Sesame Production Manual

Good Agricultural Practice Guidelines for Sesame Cultivation in Malawi

October, 2016

MESET Consult Plc.

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Preface

Sesame is one of the minor crops yet in Malawi. Nevertheless, the crop offers interesting income opportunities for smallholder farmers. Particularly for those living in the warmer and semi-arid areas of the Shire Valley Plains, along the Lakeshore and other districts in Malawi. Sesame thrives well under more challenging conditions and, taking increased market opportunities into account, NCBA CLUSA, under the UBALE program, seeks to develop the sesame value chain as a potential cash crop for smallholder farmers in Malawi.

As part of this effort, NCBA CLUSA engaged MESET Consult to review and update Good Agricultural Practices (GAP) guidelines for sesame production, harvest and post-harvest handling in Malawi. This sesame production manual aims at enhancing technical capacity of government agriculture extension officers particularly at District and EPA levels, as well as extension staff of NGOs, lead farmers, producer organizations and other private and civil society organizations engaged in the development of the sesame value chain.

The development of this training manual is based on existing guidelines, own agronomic knowledge and experience and extensive feedback received from farmers, extension staff and traders. Through field visits, focus group discussions and validation workshops combined with existing literature on sesame production and our experience in growing sesame, we tried to compile a practical manual that fits in well with the specific, local agro-ecological conditions in Malawi.

Success lies not only in effective training but also in an effective system of reaching out to smallholder farmers. This manual should definitely make an impact on its users, so that extension officers and lead farmers are consciously committed to transfer latest insights and practices to the sesame farmers they work with. The dedicated implementation of these GAP guidelines and the results in increased sesame production, quality and ultimately farmers’ incomes will give us the real satisfaction.

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This manual is the result of the collaborative efforts of many people, who in some way or another, are involved in sesame production. We are indebted to a large number of people who have contributed to this manual during the validation workshops. Their contributions have significantly improved the quality of this manual. These are: Mrs. Joan Phiri, Peter Malata, Mrs. Eda Suluma, Patrick Sikanda, Angus Nyangulu, Madalitso Makondi, Frank Nakwanje, Mrs. Judith Kaduya, MacFord Tsamdoka, Robert Malemba, Robiam Dzinyemba, Jackson Kachidede, Donald Binzi, Mike Nankhumwa, George Chilumpha, Saona Gama, Potipher Mwale, Ernest Jumbe, Phillip Kondowe, Ronald Phiri, Mrs. Ruth Mwenye, Epimack Muna, Alick Nthyolamwendo, Laston Gama, Tiwonge Msiska, Alex Chimbizi, Owen Mapeto, Samson Banda, Baston Chilombwe, Mwangitana Chavula, Aarim Daxson, Peter Mtemangwa.

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Acronyms

g. gram
µg. microgram (one millionth (1×10⁻⁶) of a gram)
kg kilogram; 1,000 gram
Kcal kilo calorie
m/masl meter above sea level
mm millimeter
ml milliliter
m² square meter
Ha Hectare
cm centimeter
°C degree Celsius
GAP Good Agricultural Practices
PM Physiological maturity
pH Symbol used to express the acidity or alkalinity of a solution on a scale of 0 to 14, where less than 7 represents acidity, 7 neutrality, and more than 7 alkalinity
N Nitrogen
P Phosphorus
K Potassium
EPA Extension Planning Area
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1. Sesame Production

1.1 Global Sesame Production

Sesame *Sesamum indicum* is one of the oldest crops cultivated by man in the Middle East and Africa for over 5,000 years for cooking and medicinal needs. World production is estimated to be over 6.2 million hectares and over 57% of the world production is in Asia. Most of the Asian production is in India, China and Myanmar. Africa grows 15% of the world’s sesame, with Sudan, Ethiopia, Uganda and Nigeria being leading producers. Latin America grows 4% of the total world production in Mexico, Guatemala, and Venezuela.

Sesame is grown for its seed, and the primary use of the sesame seed is as a source of oil for cooking. The young leaves may also be eaten in stews, and the dried stems may be burnt as fuel with the ash used for local soap making, but such uses are entirely subordinate to seed production. Globally, sesame is commercialized in a number of forms. Most sesame is processed directly into oil by the grower or within the producing region, but can also be sold in various stages of processing, for various uses, such as meal, paste, confections, and bakery products. Once harvested, the seed is cleaned and dried to about 8% moisture and then stored before crushing. The seed is typically crushed intact for the oil. This, however, yields a meal that is made bitter and somewhat indigestible by the presence of the fibrous husk. As such the meal is only useful as cattle feed.

![Figure 1 – Global sesame production](image)

1.2 Sesame in Malawi

Sesame (*chitowe* in Chichewa) is grown in Malawi either for food or as a cash crop. The seed can be pounded into a cake (*Sesame candy*) which is eaten as a confectionery or sesame flour (*nsinjilo*) for seasoning side dishes. Sesame oil extracted from seeds is used for cooking and soap making. The processed oil is odourless and has a long shelf life. Whole sesame seeds are also used in bakeries for bread decoration.
Although sesame is considered a minor crop to Malawian agriculture, it is quite extensively cultivated in various regions in the country. From 2011 onwards there has been a major boost in sesame production. Most farmers have grown the crop due to an increase in demand on the world market. For the most part the surplus crop is commercialized, bulked up and exported with minimal processing limited to drying and cleaning.

Though accurate sesame production figures are not available, an estimated average of 5,600 hectare of sesame is planted annually along the Lakeshore, the Shire Valley, Phalombe, Mzimba, Rumphi, Chitipa and Lilongwe. Annual output of sesame is difficult to estimate as much of the production is consumed locally without entering into formal trade. Average yields are estimated at 250-300 kg/ha viz. a viz. potential yields of over 1,200 kg/ha. Key informants in the sesame industry estimate the current sesame trading volumes (2015/2016 season) at 2,000 MT compared to another study that suggests a sesame production between 5-10,000 MT (CISANET, 2015).

1.3 Advantages of Sesame Production

Sesame cultivation offers a number of advantages for Malawian farmers over other crops in areas that are suitable for sesame production:

✔ Compliments cotton production as a cash crop in rotation and so diversifying production risks.
✔ Sesame requires less labor and chemical inputs, has a high productivity and currently attracts good market prices.
✔ Sesame has an excellent tolerance for both drought and heat. The crop efficiently utilizes limited water availability in the soil; performs where other crops may fail. As such, sesame is a versatile crop grown in semi-arid regions with unique attributes to fit almost any cropping system. Deep tap root may reach and utilize nutrients and moisture below the root zone of other crops.
✔ Sesame proved to be profitable with limited resources compared to other crops using the same level of resources.
✔ Sesame is highly tolerant to diseases and insects.
✔ Sesame, a non-host for root-knot nematodes, reduces nematode levels in the soil compliments crops grown susceptible to nematodes.
✔ Grows well in zero and minimum-tillage conditions and improves soil structure and top-soil protection.
2. Sesame - Crop Description and Growth Stages

2.1 Crop Description and Morphology

Sesame is deep rooting and well adapted to withstand dry conditions. Even on poor soils that are unsuitable for other crops, sesame is cultivated, though yields are equally modest. Sesame is widely valued for its nutritional and financial yield from otherwise harsh conditions. It is well suited to smallholder farming with a relatively short production cycle of 125 –135 days. Sesame thrives well between mean annual temperatures of 21-28 °C. and with 300 – 800 mm mean annual rainfall. When night temperatures fall below 20 °C it takes longer for the crop to mature. Sesame is heat tolerant but it does not perform as well in cooler temperatures.

Sesame morphological characteristics:

- **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 determine varietal characteristics and branching is affected by seed rate, rainfall, day length, and variety.

- **Roots:** Sesame has a deep thin taproot of about 1-meter-long with a well-distributed secondary root system for maximum exploitation of soil moisture.

- **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 3-17.5 cm in length and 1-1.7 cm in width, and with the petiole length of 1-5 cm.

- **Leaf Color:** Leaf color is mostly darkish-green or light green with a yellowish tint. Leaves are mucilaginous and hairy. Abscission is early and complete at maturity.

- **Flowers:** Sesame produces bell-shaped white to pale-rose flowers that begin to develop in the leaf axils. Flowering starts 35 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 20-30 cm 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 2.5-8 cm, with a diameter of 0.5-2 cm. Depending on variety, it is bicallate and number of locules ranges from 4-12 cm.

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 (opens) 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 75% of the stem turns yellow. Sesame normally dries down in about 150 days. Thus, it is not advisable to 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 commercial sesame cultivars in the world are shattering type, which open by cracking of pods from top to bottom and releasing all seeds to fall on ground. Dehiscent varieties that are patented, are not available in Africa.

2.2 Nutritional Value

The seed is consumed whole in bakeries or pressed for oil extraction. Light colored seeds are generally considered to yield better quality oil than dark. However, dark colored varieties have a higher oil content compared to light colored seed. White-seeded varieties are preferred when roasted and eaten. In international trade white seeds 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% carbohydrate; 3% and 4% mineral, respectively. Whole sesame seed contains total fiber 6.3g; ash 5.3g; iron 10.5µg, sodium 60µg; potassium 725µg; calcium 1,160µg and phosphorous 616µg; vitamin A 10 µg/100g, thiamine 0.98 µg/100g; riboflavin 0.24µg/100g; niacin 5µg/100g.

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 40-60% depending on verities and growing conditions. It is a rich source of energy providing 582 and 884 kcal, and fat 53.4g and 49.1g for whole and hulled seeds, respectively. The oil from sesame seeds contain high amount of protein: 15-25%.

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 a preferable vegetable oil.
2.3 Growth Phases

The development of the plant can be divided in four major growth phases: vegetative, reproductive, ripening and drying phase. These phases in turn can be further sub-divided by their respective stages as indicated in table 1. However, such sub-division becomes relevant for highly mechanized sesame production. For smallholder farmers it is suffice to know the phases and moment of harvesting.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Stage</th>
<th>End-point of stage</th>
<th>Days after planting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative</td>
<td>Germination</td>
<td>Emergence</td>
<td>0-5</td>
</tr>
<tr>
<td></td>
<td>Seedling</td>
<td>Third pair true leaf length equals second</td>
<td>6-25</td>
</tr>
<tr>
<td></td>
<td>Juvenile</td>
<td>First buds</td>
<td>26-35</td>
</tr>
<tr>
<td></td>
<td>Pre-reproductive</td>
<td>50% open flowers</td>
<td>36-40</td>
</tr>
<tr>
<td>Reproductive</td>
<td>Early bloom</td>
<td>5 node pairs of capsules</td>
<td>41-48</td>
</tr>
<tr>
<td></td>
<td>Mid-bloom</td>
<td>Branches and minor plants stop flowering</td>
<td>49-74</td>
</tr>
<tr>
<td></td>
<td>Late bloom</td>
<td>90% of plants with no open flowers</td>
<td>75-80</td>
</tr>
<tr>
<td>Ripening</td>
<td>Physiological maturity(PM)</td>
<td></td>
<td>81-102</td>
</tr>
<tr>
<td>Drying</td>
<td>Full maturity</td>
<td>All seed mature</td>
<td>103-112</td>
</tr>
<tr>
<td></td>
<td>Initial dry down</td>
<td>First dry capsule</td>
<td>113-123</td>
</tr>
<tr>
<td></td>
<td>Late dry down</td>
<td>Full dry down</td>
<td>124-134</td>
</tr>
</tbody>
</table>

Figure 1 below presents the growth curve of a sesame plant. Remarkable is the slow growth during the first weeks as the crop’s taproot develops.

Figure 2 – Sesame plant development over time (in days)
2.3.1 Growth stages

**Vegetative Phase**

*Germination stage*
Soil temperature is important during the germination stage as it needs to be at 21°C at planting depth early morning. Rain may create a crust layer on the top soil – capping, hindering the germination of the seed. A good assessment of the crop’s germination can be made after 7 days.

*Seedling stage*
The seedling stage starts with the emergence of the seed above the soil level and it forms its first pair of leaves. This stage is a challenging phase as plant growth is slow, and too small to cultivate. This underlines the importance of sowing in a clean, weed free land. The stage ends when the 3rd pair of true leaves are as long as the 2nd pair.

*Juvenile stage*
Contrary to the previous stage, in the juvenile stage the plant shows a rapid growth. Weeding is critical during this stage. If weeds are allowed to emerge and develop, the sesame plant will stunt due to nutrient and water competition and the plant hold back its growth. Once the first green pods appear, the juvenile stage is over.

*Pre-reproductive stage*
Pre-reproductive stage is the last stage before full flowering. In this stage, and only when sesame is sown in rows, final weeding can be done. Once 50% of the crop is flowered, this stage ends.

**Reproductive Phase**
When flowers are pollinized they create the pods. The pod creation of the sesame plant continues systematically as the plant grows in height starting at the bottom. Generally, the bottom part of the crop where it flowered earlier, may already have developed pods while the top part can still be flowering.
In the early bloom stage, flowers may not make capsules. *Corolla’s* or white flower petals sometimes fall off the buds. Only the flowers that make capsules remain on the plant, the rest will fall with time. As the plant progresses, the stem and the main branches begin making capsules. As the plant is grown to its full length almost, the bottom leaves begin to drop form the lack of sunlight, the root system is well developed with strong tap root and a web of secondary roots to absorb as much moisture from the soil. At this stage – late bloom –, almost all flowers in the plant have fallen and the pods are taking their place.

**Figure 4** – *Sesame early bloom (left) and late bloom (right)*

**Ripening Phase**

This phase is not divided into stages. Technically this phase starts during the reproductive phase when the first capsule is formed. During this phase most of the leaves will turn yellowish green and fall off, due to reduced moisture in the plant. Leaves that drop due to drought are not considered self-defoliation by maturity.

The pods are ripening turning yellowish as well with a darker color on the tip signalizing the ripening of the seeds. The phase ends at *physiological maturity* (PM).

Physiological maturity is when 75% of the capsules on the stem have seeds changed from white color to creamy brownish and a dark tip. The seed will also have a dark line on one side. Eventually all leaves fall off and at this point, the yield of the plant is already determined for the major part, as any development afterwards will not influence the yield. This allows farmers to plan their harvest quantities towards the end of this phase.

At this point the crop is mature and should be harvested.

**Drying Phase**

This phase and its sub-division is relevant for dehiscent varieties that are harvested by combine and as such not relevant for sesame cultivation in Malawi.

**Figure 5** – *Sesame at ripening phase*
3. Land preparation

3.1 Field Selection

3.1.1 Altitude
For optimum growth sesame requires warm weather conditions, which are usually low-altitude areas up to 1,250 meters above sea-level. In Malawi the crop grows well in the Lower Shire area, along the Lakeshore and Phalombe. Sesame does also well in the warm Central and Northern plateau areas of Lilongwe, Mzimba, Rumphi and Chitipa.

3.1.2 Temperature
Sesame requires hot conditions to produce maximum yields. For optimum crop development and yield, sesame requires 25 – 37 °C throughout its growth period. A temperature of 25 – 27 °C encourages rapid germination, initial growth and flower formation. Sesame is a heat tolerant crop. Temperatures below the optimum affect the crop more so than temperatures above the optimum: temperature below 20°C for any length of time inhibits or delays germination. A temperature below 18 °C after crop emergence may retard growth of seedlings. Seeds will not germinate at all at temperatures below 11 °C.

3.1.3 Soil Requirements
Sesame is adaptable to many soil types. However, the crop performs best on well-drained and medium textured fertile soil with a 5.5 – 8.0 pH. Sesame is unsuitable for heavy clay soils, salty and waterlogged soils as the plant is very susceptible to even short periods of water logging at any phase of growth.

3.1.4 Water Requirements
In considering a field, the most important consideration is drainage. Sesame does not tolerate standing water on the stems and will die.

Sesame is a drought-resistant crop. This indicates that, once established, sesame is capable of withstanding a higher degree of water stress than most of other cultivated plants. Nevertheless, in its seedling stage, sesame is very susceptible to shortage of moisture. Moisture is hence required for germination and early growth. A precipitation of 300 – 800 mm distributed over the growing season is required for good yields. Optimum yields can be expected in areas with 500 – 650 mm precipitation well distributed over a four months’ growing season. Water is also needed during seedling, flowering and grain filling stages.

Heavy rain at flowering will seriously impact on yields. Cloudy weather, persisting for any period at this time may result in severe bacterial blight infection, which will also negatively impact yields.

3.2 Crop Rotation
Different studies around the world have indicated that sesame mono-cropping for a prolonged period of time will decrease productivity due to depletion of nutrients absorbed by the crop year after year and increased susceptibility to pest infestations and diseases. Therefore, crop rotation is advised. The following rotations can be recommended:

- Sesame as a primary crop.
  Sesame is planted in rotation with cotton, sorghum, millet, maize, peanuts, soybeans. Successful rotations are further reported with onions and other vegetables, wheat, rye, alfalfa in sesame producing countries elsewhere in the world.
• *Sesame as a catch crop for a failed cotton start*
  The sesame cycle is about 30 days shorter than cotton and thus can be planted later than cotton. Upon a failed start of cotton, farmers can decide to plant sesame.

### 3.3 Land Preparation and Cleaning

Sesame requires a warm, moist and weed-free soil for germination. Soils need to be weed-free to avoid plant competition with weeds for nutrients and water. To keep the soil balanced, ideally, tillage is required at different depth and levels. Farmers have to choose tillage practices that keeps the soil in its best physical condition to ensure a favorable germination and development of sesame.

A first tillage in August-September is recommended after the previous season’s harvest to bring in crop residues into the soil and to control weeds. The main purpose is to improve soil fertility (organic matter and moisture holding capacity) minimize weed infestation for the next season and disturb breeding and living sites of pest insects. Tillage further exposes soil born fungi, insects and bacteria to the sun (e.g. termites/ants, (false) wire-worm, sesame seed bug, etc.)

It is highly recommended to plant sesame on ridges to avoid waterlogging conditions, to compete with weeds and to facilitate crop management in general. For ridging, generally recommended spacing of 75 cm can be followed.

![Figure 6 – Recommended ridge planting](image1)

![Figure 7 – Heavily weed infested sesame field](image2)
4. Sesame Planting

4.1 Seed Selection and Treatment

Sesame farmers should preferably use improved seed varieties that are certified by the Ministry of Agriculture. However as certified sesame seed is not yet available in the country and neither do farmers have access to improved varieties. As farmers have to use locally available seeds (e.g. from local markets, friends or own stock), the following steps are recommended to improve the quality of sesame seed:

1. Farmers purchase local seed or use own seed from the previous season. From this initial seed stock sort out good seeds only: well-shaped, white-colored, non-damaged, of equal size and appearance; visibly free of fungi/pests/diseases and inert materials and broken seeds (sanitary clean).

2. Apply a seed dressing.
   Using dressed seeds significantly reduces risks of pests and diseases in first weeks and increases yield potential upon harvest. The use of dressed seeds is especially important for control of soil pests, termites, ants and soil borne diseases.
   Farmers may use Cruiser or Gaucho at a rate of 300ml/100kg seed. Taking these 'working quantities' into account, seed dressing should preferably be done by seed multiplication groups or cooperatives.

3. Grow sesame from this selected and dressed seed in the next growing season according to GAP guidelines

4. Select the healthiest sesame plants, which seed can be used for the next season. Mark selected sesame plants with a ribbon and harvest the seeds when ready.

Abovementioned procedure is repeated for the next 2-3 seasons: seeds of selected healthiest plants are sorted, cleansed and dressed; sown and plants are selected again until the crop is uniform in appearance.

4.2 Planting

Planting sesame is one of the most critical phase of its management. Sesame will not emerge from soils that are even slightly crushed. Sesame is considered drought tolerant but needs good soil moisture to get established.

4.2.1 Time of Planting

Farmers have to plant as the soil is sufficiently moist to allow seed germination and the heaviest rains that may create waterlogging conditions are over. Recommended planting time is from mid-January to mid-February as heaviest rains are usually over by that time. Sesame planted in this period will mature under dry weather conditions.

Sesame planted earlier are prone to waterlogged conditions and reportedly prone to increased attacks of insect pests and diseases like bacterial blight.
4.2.2 Plant Density

It is recommended to sow sesame on ridges and not to broadcast. Farmers in Malawi practice ridge spacing of 75 cm for most crops. This ridge spacing can also be applied for sesame to facilitate crop rotation. In that case, plant stations are recommended at 20 cm apart in the row with 4-5 dressed seeds per planting station, resulting in a plant population of 212,000 – 266,000 plants (assuming approx. 85% germination rate).

**Figure 8 – (Hand) planting of sesame seeds in rows (left); take note of the correct spacing in case of planting one seed per station (right)**

Depth of planting is 2-4 cm varying with soil type and soil moisture.

Other recommendations when sowing sesame:

- Sow after rain. If farmers have to sow under dry conditions, best is to have a well prepared land with good soil moisture and seeds to be dressed against insects.
- In each case, ensure a seed depth of 2-4 cm and cover seeds with soil unless there is hot winds during the planting season which can dry the surface of the soil then it needs to be planted deeper.
- In case of manual row planting, use a line or a rope from both field sides to ensure straight lines.

4.3 Fertilizer Application and Nutrient Management

Sesame is more productive with limited sources than most other crops using the same level of resources. However, as for every crops, performance will improve when grown under the right conditions.

In Malawi the crop performs well without addition fertilizer application on non-marginal, lighter, well drained soils, particularly in rotation with crops for which fertilizer was applied (e.g. cotton) or fixing nitrogen (e.g. legumes). As such, additional fertilization application is not recommended.

In order to achieve maximum yields (> 1,200 kg/ha) by commercial farmers however, fertilizers need to be applied according to the following recommended quantities (table 2):
### Table 2 – Recommend fertilizer application (emerging and commercial)

<table>
<thead>
<tr>
<th>Type</th>
<th>Quantity</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK</td>
<td>120 kg/ha</td>
<td>At planting</td>
</tr>
<tr>
<td>K₂SO₄</td>
<td>50 kg/ha</td>
<td>At planting</td>
</tr>
<tr>
<td>Urea</td>
<td>50 kg/ha</td>
<td>When first flowers begin to appear</td>
</tr>
</tbody>
</table>

Regarding fertilizer application, it is important to know for which market is produced: sesame seed or sesame oil. Quantity of Nitrogen (N) application affects the seeds’ protein:oil ratio. Higher N-levels results in more protein which is favorable when producing for the confectionary industry, but in lower oil content.

High N-application will also result in continued vegetative growth resulting in less seed production.

#### 4.4 Gap Filling/Thinning and Transplanting

Filling empty spaces between plants is not recommended. Delayed gapping will result in uneven maturity and may create difficulties during harvesting.

Usually sesame plants adjust to the population density in a given area. If the population is too high it will produce thin stems, wherein in a low population, it will develop more branches to fill the spaces. For the same reason thinning is also not recommended as the plants will adjust to crop density.

Transplanting of (thinned) plants is not recommended. As the plant starts to develop a long taproot it is likely to damage or break this taproot or J-shape it when transplanting, all causing the plant to wither or to die. Surviving plants will mature unevenly.
5 Weed Management

Because of their slow early growth, sesame plants are poor competitors against weeds for nutrients, moisture and sunlight. Weeds also serve as host plants for pest insects. Therefore, weeds need to be eradicated at the earliest possible stage. Crop yields 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.

Critical weed competition period for sesame are the first 6 weeks of crop establishment. At the end of vegetative phase, the crop is expected to have developed sufficient canopy to suppress further weed growth. In this period the weeks 1-2, and 4-6 are very critical. Therefore, sesame seedlings have to be hand weeded during that period. However, farmers should take account of their specific environments for weeding.

The following weed management practice during the sesame growing season is recommended:

- A first tillage is recommended in August-September, after the season’s harvest to control emerging weeds (as well to improve soil fertility).
- When preparing ridges for planting all weeds need to be removed.
- After planting at least two times at 10-15 days and 30-45 days after emergence.

5.1 Chemical Control and Dosage

Although hand-weeding is recommended, weeds can also be controlled by herbicides. Round-up with the active ingredient glyphosate is widely used to control weeds in Malawi. It is recommended that use of herbicides is restricted to pre-planting land cleaning (August-September) as sesame is very susceptible glyphosate, 2,4D and glufosinate.

Farmers must be aware of drift from adjacent fields, cotton in particular, as it may impact sesame production up to 35 m from cotton fields.

For dosage refer to the product labels of the herbicide to be applied.
6 Pest & Disease Management

6.1 Crop Scouting

Farmers should regularly check their crop on pests and diseases infestations and crop stand in general. Farmers should inspect the plants from top to bottom as different pests will settle at different parts of the plants: top stem, centre of the crop, top or bottom of the leaf, etc. As crop height allows farmers can cross their field in the form of a ‘W’ to efficiently scout their crop (see figure 10). Along this line, farmers may have to check plants in a small circle around him/her every 10-15 meters and repeatedly checking the same plants during the growing season.

![Figure 9 – Crop scouting: field layout](image)

Spots infested with pests and diseases should be clearly marked, e.g. with a stick. This will enable farmers to regularly check these spots and to take control measures.

![Figure 10a, b – Scouting is an important preventive measure for pest a](image)
6.2 Pest Control

Sesame yields can be seriously affected by pest insects. Most damaging pest insects\(^1\) that need to be controlled are:

- Sesame webworm (*Antigastra catalaunalis*)
- African bollworm (*Helicoverpa armigera*)
- Sesame seed bug (*Elasmolomus sordidus*)
- Gall midge (*Asphondilia sesami*)
- Mealy bug (*Pseudococcidae*)

Of the soil borne pests, cut worm (*Agrotis sp.*) and false wire worm (*Gonocephalum*) may cause major damage on sesame crops.

Other insects to be monitored are: aphids, whitefly, grasshoppers, field crickets, termites, warehouse moth and red flour beetle. Particularly aphids can act as a vector for diseases such as Phyllody.

6.2.1 Sesame Webworm

Webworm is a 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 as it feeds 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.

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\(^1\) These pest insects generally affect sesame production in various parts of the world and are likely to impact sesame cultivation in Malawi. Field research is needed to specify the species that affect sesame production in Malawi and to what extent, i.e. economic thresholds.
**Identification**

Larvae: Greenish in colour with black head having short white hairs

Adult: Medium sized moth (20 mm) with reddish yellow forewings. The post-median band on the hindwings is slightly darker than the rest of the forewings.

**Damage**

- The young larvae roll together a few top leaves and feed them.
- In the early stage of infestation, the plant dies without producing any branch or shoot.
- Young larvae are less frequent on pods than on other plant parts. They feed externally by making a loose web, which sticks several leaves together.
- The larvae feed on leaves and young shoots. Excreta remains between the leaves and the loose web.
- At a later stage, the larvae infest the sesame fruit capsule making an entrance hole on the lateral side and feeding on the seeds inside the capsule; they leave excreta on the seeds.

Figure 13 – *Sesame webworm and its damage symptoms*

1) Adult, 2) young larvae feeding on leaf, 3) matured larvae, 4) damaged young shoot, 5) capsule/pod damage
Generally, webworm can cause high yield losses during critical period of flowering stage if not treated in time. Nevertheless, webworm damaged capsule may inflict up to 100% seed loss. The larvae move from pod to pod and down to already matured pods. Thus, late infestation should also be given due attention.

**Control measures**

Apart from the recommended good agricultural practices such as field hygiene and crop rotation (i.e. cultural practices) regularly preventive spraying with neem formulation is advised.

For neem formulation and application refer to section 6.6.

If good agricultural practices are followed, chemical control is likely not necessary. In case of high infestation and significant economic damage can be expected chemical control is an option. For chemical control see Annex I.

6.2.2 African Bollworm

* *African Bollworm* is widely distributed throughout the tropics and subtropics. These species are highly polyphagous and attack a number of crops, including sesame. The life-cycle of the African Bollworm is presented in figure 14.

![Figure 14 – Life cycle of African Bollworm](image)

**Identification**
- Moths are 35 mm long.
- Newly hatched larvae are white in colour with dark heads. Larvae go though up to six stages (instars). As they grow, larvae become darker with dark spots on their segments, but vary widely in colour.
- Medium larvae (10 mm long) have lines along the side of their body and a saddle of darker colour on the 4th segment back from the head. Large larvae are 35–40 mm long and have white hairs around the head and on the body.
Damage
Most damage is from larvae feeding on tips, buds, flowers and pods. Larvae will also feed on leaves, but this is usually insignificant. Similar damage features as caused by webworm.

Control measures
Apart from the recommended good agricultural practices such as field hygiene and crop rotation (i.e. cultural practices) regularly preventive spraying with neem formulation is advised.

For neem formulation and application refer to section 6.6.

If good agricultural practices are followed, chemical control is likely not necessary. In case of high infestation and significant economic damage can be expected chemical control is an option. For chemical control see Annex I.

Figure 15 – African bollworm: A. eggs; B. larval stage; C. Pupa; D Adult (wings spread); E adult (wings fold)
### Table 3 – General control measures against caterpillar type of insect pests.

<table>
<thead>
<tr>
<th>Control measures</th>
<th>Specific measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranging from preventive (long-term) measures to curative measures (short-term)</td>
<td></td>
</tr>
<tr>
<td>Cultural practices</td>
<td>Crop rotation, enhancement of soil quality, choice of resistant varieties, water management, monitoring/screening, field sanitation, mechanical barriers, post-harvest treatment</td>
</tr>
<tr>
<td>Habitat management</td>
<td>Wild flower strips, hedge-rows, functional biodiversity (regulation of pests through conservation and enhancing of indigenous natural enemies (beneficials))</td>
</tr>
<tr>
<td>Biological pest control</td>
<td>Introduction of predators and pathogens (e.g. beneficial insects, bacteria, viruses and fungi)</td>
</tr>
<tr>
<td>Bio pesticides and physical measures</td>
<td>Plant extracts (e.g. neem oil), natural products, pheromones, insect traps and baits</td>
</tr>
<tr>
<td>Chemical control</td>
<td>See Annex I</td>
</tr>
</tbody>
</table>

### 6.2.3 Sesame Seed Bug

Sesame seed bug’s infestation depends on climatic conditions of the season, and it can increase on higher humidity and temperature. Sesame seed bug is also related to mono-cropping of sesame for a few seasons in a row at the same land. These bugs feed on many other species of weeds, trees, and vegetable crops.

**Identification**

- Adults are dark brown in colour. It lays eggs singly or in batches in the soil.
- The seed bug has three developmental stages, egg, nymph, and adult. The development of egg to adult death ranges between 39 and 54 days. The egg period is 4-5 days. Nymphs are pinkish. It is nocturnal in habit. It hides under the weeds, cracks and crevices in soil and debris during the day time. The nymphal period is 23-39 days.
Sesame is usually attacked in the field during drying and in warehouses by nymphs and adults, which suck the entire seed contents. 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.

**Seed bug control measures**

- **Preventive:**
  - early harvesting and threshing;
  - reducing seed loss during threshing;
  - winnowing of seeds;
  - stalk removal soon after harvesting and threshing, field clearing and ploughing under;
  - destruction of weeds and other alternate hosts that could harbor the pest;
  - keeping cleanness of stores and sealing off all openings around the stores: warehouse and storage cleaning have a significant impact on survival and fecundity of sesame seed bug;
  - storing in polyethylene bags with inner lining (PICs bags) and in standard warehouses.

- **Botanical:** Neem oil products like Nimex, Neembicidine or Neemgold control seed bugs effectively in closed containers or in airtight warehouses. For dosage refer to the product labels.
  
  For neem formulation and application refer to section 6.6.

- **Chemical:** See Annex I.
6.2.4 Gall Midge

Where it occurs, the sesame gall midge causes extensive damage and the larvae cause the main damage. 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. Even though not yet quantified, estimated yield reduction could reach more than 30% in heavy infestation years.

**Identification**
- Adult is a small mosquito-like fly. Female adult lays eggs in the flowers or buds. The egg white, found inside the flowers.
- The larval period is about 2-3 weeks.
- It pupates inside the malformed capsules.
- The fly emerges from galls in 7-12 days.
- The total life cycle is completed in 23-27 days.

**Damage**
Maggots feed on the ovary and results in the malformation of pods without proper setting of seeds. Typical symptom of attack are flowers, leaves and young capsules with gall like swellings (see figure 19).

**Control measures**
- *Preventive*: Rotating sesame with cotton, sorghum, and other unrelated species will decrease its severity.
- *Botanical*: Nimex, Neembicidine or Neemgold. For dosage refer to the product labels. For neem formulation and application refer to section 6.6.
- *Chemical*: See Annex I
6.2.5 Mealy Bug

Identification
Male and female mealybugs have distinct morphological differences. Female adults are about 3 mm long. Female adults and nymphs are oval and covered by a white, waxy coating. Males are small, aphid-like, winged insects.

Figure 19 – Mealy bugs: male (left) adult females in typical appearance (centre and right)

Damage caused
- Female mealybugs colonize shoots, stems and leaves, forming a white mass. They are piercing and sucking insects that can stunt plant growth.
- Male mealybugs are short-lived and do not feed as adults

Control
- Botanical: Nimex, Neemcidine or Neemgold. For dosage refer to the product labels. For neem formulation and application refer to section 6.6
- Soap (liquid detergent) – spray water mixed with a liquid detergent
- Beneficial insects: ladybugs, lacewings

6.2.6 Aphids

Identification
Adults are 2 mm long, soft-bodied, pear-shaped and in various colours. Both winged and wingless forms occur, though the latter in crowded conditions only.
**Damage**

Both nymphs and adults pierce the plant tissues and suck the sap from the leaves resulting in curling and crinkling of leaves. Leaves appear shiny and sticky due to honeydew excreted by the insects. In severe infestations, the entire stem dries up and dies.

Later sooty mold grows on honey dew and leaves have a black coating. The mold reduces photosynthesis causing poor plant growth. Aphids (as well as white flies) 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.

**Aphid control measures**

- **Preventive:** Apply seed dressing: treat the seeds with Gaucho or Cruiser before planting.

- **Botanical:** Nimex, Neembicidine or Neemgold. For dosage refer to the product labels.

  For neem formulation and application refer to section 6.6.

- **Chemical:** See Annex I.

### 6.2.7 White fly

**Identification**

The adults are pale yellow with white wings covered with waxy powder. It typically lays eggs in clusters on the under surface of leaves. Adult flies easily fly up when walking through
the plants. Nymphal stage undergoes four instars. The life cycle is completed in 19-21 days under optimal weather conditions.

**Figure 22** – A. Typical way of egg laying; B. White fly (adult) (*Trialeurodes vaporariorum*) C. Young white flies feeding on a leaf and damaging leaf cells.

**Damage**
Sucking damage on the leaves which become yellow and dried off. Damage due to honeydew excreted by the insects (see also honeydew damage caused by aphids). Indirectly white flies can cause damage as a vector for viruses.

**White fly control measures**
- **Preventive**: Apply seed dressing: treat the seeds with Gaucho or Cruiser before planting.
- **Botanical**: Nimex, Neemcidine or Neemgold. For dosage refer to the product labels.
  For neem formulation and application refer to section 6.6.
- **Chemical**: See Appendix 1.

### 6.2.8 Other Pests
A number of insect species with minor economic consequences infest sesame, among which: grasshoppers, field crickets and thrips are some to mention. Except for field crickets all others feed on the sap of sesame plants in the field and retard growth and development. Regular neem application is recommended and should suffice to control these pests.

### 6.3 Soil borne pests
Sesame production can be affected by a number of soil dwelling pests. These pests cause early dying off of seedlings, often after a few days of germination. Major soil borne pests in sesame are:
- False wire worm (*Gonocephalus*)
• Cut worm (*Agrotis* sp.)
• Termites (*Microtermes* spp.).
• Earwigs (*Forficula auricularia*)
• Scarab beetles – white grub (*Scarabaeidae*)

![Figure 23 – Cutworm: larvae (left); adult moth (right)](image)

**Figure 23** – *Cutworm: larvae (left); adult moth (right)*

- **Preventive:** Apply seed dressing: treat the seeds with Gaucho or Cruiser before planting.

### 6.3.1 Wire worms and false wireworms

**Wireworms**

(family *Elateridae*; numerous species)

**False wireworms**

*Gonocephalum* spp.
Identification
Wireworm (click beetle larvae) and false wireworm larvae are white or cream, shiny, hard bodied, and virtually indistinguishable and special expertise is required for their identification. Fully grown larvae are 2.5–3.5 cm long and 2 mm thick. Pupation takes place in the soil.

Adult wireworms (dusky brown beetles) occur on foliage and flowers.

Figure 26 – False wireworm larvae (left); adult beetle: red flour beetle (right)

Damage:
The larvae of (false) wireworms are mostly found damaging sesame seedlings/seedling stems shortly after germination at or just below the soil surface. Affected crops may develop bare patches, that could be large enough to require replanting.

Control measures
Preventive:
- Crop residues and weeds favor survival of larvae and over-seasoning of adult beetles. Removal or ploughing under of crop residues and weeds will starve adults and larvae by exposing them to hot dry conditions, thus preventing population increases.
- Suitable crop rotations may also limit increases in population numbers.
- Use dressed seeds/apply seed dressing: treat the seeds with Gaucho or Cruiser before planting.

6.3.2 Termites

Termite is an important pest of sesame in the field and storages,
particularly in areas with low and poor rainfall distribution. Field attack may start from seedling stage and continue to harvest and stacking. Termites attack usually weak plants in the field as well as harvested 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.

**Termite control measures**

Although there is no single effective method of controlling termites in sesame, good agricultural practices increase crop tolerance against termite infestation:

- Carefully select threshing and stacking grounds away from termite mounds or tunnels;
- Make insecticide barriers by applying Chlorpyrifos, Endosulfan or Malathion dust away from the stacked sesame. For dosage refer to the product labels of the pesticide to be applied;
- Thresh immediately, within 10-15 days and move to store with concrete floor;
- Do not allow termites to multiply in or near your field.

6.4 **Disease control**

Main diseases that affect sesame are: Bacterial blight, Bacterial leaf spot, Phyllody and Fusarium wilt. Bacterial blight is a major problem in sesame cultivation.

6.4.1 **Bacterial blight, Bacterial leave spot**

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. Water logging encourages the spread of the disease.

**Bacterial blight and leave spot management options**

- **Preventive:** Use of clean seed, stable removal, burning, deep ploughing, and crop rotation, may control blight incidence.

So far no Bacterial blight tolerant varieties are available in Malawi.
Figure 28 – Bacterial blight infection in sesame: damage symptoms on leaf, capsules and stem.

Figure 29 - Symptoms of leaf spot of sesame: A. Typical symptoms of leaf spot composed of light brown angular spots with dark purple margin B. Early symptoms of leaf spot, Pin-point-sized dots on sesame leave (arrows). Dots expand and become small brown and purple spots as the disease progresses. C. Lesion enlarged with spots surrounded by purple margins. D&E. In the late stage of infection, the lesions elongated very rapidly toward the leaf tips turned blackish and purplish symptoms developed.

6.4.2 Phyllody
Phyllody is a disease that can severely affect sesame particularly in dry cultivation areas. The disease causes deformation of leaves and flowers, which remain green with the calyx and corolla, sometimes stiff, forming a half-open hood. The deformed top parts have shorter internodes, much brunched, and change to broom shape or become bunchy. Phyllody infected plants do not bear capsule, or are deformed, crack before maturity and seeds are shriveled. Phyllody and other virus diseases are transmitted by aphids and whiteflies; managing these pests reduce further spread of the disease.

![Figure 30 – Phyllody diseased sesame plants: deformed capsules (right)](image)

**Phyllody control measures**

- **Preventive:** Do not use seeds harvested from Phyllody infected fields. Destroy sesame plants with disease symptom from field and burn them immediately. Alternate host plants of aphids be destroyed from field edges.
- Controlling aphids as being the vector for Phyllody virus infestation. See also section 6.2 on aphid, white fly and mealy bug control.

6.4.3 Fusarium 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.

![Fusarium diseased sesame plant](image)

**Fusarium control measures:**

- **Preventive:** Highly recommended practices are: field sanitation, crop rotation, no water logging conditions, expose fungus to desiccation.

6.5 Post-harvest Pest Management
Among storage insect pests, the seed bug and tropical warehouse moth are relevant to control. 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 mold growth and toxin elaborations.

Sesame seed bug (described in section 6.2.3) and red flour beetle (section 6.3.1) are the major pests in stacked sesame and storage. These insects suck all seed contents and cause shriveling and increase in free fatty acid concentration. Sucked seeds become unmarketable because of its bitter taste, dark color, and shriveled shape.

**Storage pest management control measures**

- **Preventive:** Sanitation around storage places is the best method of control
- **Chemical:** See Appendix 1

### 6.6 Production and Application of Neem Biopesticide

**Neem – ecology and neem oil**

Neem tree seeds form the basis of neem biopesticide. Neem oil is a vegetable oil pressed from the fruits and seeds of the neem tree (*Azadirachta indica*), an evergreen tree which originates from the Indian subcontinent but is endemic to many other areas in the tropics.

The neem tree is noted for its drought resistance. It thrives in areas with sub-arid to sub-humid conditions, with an annual rainfall of 400–1,200 mm. It may grow in regions with an annual rainfall below 400 mm, but in such cases it depends largely on ground water levels. Neem can grow in many different types of soil, but it thrives best on well drained, deep and sandy soils. It is a typical tropical to subtropical tree and exists at annual mean temperatures of 21–32 °C. It can tolerate high to very high temperatures.
Neem oil varies in color: it can be golden yellow, yellowish brown, reddish brown, dark brown, greenish brown or bright red. Neem oil has a rather strong odor. Neem oil does not easily mix with water. In order to emulsify it in water for application purposes, detergents have to be added.

Neem oil is unsuitable for cooking and consumption.

Figure 33 – Neem seeds

**Pest, disease and fungicide control**

Formulations made of neem oil are widely used as a biopesticide and as such provides a natural alternative to synthetic pesticides. The active ingredient in neem seed is Azadirachtin. Neem oil is effective as a broad spectrum insecticide and fungicide and is not harmful for mammals, birds, earthworms and some beneficial insects such as butterflies, honeybees and ladybirds.

Neem is effective as a repellant against: ants, army worms, aphids, caterpillars, beetles, moth larvae, leaf miners, mealy bugs, locusts, snails, thrips, white flies, mites, scales and nematodes. It can also be used as a household pesticide for bedbugs, cockroach, housefly, sand fly and mosquitoes, both as repellent and larvicide. Neem also controls black spot, powdery mildew, anthracnose, rust fungi and root rot. The cause of root rot is a fungus. Species of the *Pythium*, *Phytophthora*, *Rhizoctonia*, or *Fusarium* fungi are the usual culprits. These fungi thrive in wet soil.

**Spray Ingredients and preparation**

*(for 10 liters or 1 knapsack sprayer)*

- Grind 0.5 Kg of neem seed and soak 1-2 days in 10 litres of water
- After soaking, separate the oil & water mixture from the solids
- Put the 10 litre oil/water mixture into the knapsack
- Add 50ml liquid detergent soap
- Mix thoroughly

**Application**

- Spray onto the crop – ensure good coverage: top and bottom of leaves
- Use fresh preparation each time of spraying
- To be effective, spray crop every 7-10 days with fresh mixture.
- Apply neem oil only in indirect light or in the evening to avoid the product burning foliage and allow the preparation to seep into the plant. Also, do not use neem oil in extreme temperatures, either too hot or too cold. Avoid application to plants that are stressed due to drought or over watering.

**Neem/soap action**

Neem does not kill insects, but acts as an anti-feedant, repellant, and egg laying deterrent: protecting the crop from damage. The insects starve and die within a few days. Neem also suppresses the hatching of pest eggs. The soap helps to mix the oil with the water and spread the oil over the leaf surface. The soap also suffocates insects by destroying the insect protective wax layer and water/neem enters insect pores.

**Neem seed requirements**
Spraying crops during the main growth phase, and when pest and disease pressure is high is most important. This is normally a period of 4 to 8 weeks. Important to know how much area/plants 1 tank of spray mix will cover. (another good reason to keep records!)

During the dry season when neem seeds mature, collect enough seeds to provide the necessary crop protection required. 10 liters will cover approximately 200 m² (1 liter: 20 m²). Therefore, for a crop of 0.2 Ha will require approximately 100 liters of spray mix (5 Kg neem seed) every 10 days. A crop will require approximately 6 sprays per season (8 weeks = approx. 60 days). Therefore, a 0.2 Ha crop area requires approximately 60 Kg neem seeds per season. For an acre (0.4 Ha) a quantity of at least 120 kg neem seeds are required. Farmers are recommended to measure out their land in order to calculate the right quantities of seed needed.

**Summary of Neem extraction.**
- 1 Kg neem seed produces approximately 100 ml of neem oil
- Require approximately 5 ml neem oil/liter of water as a spray mix
- Require 5 ml/liter water of liquid detergent as a spray mix

### 7 Harvesting & Post-harvest handling

#### 7.1 Maturity

Determinants of crop maturity are: length of the growing season, variety and indeterminate nature of the crop. 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 conditions. 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 75% of the seed in the capsules 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 threshed with a minimum of force. The faster the seed dries down, the less exposure to pest attack and wind damage.

7.2 Preparation of drying spots

Prepare drying spots in dry places with porous sheet (plastic, tarpaulin), so that water eventually can drain to prevent seeds germinating/spoiling.

7.3 Harvesting and stacking

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 harvesting sesame, the mature plants are cut, bundled, and stooked to dry. Best practice is to bring the stooks to a stooking fence or a threshing floor rather than stooks left in the field, although the latter is commonly practiced. As the plants dry, the capsules open and some of the seed can fall out. If on a threshing floor, the stooks can be moved every few days, and the seed collected. If in the field, the fallen seed may be lost, unless plastic cover is used. Stooks are also more prone to pest attacks.

![Figure 34a, b – Harvesting by hand and stacking it in the field on top of a plastic cover](image)

7.4 Threshing, Winnowing and Cleaning

Sesame will be ready for threshing and winnowing within 2 weeks after harvesting. In areas with termite infestation, it is important not to allow extended drying in the field. Monitor field frequently and thresh as early as possible.
Caution is recommended to minimize seed loss during taking to threshing ground. Threshing ground should be concrete floor because gravel, dust and other inert materials that reduce quality of sesame seed.

Clean the seeds by repeated winnowing until the seeds are separated from chaff and other inert matters.

Figure 35 – Stacking in the field and threshing by hand (left); winnowing with a sieve (right)

7.5 Bagging & Storage

Sesame should be stored in strong, clean, and undamaged bags, preferably new ones.

Because of the small size and the flat shape of the sesame seed, air flow within the bags can be difficult. The temperature can increase significantly mainly when the seeds have moisture. It is recommended to stack on several piles with enabling for air flow.

Maintenance and hygiene of the storage space is important to get rid of the live insects, rodents, mold and other contaminators. Cleaning and dusting is also required on the sesame bags piles together, getting rid of dust and other possible contamination.

Figure 36 – Proper storage of sesame bags in the field
The storage space should provide a temperature preferably not warmer than 18 °C, with low humidity and no other aromas around the sesame bags such as other foods, oils, fuel, pesticides or other chemicals. These should be stored separately.

The storage space/warehouse should be insulated against rainwater leakage, direct sunlight and other weather factors.

7.6 Transport

Transportation of sesame seeds can directly influence its quality before it is stored or handled by end-users. Freshly harvested seeds usually contain higher moisture levels and should not left long on a truck as seed can be spoiled without protection in bright sunlight. It is recommended, after the cleaning process to wait a couple of days until the dry-down is fully complete, before bagging the seeds and transporting them. Before bagging the sesame seed, the bags themselves should not have been exposed to contamination, set in dump places or been used for chemical transportation. Hygiene is essential.
8. Monitoring and Evaluation

Good practice is to record all farming operations so that farmers are able to evaluation and compare the improvement in sesame production from year to year.

In order to know production costs, margins and profits, as well as production figures, sesame farmers should keep account of all their activities and expenditures. By doing so farmers and farmers’ groups will be able to improve their performance and to plan for the future.

Farmers should record:

- Dates of field operations, activities and associated (input) costs.
- All labour activities and costs, including farmers’ own labour.
- Record scouting dates, findings and actions taken.
- Produce prices
- Field visits by extension officers, development facilitators and other professionals and their advice given.

Information can be written down in a notebook or record keeping files that may be available at EPA extension offices.
References

2. CISANET (2014), Sesame Value Chain Analysis Policy Study.