East and West Wellega</td>
<td>1250-1650</td>
<td>700-1100</td>
<td>White-tan</td>
<td>-</td>
<td>52-54</td>
<td>130-150</td>
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<td>Dicho</td>
<td>West Wellega</td>
<td>1250-1650</td>
<td>700-1100</td>
<td>White</td>
<td>-</td>
<td>51-52</td>
<td>120-140</td>
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<td>West Tigray</td>
<td>600-1100</td>
<td>400-650</td>
<td>White</td>
<td>-</td>
<td>54-56</td>
<td>110-120</td>
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<tr>
<td>Setit-1</td>
<td>Kafta-Humera</td>
<td>600-800</td>
<td>400-650</td>
<td>White</td>
<td>-</td>
<td>52-54</td>
<td>100-110</td>
</tr>
<tr>
<td>Barsan</td>
<td>Somali Region (Gode, Kelafo)</td>
<td>500-700</td>
<td>&lt;450 + Ir</td>
<td>Brown</td>
<td>7-8</td>
<td>46-47</td>
<td>80-90</td>
</tr>
<tr>
<td>Lidan</td>
<td>Somali Region (Gode, Kelafo)</td>
<td>500-700</td>
<td>&lt;450 + Ir</td>
<td>Brown</td>
<td>7-8</td>
<td>45-46</td>
<td>80-90</td>
</tr>
</tbody>
</table>
Row Spacing

The recommended planting distance for sesame in Ethiopia is 10 cm between plants and 40 cm between rows making 250,000 plant populations per hectare. In row planting, the inter-row distance (40cm) can be maintained at planting, while intra-row distance (10cm) is established afterwards during thinning. The wider the row, the more likely the farmer is able to cultivate for weed control. Wider row spacing is used when planting earlier or in drier areas. Narrower row spacing is used when irrigation is possible, in higher rainfall areas and when planting closer to the end of the planting window.

Sowing

For a successful establishment of sesame careful seedbed preparation and close attention to soil moisture is required. Sesame seedlings do not emerge from the soil that is slightly crusted and it needs warm soil.

Sesame seed is small and has less push than many crops like cotton, peanuts, sorghum, soybeans, or mung beans. It needs less cover and compaction than most other field crops. Thus, it is best to plant into moist soil and covers the seed by light soil to avoid drying out before emergence.

Sow the seeds after rain or irrigate soon after sowing. The seeds require adequate moisture in the soil for around three days to germinate. In rainfed areas never sow the seeds on dry soil, always wait for rain. Sow recommended rate of seeds in well-prepared soil with good moisture.

Depth of planting varies with soil type and soil moisture from 3 to 5 cm. Uniform depth and seed rate are essential for good stand
establishment resulting in maximum yield. Minimize seed depth to reduce the amount of time required for emergence. Irrigating the crop after planting is often unsuccessful if the seeds are buried deep enough because of the weakness of sesame seedlings in breaking through even a thin soil crust.

Optimum time of sowing

Planting sesame is the most critical phase of its management. Availability of moisture, length of the rainy season and temperature are the three major factors determining time of planting. In rain-grown sesame, planting dates virtually depend on on-set of rainfall and length of growing season. In dry areas with short rainy months, it is advisable to sow immediately after the first rains. Nevertheless, in areas with long growing seasons, time of planting should be adjusted with the time of harvesting in such a way that the crop is matured when the rain stops. Research recommended dates of planting for rain-grown sesame is mostly between mid Junes to mid July. When sesame is grown under irrigation, temperature, instead of moisture, is a decisive factor to
establish planting date. Mid June for the main season and late November for the off-season is optimum planting dates for sesame production under irrigation.

**Emergence and seedling development**
Sesame should be planted in moist and warm soil for a fast, vigorous germination and emergence. Cold wet condition following planting will seriously reduce seedling emergence. When grown in areas where there is a short but intense rainy season, sesame is best planted after the main rains have fallen and when soil has accumulated enough moisture and temperature. When grown under irrigation, substantial (75mm) after planting watering is very essential to boost fast emergence of seedlings. Sesame germinates moderately slowly, and the young seedlings make slow initial growth. If the temperature is favorable sesame fully germinate within 5-7 days time. At early growth stages, it has a very rapid growth and development to overcome weed competition and to give good stand establishment. Sesame has an ability to germinate and withstand lower temperatures; however, extended cool weather severely affects crop development.
Gapping/Filling in open spaces
The empty space between plants in a row can be filled in by re-sowing seeds to replace the lost plants and maximize yield. Nevertheless, this has to be done very soon and if the empty space is too much otherwise, farmers seldom practice gapping for sesame. Delayed gapping will result in uneven maturity and may create harvesting difficulty.

Thinning
When the plants attain height of 10 to 15 cm seedlings are thinned to 10 cm distance between plants by removing the weak or diseased plants. Crowding results in weak plants and bears very few pods. It is important to achieve 22 to 25 plants per meter or to maintain plant population of 222,000 to 250,000 plants/ha to attain the maximum yield.

Soil fertility management
Sesame, which has an extensively branched feeder root system, appears to improve soil structure. Like most alternative crops, sesame’s fertility needs are modest. Mostly sesame’s nutrient requirements are not known exactly, but fulfilled through organic sources, such as weeds and crops remain. Nevertheless, due to the current mono cropping practice fertility level is dwindling with subsequent reduction in productivity.

Fertilizer studies on sesame, in Ethiopia, are highly limited in scope covering a small proportion of the sesame growing areas in the country. The result of these limited research activities suggested that sesame did not respond to fertilizer addition. But the very recent studies at Bako indicate 35% yield increment due
to application of 38/29 kg/ha NP<sub>2</sub>O<sub>5</sub> fertilizers at planting. At Humera application of 120 kg/ha NPK (19:19:19) + K<sub>2</sub>SO<sub>4</sub> 50kg/ha + urea 50kg/ha at planting gave 32% yield increment over zero fertilization. In any case before application of fertilizers consider the growth stage of the plant; population; and amount of soil moisture available.

Fertilizer applications should be based on soil test results. Commercial inorganic fertilizer is not allowed in organic farming. Ask assistance from the local agriculture office for advice how to grow organically, maintain, and supply the nutrient requirement of the plants.

**Cropping system and rotation**
Sesame is grown as intercrop with sorghum in Haraghe and with tef in North Shewa. Sesame requires abundant solar radiation for maximum photosynthesis. Hence, it is recommended to consider short stemmed grain crop for intercropping. Sesame fits well to crop rotation system. In the lowlands, it is regularly planted after sorghum, cotton, peanuts, soybeans, onions, and other vegetables without any problems. It has been reported for yield increases in cotton, sorghum, soybeans, and millet.

**Pest Management**
A wide range of weed species, insect pests, and diseases attack sesame around the world. In Ethiopia, weeds presume primary importance, followed by insect pests and diseases. Among insects only the sesame webworm, seed bug, gall midge, green vegetable bug, grasshoppers, African bollworm, and crickets have been recorded. They become more serious as crop acreage expands and mono cropping is practiced largely.
Weeds
Weeds are unwanted plants found in sesame fields. They compete with sesame crops for nutrients, moisture, and sunlight, which can decrease the crop quality, higher the production costs due to increased cultivation and hand weeding, and considerably reduce the crop yields. They also serve as alternate hosts of insect/mite pests and diseases.

Numerous species of weeds infest sesame, among which grasses are the most abundant weeds in the northwest. For example in Metekel Zone, graminaceae species are the most dominant ones, 22%, followed by compositae (17%). So far more than 98 weed species in 31 families causing damage to sesame crop were identified only from major sesame growing areas of the country. In sesame field grasses, sedges, bind weeds and some broad leaf weeds are most dominant.

Because of their slow early growth, sesame plants are poor competitors against weeds. Thus, it is very important to eliminate weeds from sesame fields as early as possible. Weeds in sesame can be controlled using different methods, mechanical/hand weeding, physical, and chemical. However, before starting weeding sesame fields it is very important to know how much yield/economic loss is encountered by weeds, and then be decided when, how many times and how to weed sesame.

The critical weed competition period for sesame may differ according to location; weed emergence pattern and species composition of a particular environment. However, studies made at Werer, Humera, Pawe, Metema, and Bako recorded 1-2 and 4-6
weeks after sowing to be very critical. Therefore, sesame seedlings have to be hand weeded at least two times at 10-15 and 30-45 days after emergence. However, in East Wollega weeding at 33 and 55 days after emergence is recommended. Nevertheless, farmers should take account of their specific environments for weeding.

Crop yields often depend on the amount, size, and proximity of weeds present after crop emergence. Weed vigor on the other hand is also influenced by crop abundance, size, and proximity. Yield loss due to weeds vary according to environment, weed species and management options practiced. For example in Metekel Zone, overall yield loss of 42% was recorded. At Humera when weeds were allowed to grow uncontrolled throughout the growing season, a yield loss of 83% was reported. At Werer under irrigation, a yield loss of 92% was observed in a weedy control and late weeded plots. As a thumb rule, not weeding sesame may result in 100% yield loss depending on soil type, weather conditions and weed species.
Pre-plant tillage
Sesame has fine and fibrous superficial roots, which are easily damaged during cultivation particularly at early stage. Hence, preparing a weed free field is crucial to ensure maximum seed yield. Generally, twice plowing to a depth of 25cm at 2-4 weeks interval is recommended to suppress weed infestation and increase seed yield.

Post-emergence cultivation and hand weeding
The weeds in sesame fields can be removed through hilling-up the furrows with a plow, hoeing, mowing, or cutting. Make shallow cultivation/s of sesame fields close to the rows taking care not to damage the fine, fibrous roots that are easily damaged. Early (2-4 weeks) hoeing/cultivation cause seedlings to grow faster, possibly because of improved soil aeration and the lifted competition for nutrients. In row planted sesame crop, it is possible to hoe the space between rows and at the same time to hand pick weeds between sesame plants. In broadcast planted sesame, hoeing is not possible, in this case hand removal of weeds is recommended. Do first weeding 2 to 4 weeks after sowing, depending on weed infestation. The second weeding should be done between 4 and 6 weeks after planting. In any case, do not let the weeds to flower and remove them before they start to flower and shed seeds.

Chemical control
No herbicide is currently registered for sesame weed management in Ethiopia. However, herbicide screening trials were conducted against broad-leaved and grass weeds at Werer. Out of which application of herbicide Metholachlor 960 EC at 2.5 l ha$^{-1}$ in combination with hand weeding at 30-35 days after crop emergence reduced weed infestation and significantly increased
seed yield. Nonetheless, crop injury was observed during early growth stage though damaged plants or its parts recovered easily. Therefore, integrating hand weeding, hoeing, and herbicide application is important to contain the advent of weeds.

**Insect Pests**
Sesame yields are seriously affected by pests. Out of which sesame webworm (*Antigastra catalaunalis*), sesame seed bug (*Elasmolomus sordidus*), gall midge (*Asphondilia sesami*), termites, green vegetable bug (*Nezara viridula*), African bollworm (*Helicoverpa armiger*), grasshoppers, aphids, jassids, whitefly, field crickets, warehouse moth and red flour beetle are some to be mentioned.

**Sesame seed bug**
Sesame seed bug was reported long ago in Ethiopia, however, its prevalence and damage was restricted to the northwestern part of the country, and it is so important only in years of outbreaks. Seed bug is considered as a local pest that appears in large numbers at harvest time. Currently, however, infestation of seed bug is increasing from year to year depending on climatic conditions like rainfall and humidity.

In Humera, bugs were found feeding on many species of weeds, trees, and vegetable crops. Sesame is usually attacked in the field during drying and in warehouses by nymphs and adults, which suck the entire seed contents. The seed bug has three developmental stages, egg, nymph, and adult. The development of egg to adult death ranges between 39 and 54 days. Both nymphs and adults cause damage to sesame by sucking the seed oil and its content, causing two types of losses, qualitative and quantitative. Weight loss of more than 50% was recorded after only 10 days of
storage on open and bug infested ground, if left long losses could be as high as 100%. The quality loss resulting due to bug feeding is expressed in color and taste change that makes the seed bitter and dark/unmarketable.

Seed bug control measures
Cultural: soon after harvest stalk removal, field clearing and plowing under, alternate host destruction around fields, warehouse, and storage cleaning had a significant impact on survival and fecundity of sesame seed bug.

Botanicals: Using 10% neem seed kernel extract and formulated neem oil (Nimex 0.03%) controlled seed bugs effectively in closed containers or in airtight warehouses.

Biological: Numerous species of bio-control agents (predators and parasites) were found feeding on seed bugs. Among the recorded predators, ants of different species, termites, spiders, lizards were the major ones found hunting for nymphs and adults. Around Humera, an effective wasp, egg parasite Grionini sp. was known
to causes 40-80% egg parasitism. The wasp most likely occurs in all places where seed bug egg is available under sesame stalks. However, the number may vary from place to place.

**Chemical:** even though there is no registered insecticide for the control of sesame seed bug in Ethiopia, farmers in Humera and Metema spray Malathion 50% EC or Ethiosulfan 35% EC 1-3 times at the base of sesame stalks in stack, locally known as Hilla. Dusting the base of stack and the soil around them with Ethiolathion 5% Dust, and carbaryl 85% WP was well practiced. Fenitrothion and diazinone could also be used as foliar spray before harvest. In warehouses and storage areas malathion 50% EC, Carbosulfan 25% ULV, Ethiosulfan 25% ULV, Lambda-cyhalothrin (Decis 0.5% ULV and Karate 0.8% ULV) are very effective even at very low rates. For effective control, spray applications should be made in breeding sites but not on feeding spots such as piled sack and must be repeated every three days until nymph emergence stops.

**Integrated management of sesame seed bug:** Combining cultural and chemical control tactics to manage the seed bug has proved effective. Sanitation measures both at field and storages have either greatly eliminated or reduced bug numbers.

Important IPM components to be considered for effective seed bug management include

- early harvesting and thrashing;
- removal of the stalks soon after harvesting or thrashing;
- reducing seed loss during thrashing;
- winnowing and transporting;
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- destruction of weeds and other alternate hosts that could harbor the pest;
- storing in polyethylene bags with inner lining and in standard warehouses; and
- keeping cleanliness of stores and sealing off all openings around the stores

Sesame webworm

Webworm, *Antigastra catalaunalis*, is a well-established and widely distributed insect pest of sesame. It is a sporadic pest that causes greatest damage during the seedling and flowering stages, and may continue until harvest, feeding on mature seeds hidden inside capsules. The caterpillar does best in the dry conditions that follow rains, so its development and spread is closely linked to the developing climatic conditions.

The larvae feed on leaves, flowers, pods, and growing shoots. The young larvae mine young leaves and shoot tips; they fasten together leaves and shoots and feed inside. At later stages, the larvae infest the sesame capsules, making an entrance hole on the lateral side (Fig. 2). Generally, webworm can cause yield losses of between 25 and 35% and critical period for control action is flowering stage. Nevertheless, webworm damaged capsule may inflict up to 100% seed loss. Most farmers do not consider webworm as a pest; no action is taken in many cases, especially 7-10 days after the end of flowering. The larvae move from pod to pod and down to already matured pods. Thus, late infestation should also be given due attention.
Figure 2: Sesame webworm and its damage symptom, 1) adult, 2) young larva feeding on leaf, 3) matured larva, 4) damaged young shoot, 5) capsule/pod damage at maturity
Webworm control measures

Due to sporadic nature of the pest there is no as such effective pest management practice developed rather than using pesticides. Insecticides such as endosulfan 35% EC at 2 l/ha, cypermethrin 20% EC at 4.5 l/ha, lambda-cyhalothrin 5% EC at 0.32 l/ha, pirimiphos-methyl 50% EC at 2 l/ha, and Bacillus thuringiensis SC at 2 l ha\(^{-1}\) control the pest effectively. Nevertheless, pesticide application should terminate before capsule opening. **Do Not Apply Any Pesticide On Open Capsules!**

Termites

Termites is an important pest of sesame in the field and storages in drier areas, especially in places with low and poor rainfall distribution. Field attack may start from seedling stage and continue to harvest and shocks. Mostly termites attack weak plants in the field and cut and stacked sesame on drying ground. Infesting stacked sesame causes severe economic damage as termites build soil on shocks and contaminates the seed during trashing. It is very difficult to trash and clean termite soiled sesame. Therefore, farmers’ prefer not to trash such hillas/shocks, as the seed is not marketable. So far, yield loss from termite damage is not quantified in sesame however; farmers’ may bear up to 100% loss in severe cases.

Suggested termite control measures

- There is no single effective method of control for termites; however, good agronomic practices increase crop tolerance to termite infestation in the fields;
- Carefully select shocking ground away from termite mounds or tunnels;
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- Make insecticide barriers by applying Chlorpyrifos, endosulfan or malathion 5% dust away from the shocks/hilla;
- Thrash immediately, within 10-15 days time and move to store with concrete floor; and
- Do not allow termites to multiply in or near your field.

![Image of sesame plant with insect damage]

Figure 3: Termite and its damage symptoms on sesame

Sesame gall midge
The sesame gall midge, *Asphnodylia sesami* belongs to order Diptera, family *Cecidomyidae*. The gall midge was minor pest of sesame in Humera area, but now days it became key pest mainly due to mono cropping system of sesame production.

Where it occurs, the sesame gall midge causes extensive damage and the larvae are the damaging stage. Eggs are laid in ovaries of flowers and the gall begins to develop before the petals wither or become twisted and stunted and do not develop into flower or capsules (Figure 4). Even though not yet quantified, estimated yield reduction could reach more than 30% in heavy infestation years.
Gall midge control measures

Cultural: Early sowing reduces the damage as the crop blooms before the fly number goes up. Destruction of wild and volunteer sesame plants is recommended in many countries for gall midge management. In Ethiopia, sesame gall midge infestation increased with changes in cropping system, especially mono cropping of sesame. Thus, rotating sesame with cotton, sorghum, and other unrelated species will undoubtedly decrease its severity.

Chemical: Applying dimethoate, diazinon, Malathion, or phosphamidon as off the flowering period effectively controlled gall midge in many countries. Bait sprays of Malathion or Dipterex could also be used for midge management. In India using 10% neem seed kernel or leaf, extract with weekly application interval reduced fly population. The commercial neem product, Neembicide (0.03%) and Neemgold were found more effective than the home made neem extracts.
**Insect pests of minor economic importance**

A number of insect pest species with minor economic importance infest sesame. Among which bugs (green stinkbug and other unidentified species), jassid, aphid, whiteflies, grasshoppers, field crickets, trips and African bollworm are some to mention. Except the bollworm and field cricket all others feed on the sap of sesame plants in the field and retard growth and development.

Aphids and Whiteflies: Both insects develop similar damage symptom on crops. Nymphs and adults of both species pierce the plant tissues and feed on sap. Heavy feeding of both species on leaves cause crinkling and cupping, induce production of honeydews that serve as the substrates for the growth of black sooty molds, and result in stunted growth. The mold reduces photosynthesis causing poor plant growth. These insects are also known to transmit virus diseases of many crops. Heavily infested sesame plants will turn yellow, eventually wilt because of excessive sap removal, and finally die off.

**Whiteflies and aphid control measures**

**Botanicals:** Add 15 ml of neem oil into 1 liter of soapy water. Constantly shake the container or stir the extract while in the process of application to prevent oil from separating.

**Chemicals:** Treat the seeds with 300-350 g Gaucho or Cruiser before planting. At vegetative growth stages apply carbosulfan 25% ULV 2 l/ha, Polo 500 SC 1 l/ha, Deltanate 200 EC/ULV 2 l/ha, Applaud 3 l/ha, Thiodan 35% EC 2.5 l/ha, Karate 2 l/ha or Decis 2 l/ha.
Post-harvest pest management
Among storage insect pests, seed bug, webworm, tropical warehouse moth and red flour beetle are important. Sesame and its oilcake is rich in proteins and fats and, hence, is vulnerable to infestation of stored product insect species resulting in weight loss, contamination and deterioration in quality and flavor because of mould growth and toxin elaborations.

Sesame seed bug is the major pest of sesame in storage and field in the northwest, especially Humera and Metema areas. It sacks all seed contents and causes shriveling and increase in free fatty acid concentration. Bug sacked seeds become unmarketable because of its bitter test, dark color, and shriveled shape.

Storage pest management
Sesame seed bug that infest staked sesame and sack seeds stored in bags is considered a major pest. Sanitation around storages is the best method of control followed by insecticide application. Chemicals such as Decis 5% EC 2 l/ha, malathion 50% EC at 2 l ha⁻¹, Thionex and Thiodan 25% ULV at 2.5-3 l ha⁻¹ should be applied on breeding sites but not on feeding sites, such as piled sesame bugs and concrete floored stores.

Other storage insect pest of sesame could be controlled by application of fenitrothion 3% dust at 30 g/100 kg, Baythion at 100 g/100 kg, aluminum phosphide at 5 tablets, and pirimiphos-methyl at 300 ppm. However, this recommendation works for seeds that are being stored for planting only. Fumigation with phosphine and other alternatives could also control insect pests in modern storage facilities.
Diseases
Currently among sesame diseases bacterial blight in humid and phyllody in drier areas are very important, while powdery mildew and wilt are sporadic and minor economically.

Bacterial blight
Bacterial blight and bacterial leaf spot of sesame are caused by two pathogens *Xanthomonas sesami* and *Pseudomonasa sesami*. Both pathogens may occur together or separately and can cause complete crop failure in years of favorable conditions for disease development. Bacterial blight incidence and severity varies depending on topography, altitude, and weather conditions. Disease incidence may reach up to 100% in areas such as Wellega, Pawe, and Gambella where high humidity persists for longer time while it is about 10-50% in semi-arid areas like Werer and Humera. Water logging encourages the spread of the disease.
Bacterial blight disease of sesame, damage symptom on leaf, capsules and stem

**Bacterial blight management options**

**Variety selection:** Use tolerant varieties such as Obsa and Dicho for Wollega, Abassena for Pawe and Tate for southern areas.

**Cultural:** Use of clean seed, stable removal, burning, deep plowing, and crop rotation controls blight incidence.

**Physical method:** Hot water treatment at 52°C for 12-14 minutes reduces initial blight infection but avoid field re-infection.

**Chemical:** Streptomycin solutions of 750-1000 ppm were found to reduce blight incidence, but field re-infection was a problem that could not be managed.

**Phyllody**
Phyllody is most destructive disease of sesame in drier areas like Werer, Babille, and Bisidimo and partly in the north-west. The disease causes deformation of leaves and flowers, which remain green with the calyx and corolla, sometimes stiff, forming a half-open hood (See figure below). The deformed top parts have shorter internodes, much brunched, and change to broom shape or become bunchy. Phyllody infected plants do not bear capsule, if does they are deformed and crack before maturity and seeds are shriveled. Phyllody and other virus diseases are transmitted by jassids and whiteflies, thus, managing these pests reduce further spread of the disease.

Variability in symptom expression of phyllody diseased sesame plants

Phyllody control measures
Cultural: Do not use seeds harvested from phyllody infected fields. Destroy sesame plants with disease symptom from field and burn them immediately. Alternate host of jassids should also be destroyed from field edges.

Chemical: There is no chemical that controls phyllody disease, but insecticide application against its vector (jassid = *Orosius albicnatus*) minimizes its spread.

**Wilt**

Wilt is caused by a fungus, *Fusarium oxysporium f. sesami*. Infected terminal leaves turn yellowish, desiccate, and droop, the symptom progressing down to the stem. Mostly infection is patchy and when mature plants are attacked, only one side of the plant shows symptoms. When uprooted, roots will be wholly or partially rotten.
Wilt disease of sesame, Humera

**Wilt control**: Seed selection, early plowing/cultivation and exposing the fungus to desiccation, avoiding water logging conditions in the field, field sanitation, and crop rotation are highly recommended.

**Maturity**

The length of growing season for sesame cultivars planted in Ethiopia varies depending on the length of the rainy seasons in each agro-ecology. In Humera and similar short season areas, sesame is ready to be harvested within 100 days and varieties that can mature early are grown. In Wellega, Benshangul Gumuz, Gambella and similar long season areas, sesame usually matures within 150 days and there late maturing varieties are grown. Apart from the length of the rainy season, the nature of the crop i.e. its
indeterminate nature needs cautions to decide proper planting time. Since flowering occurs in an indeterminate fashion, seed capsules on the lower stem are ripening while the upper stem is still flowering.

At maturity leaves and stems tend to change from green to yellow, then to dark red in color and the leaves will begin to fall off, and normally dries down in 2 to 3 weeks depending on climatic condition. Depending on the moisture and fertility, the currently grown varieties stop flowering at about 72-90 days after planting. Self-defoliation and seed maturity begin as the flowering stops. The plants normally hold on to the top leaves until the upper capsules mature.

Sesame plants physiologically mature when the seed in the capsules ¾ up on the capsule zone have turned from milky white to an off-white color. As the capsules dry, the tips will open and expose the seeds. This opening of the capsule is critical to drying the seed faster and to allowing the seed to be thrashed with a minimum of force. The faster the seed dries down, the less exposure to pest attack and wind damage.
Harvesting and Stacking

Sesame is ready for harvesting 90 to 120 days after planting depending on variety. In general, non-branched varieties mature earlier and harvesting starts when 75% of the pod/capsules are ripened. Timely harvesting and stacking is very essential for quality harvest and decrease losses due to shattering in cases of labor limitations.

In harvesting sesame, the mature plants are cut, bundled, and shocked to dry. In some areas, the shocks are left in the field. In other areas the bundles are moved to a shocking fence — as in, parts of Africa—or to a thrashing floor—as in parts of India. As the plants dry, the capsules open and some of the seed can fall out. If on a thrashing floor, the shocks can be moved every few days, and the seed collected. If in the field, the fallen seed is lost. White seeds are very visible on the ground, but to estimate the amount of loss in kg/ha; on the ground, mark off an area 1m by 1m in a
representative area and collect and weigh the seeds/m\(^2\) and then convert to ha by multiplying in 1000.

Mechanical harvesting is more successful with varieties that have minimal branching and a height from the soil surface to the first capsule of about 30cm and above. The harvester named SAHARA-3 was evaluated at Humera for its efficiency and was found successful. The harvester cuts one hectare of sesame in one hour and 25 minutes with only one cutter, but it is possible to fix three cutting units (blades) at the same time it can operate well without any difficulties. Therefore, sesame harvester SAHARA can be used to withstand the labor shortage observed during sesame harvesting.

In the northwest, (Humera and Metema) freshly hand cut sesame plants are usually swathed green in small hand full bundles. About 400 small bundles make one shock locally known as Hilla, which is placed upright. In other parts of the country, cut sesame plants are bundled and stacked upright in shocks of 6-8 bundles. Each shock has to be pegged to protect wind damage by tightening strings around it.

Under sunny conditions, sesame will be ready for thrashing within 2 weeks. If cloudy days prevail longer, then wait for one more week. In areas with termite infestation, do not allow longer drying in the field. Heavy wind and rains during drying seriously damage seed. In such cases monitor field frequently and thrash as early as possible.
Sesame production manual

Sesame harvester “SAHARA-3

Sesame stooking & drying techniques, Ethiopia
Thrashing

Two weeks after harvesting, thrash and winnow the seeds. However, caution is recommended to minimize seed loss during taking to thrashing ground. Thrashing ground should be concrete floor or use canvases to free from soil, gravel, dust and other inert materials that reduce quality of sesame seed.

Sesame thrashing,
Humera, Ethiopia
Cleaning, Transporting and Storing

Cleaning
On dry down the shocks are inverted over a cloth/canvases/plastic sheets in the field. Depending on the amount of shattering, the bundles may be hit with a stick until all seeds fall-off. Clean by repeated winnowing until the seeds are separated from the chaff and other inert matters.

Transporting
Freshly thrashed seed above 7% moisture content should not be left sitting on a truck for a long time to avoid spoilage. Trucks with sesame on board should generally not be trapped on a sunny day, since the cover can increase heat build-up. Clean and dry in sun for about 7 days before bagging and transporting. For maximum protection, sesame seeds have to be moved from the farm to the storehouse in bags weighing approximately weighing 98 ± 2 kg. The bags with or without seed should not be loaded on pesticide or oil contaminated trucks or put in a damp place or any place where it may be exposed to contamination.

Storage
Due to small seed size and flat shape of sesame seeds, it is difficult for ambient and fresh air to move through it in storages. Therefore, it is recommended that the seed be thrashed as dry as possible, and stored at moisture content of below 7%. If the seed is too moist, it can quickly heat up and become rancid.
Sesame production manual

The warehouse/stores must be clean and sacks must be free of live insects and their development stages. Equipment as well as working and drying surfaces and preparing and storage rooms, should be cleaned regularly and all sweepings collected from time to time.

Bags must be stacked or piled up systematically to ease counting and removing, inspection and management with a minimum of 2 meter spacing between stacks. Stacked sesame should be stored in a dark place at low temperatures (below 18°C) and low relative humidity. Under optimum storage conditions, sesame seeds can be stored for up to one year. However, it is very important to protect the seeds from loss of aroma and undesirable smells and tastes from its surroundings. Therefore, storing pesticides, fuel, oil, and other odorizing agents with sesame in the same store is not allowed. Empty bags, tarpaulins and other accessories not in use shall be stored separately.

Each stack should be inspected at least once in two weeks to check whether seeds are damaged by insect, rodents, or dampness or moisture. If damage is observed, necessary measures have to be taken. For damage by insects, fumigate with Aluminum phosphate tablets (APT) at the rate of 3 tablets per ton sesame seed. If rats are causing damage, their points of entry should be checked up and necessary measures be taken to prevent their ingress. If dampness is observed either due to seepage of water from the floor or from the walls of the store or due to leakage of rainwater, the source of dampness or rain shall be removed. For safe and long storage, all cut bags in the stacks should be either suitably repaired or replaced through periodic inspections.
Grading

In Ethiopia, there have been three market classes for sesame, which is based on seed color. These are the Humera and Gondar types, which have bright white seed color, and the Wollega type possessing dull white color. The Humera and Gondar types command market premium compared to the Wollega type.

Good Agricultural Practices

Throughout this manual, you will find suggestions for stopping or lessening pest population before they have control over the sesame field. To make a plan for you to grow a healthy crop, the following tips are the steps you ought to take:

- Select the proper variety that is well adapted to your local conditions;
- Prepare the soil thoroughly by using appropriate tillage implements;
- Follow the recommended planting date and distances;
- Monitor your field for germination and crop stand;
- Observe proper field sanitation by removing infested plants, keeping the area free of weeds;
- Learn to identify the insect/disease pests that cause damage to sesame;
- Always select plants with good stand and free from disease and insect pests;
- Practice crop rotation by planting on the next cropping season; and
- When in doubt, always ask for assistance from experts.

When controlling pests using the plant extracts and other homemade solutions, the following are the standard procedures for their preparation and application

- Select plants or plant parts that are pest-free;
When storing the plants/plant parts for future usage, make sure that they are properly dried and are stored in an airy container (never use plastic container), away from direct sunlight and moisture;
- Make sure that they are free from molds before using them;
- Do not use cooking and drinking utensils for the extract preparation;
- Clean properly all the utensils every time after using them;
- Do not have a direct contact with the crude extract while in the process of preparation and during application;
- Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight;
- Always test the plant extract formulation on a few infested plants first before going into large scale spraying;
- Wear protective clothing while applying the extract; and
- Wash your hands after handling the plant extract.
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