A manual for mungbean (Greengram) production in Uganda

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Foreword

Mungbean/greengram is one of the important legume crops in eastern and northern Uganda grown for food and income. The crop is rich in proteins and minerals and is increasingly becoming a cash crop due to the increasing demand from neighbouring countries as well as in Asia. Production of this crop in Uganda is constrained by numerous challenges such as insect pests and diseases, poor crop management practices, erratic rainfall patterns and low yield potential of currently grown local varieties/landraces. The Dryland Legume Research Program based at NaSARRI is responding to these challenges by developing new and better adaptable varieties as well as better crop management practices.

This manual contains valuable information needed for mungbean crop cultivation in Uganda and covers several aspects such as land preparation, choice of varieties, sowing, weed, pests and diseases managements as well as post-harvest handling.

The manual is carefully written chronologically in a comprehensible language. I hope this manual will be a reliable source of information for farmers, extension workers, researchers and other stakeholders interested in mungbean cultivation in Uganda.

I thank the authors for their efforts in putting the information contained in this manual together and hope that the messages contained in it will reach to the intended audience for enhanced mungbean production and improved livelihoods in the country.

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Director of Research- NaSARRI
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1. **Background information**

1.1. **Introduction**

Mungbean [*Vigna radiata* (L.) Wilczek] also known as greengram or locally as choroko is a self-pollinated diploid (2n=22) crop belonging to the family Fabaceae. It originated in India or in the Indo-Burmese region, where it has been cultivated for millennia as indicated by fossilized remains discovered in India dated 1500–1000 BC. Mungbean cultivation spread in early times to most other Asian countries and later to Africa, Australia and the Americas. In Uganda, mungbean production is concentrated mainly in the eastern and northern regions and is mainly cultivated at a subsistence level by smallholder farmers. The crop, however, is steadily being adopted by large-scale commercial farmers in the country targeting its growing demand, especially in the regional and international markets in Asia.

It is a small herbaceous annual plant growing to a height of 30 to 120 cm with a slight tendency to twine in the upper branches. The central stems are more or less erect while side branches are semi-erect. The leaves are 5-10 cm long trifoliate, with long petioles. Both the stems and leaves are covered with short hairs. The pods are linear, sometimes curved, round and slender with short pubescence. The seeds are small and nearly globular. The colour of the seed is usually green, but yellowish brown or purple brown seeds also occur.

The productivity of mungbean in Uganda is still low, estimated at less than 300 kg/ha due to a number of constraints such as low yielding varieties, disease and insect pest problems, variable climatic and soil conditions, lack of access to improved varieties, long maturing varieties and poor crop management practices.

This manual will help address some of these challenges by providing information on improved varieties and appropriate crop management practices aimed at increasing production in the country. The manual is intended to help farmers, extension personnel, and researchers in Uganda grow mungbean profitably and sustainably.

1.2. **Importance of mungbean**

Mungbean is an important pulse crop rich in protein (about 24%) and iron (6 mg/100 g dry seeds) and its cultivation improves soil fertility by adding about 30-40 kg N/ha after the harvest of the crop. Therefore, the succeeding crop (normally a cereal) requires about 25% less nitrogen application. Mungbean is also considered a hardy pulse crop and grows well in hot and dry climates. Mungbean plant residues are fed to livestock, but can also be used as green manure or as a cover crop to improve soil fertility.

For human consumption, mungbean grains are consumed in a number of ways e.g. whole seeds may be boiled, fried alone or with meat/vegetables and eaten as a relish with thick maize porridge (‘ugali’). The grains may also be split (dhali) by removing the seed coat by grinding and the split seeds may be eaten boiled, fried, salted and eaten as a snack.

The split seeds may also be ground into flour which may be further processed into highly valued starch noodles, bread, biscuits, vegetable cheese and extract for the soap industry. It can also be used as a vegetable in form of immature pods or by sprouting the seeds (mungbean sprouts).
1.3. Nutritional composition

Mungbean is a highly nutritive pulse, rich in proteins and an ideal complement for starchy or cereal based balanced human diet. The composition of mature mungbean grain per 100 g of edible portion is: water 9.1 g, energy 1453 KJ (347 kcal), protein 23.9 g, fat 1.2 g, carbohydrate 62.6 g, dietary fibre 16.3 g, Ca 132 mg, Mg 189 mg, P 367 mg, Fe 6.7 mg, Zn 2.7 mg, vitamin A 114 IU, thiamin 0.62 mg, riboflavin 0.23 mg, niacin 2.3 mg, vitamin B6 0.38 mg, folate 625 μg and ascorbic acid 4.8 mg. The essential amino-acid composition per 100 g edible portion is: tryptophan 260 mg, lysine 1664 mg, methionine 286 mg, phenylalanine 1443 mg, threonine 782 mg, valine 1237 mg, leucine 1847 mg and isoleucine 1008 mg.

The starch consists of 28.8% amylose and 71.2% amylopectin. Mungbean seed is highly digestible and low in anti-nutritional factors, therefore causes less flatulence than the seed of most of the other pulses, making it suitable for children, sick and older people. Mungbean starch is considered to have a low glycaemic index, i.e., raise the blood sugar level slowly and steadily.

The composition of sprouted mungbean grain per 100 g of edible portion is: water 90.4 g, energy 126 KJ (30 kcal), protein 3.0 g, fat 0.2 g, carbohydrate 5.9 g, dietary fibre 1.8 g, Ca 13 mg, Mg 21 mg, P 54 mg, Fe 0.9 mg, Zn 0.4 mg, vitamin A 21 IU, thiamin 0.08 mg, riboflavin 0.12 mg, niacin 0.75 mg, vitamin B6 0.09 mg, folate 61 μg and ascorbic acid 13.2 mg. The essential amino-acid composition per 100 g of edible portion is: tryptophan 37 mg, lysine 166 mg, methionine 34 mg, phenylalanine 117 mg, threonine 78 mg, valine 130 mg, leucine 175 mg and isoleucine 132 mg.

1.4. Edaphic (Soil) requirements

Mungbean is grown on a wide range of soils, including red laterite soils, black cotton soils and sandy soils. However, a well-drained loamy to sandy loam soil is best for its cultivation. The crop does not grow well on saline and alkaline soil or waterlogged soils. The soil should have a pH range of 6.3-7.2. Heavy clay soils restrict root growth and therefore should be avoided.

1.5. Climatic requirements

Mungbean grows in a wide range of climatic conditions. A warm humid climate with temperature ranging from 25-35 °C, 400-550 mm rainfall, well distributed during the growing period is suitable for cultivation. However, this crop is both heat and drought tolerant and thus can be grown in semi-arid environments. Mungbean is responsive to day length. Short days result in early flowering, while the long days result in late flowering. Different mungbean varieties vary in their photoperiod response.

2. Cultivation practices

2.1. Variety selection

The traditional mungbean varieties/landraces under cultivation in Uganda are inferior. They are late maturing, require a long harvesting period, low yielding, prone to shattering, are small seeded and susceptible to several diseases. The National Semi Arid Resources Agricultural Research Institute (NaSARRI) released two new varieties (NAROGRAM1 and NAROGRAM2). The characteristics of these varieties are given in Table 1.
Table 1: Characteristics of newly released mungbean varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAROGRAM1</td>
<td>Medium seed size, dull green seed colour, maturity period: 60-65 days, tolerant to Cercospora leaf spot, moderately resistant to powdery mildew and tan spot diseases, yield potential: 1000-1200 kg/ha</td>
</tr>
<tr>
<td>NAROGRAM2</td>
<td>Large seeded, shiny greenish yellow seeds, matures in 60-65 days, moderately resistant to Cercospora leaf spot and powdery mildew diseases, resistant to tan spot disease, drought tolerant, yield potential: 1000-1200 kg/ha</td>
</tr>
</tbody>
</table>

2.2. Cropping system

Mungbean in Uganda can be grown either as a single crop (mono-cropping) or as an intercrop (mixed cropping) with other crops by small scale farmers. The most common intercrops involve mungbean with sorghum, maize, pearl millet, cassava and sometimes finger millet. It can also be intercropped with other legumes such as cowpea, pigeonpea and common beans. When it is to be grown in rotation, it should be followed by a cereal crop such as sorghum, maize, pearl millet, finger millet and rice.

2.3. Land preparation

A well-prepared seedbed is required for proper germination and establishment of the crop. To obtain a fine seedbed free of big soil clods and weeds, 2–3 ploughings followed by harrowing are needed. Ploughing and harrowing can be carried out using tractor mounted ploughs; animal mounted mould board ploughs (oxen/donkeys) or by hand held hoes (Figure 1 and Figure 2). The seedbed may be flat or raised/ridges (standing 20 cm high). When ridges are used, they should be spaced one meter apart from the centre of one bed to the centre of the next (Figure 3). Fertilizer application is recommended based on soil analysis and availability of the soil nutrients. A fertilizer mix containing nitrogen (N), phosphorus (P2O5) and potassium (K2O) at a rate of 15, 60 and 100 kg/ha, respectively, may be broadcasted and incorporated into the soil before sowing.
Figure 1. Land opening using donkeys in Nebbi district (Photo credit: Mbeyagala K. E)

Figure 2. Land preparation by oxen (Photo credit: WorldVeg)

Figure 3. (a) Flat side bed vs (b) raised bed/ridges (Photo credits: Mbeyagala K E and WorldVeg.)
2.4. Seed rate

Seeds that are healthy, undamaged and free from insect pests and fungi should be selected. The seed rate varies with seed size and season. In NAROGRAM1 and NAROGRAM2, a seed rate of 22-26 kg/ha is appropriate. However, it is recommended to calculate the seed rate every season/year since it varies greatly depending on the variety, germination and sowing conditions. Box below gives an example of how to compute seed rate.

Calculating seed rate

Method 1:

Seed rate = \frac{\text{Target plant density per ha}}{\text{Seeds/kg x (Germination %/100) x (Establishment %/100)}}

E.g.
Target plant density = 250,000 plants/ha
Seeds/kg = 13500
Germination rate = 95%
Establishment rate = 85%

Seed rate = \frac{250,000}{13500 \times (95/100) \times (85/100)}

= 24 kg/ha


Method 2:

Calculate the quantity of NAROGRAM1 seed required to plant one hectare when the seed lot has 95% germination. The mass of 100 seeds of this variety is 12 g. The desired plant density is 200000 plants ha⁻¹.

Amount of seed required to get 100 germinable seeds:

= \frac{12g}{(95/100)}=12.63g

Weight of 200,000 germinable seeds (for 200 000 plants ha⁻¹)

= \frac{12.63 \times 200,000}{100 \times 1000}

= 25.26 kg/ha

Therefore, for 1 ha the amount of seed required is 25.26 kg/ha

2.5. Seed dressing

Soak 1 kg of seed in 200 ml of water mixed with 3 mL of imidacloprid 17.8 SL or 5 g of thiomethoxam 25 WG for 45 minutes to one hour and dry the seed under shade. Shade dried seed should be treated with captan 75 WP or thiram 80% WP @ 3 g/kg seed or with a bioagent (Trichoderma spp. @ 5-10 g/kg seed) against seed borne fungi followed by biofertilizers (Rhizobium spp., AMF- Glomus spp./ PSB-Pseudomonas spp. each @ 30 g/kg seed), before sowing. Inoculation of treated seeds with a suitable strain of Rhizobia (preferably a local strain) is recommended as it increases nodule formation, leading to 10-15% increase in yield, and also minimizes the use of nitrogenous fertilizers for the subsequent crop.

2.6. Sowing

Seeds should be planted 4 cm deep in a well-prepared seedbed with good moisture content in order to avoid staggered germination. Sowing on flat beds or ridges should be at a spacing of 45 cm between rows and 20 cm within rows (plant to plant spacing) and 3 seeds should be sown per hole and later thinned to two at first weeding.

2.7. Sowing method

Row sowing is more advantageous as it requires less seed, produces a more even crop that is easier to manage and will have higher yield potential. Broadcasting of seed, a common practice, makes weeding, crop management, and harvest much more laborious and significantly reduces crop productivity and economic return. See the illustration below for row sowing.

Illustration of row sowing for mungbean
2.8. Fertilizer application

Application of nitrogen fertilizer to mungbean crops in high amounts is not needed because the crop can fix nitrogen. However, inoculation of the seed with *Rhizobia* before sowing is highly recommended in fields where mungbean cultivation is taken up for the first time in order to increase nodulation and thus nitrogen fixation. If soil is poorly fertile, well decomposed 10-12 tonnes of farmyard manure (FYM) should be applied. The FYM is mixed with soil one month before sowing. Also a fertilizer mix containing nitrogen (N), phosphorus (P₂O₅) and potassium (K₂O) at the rate of 15, 60 and 100 kg/ha, respectively is broadcasted and incorporated into the soil before sowing. A top dressing of N at 15 kg/ha is done at flowering stage. It is always advisable to use fertilizers on the basis of soil test results.

2.9. Weed management

Weed management in mungbean is essential, so that competition between mungbean and weeds is reduced, especially at an early growth stage (Figure 4). Weeds can cause up to 50% grain yield loss if not controlled, especially at an early stage. The magnitude of grain loss varies with the intensity and type of weeds present in the field/location. One or two hoeings at 25 and 40 days after sowing/germination are recommended to keep the weeds under check. Late emerging weeds have a lesser effect on yield than the early emerging weeds. Weeds can also be controlled using herbicides (pre-emergence herbicides).

*It is always advisable to conduct soil tests and follow the recommended fertilizer applications*

*Pre-emergence herbicides should be applied immediately after sowing but before germination*

Figure 4. An example of a weed free mungbean field (Photo credit: Mbeyagala. K. E)
2.10. Mungbean insect pests and their management

2.10.1. Field insect pests

Insect pests significantly reduce mungbean profitability by reducing both yield and seed quality with damage ranging from 80-100%, if no control is undertaken. Insect pests can attack mungbean at any stage from seedling to harvest/storage, but the crop is most susceptible from budding onwards. Crops should be inspected at least weekly during the vegetative stages and twice a week from budding onwards (depending on pest pressure). While early damage is less likely, high pest pressure in seedling/early vegetative crops can lead to a massive reduction in yield potential. The most important pests attacking mungbean in Uganda are briefly discussed below:

2.10.1.1. Cowpea aphid

The black aphid, *Aphis craccivora* Koch is a polyphagous pest widely distributed across many parts of the world and infects several crops such as cowpea, mungbean, pigeonpea and groundnut. Aphids normally feed on the underside of young leaves, on young stem tissue, and on pods of mature plants (Figure 5). When present in large numbers, they cause direct feeding damage.

**Damage:** Both adults and nymphs suck plant sap and cause stunting, crinkling and curling of leaves, delayed flowering, and shrivelling of pods (Figure 5). Heavy infestation results in stunted plants with small, poorly nodulated root systems. Plant yield is reduced and in extreme cases the plant is killed. In addition to the direct damage, aphids also transmit viruses.

![Figure 5. Aphid infestation on mungbean (a) leaves and (b) flowers (Photo credit: WorldVeg)](image)

**Management:** Several natural enemies such as green lacewings (Chrysopidae), ladybird beetles (Figure 6), minute pirate bug, syrphid fly, and parasitic wasps keep aphid populations in check in the field. Certain insecticides such as dimethoate are effective against aphids, but they may also eliminate the natural enemies, thus aggravating the problem. Insecticides should therefore only be used when the pest pressure is very high with low or no natural enemies.
2.10.1.2. Bean foliage beetle

The bean foliage beetles (*Ootheca bennigseni* and *Ootheca mutabilis*) are widely distributed in Africa, where it is an important foliage feeder on legume seedlings. Adults are about 6 mm long, oval and normally shiny reddish brown, although this varies considerably and black or brown adults may occur.

**Damage:** Adults feed interveinally on the leaves, later enlarging damage into feeding holes (Figure 7). High beetle populations can totally defoliate seedlings and kill them. The larvae feed on roots but seldom cause serious damage.

**Management:** Post-harvest tillage exposes the dormant adults in the soil to the heat of the sun and increases mortality. Crop rotation with non-hosts (e.g. maize or sunflower) breaks the development cycle and reduces the emerging adult population. Delayed sowing also helps to avoid susceptible stages of the crop coinciding with peaks in the pest population cycle. Application of neem (*Azadirachta indica*) seed extracts deter infestation and reduces the damage. If the pest population is very high, application of dimethoate @ 1 ml/L is recommended.

![Figure 6. Ladybird beetle feeding on aphid colonies (Photo credit: Ampofo. J. K. O)](image)

![Figure 7. (a) A foliage beetle feeding on a leaf and (b) severe defoliation of a plant (Photo credit: Ampofo. J. K. O)](image)
2.10.1.3. Whitefly

The whitefly (*Bemisia tabaci*) is a cosmopolitan pest and occurs in nearly all bean growing ecologies in Africa. They have a wide host range which includes legume crops, cassava, sweetpotato, and various horticultural crops. They tend to breed all year, moving from one host to another as plants are harvested or dried. Low populations of whiteflies do not cause much damage and do not warrant control interventions.

**Damage:** Both nymphs and adults suck sap from leaves, resulting in mottling and light yellowish spots on the upper surface (Figure 8). Sucking of sap makes the plants very weak producing downward cupping of the leaves and the plant may die eventually due to severe attack of the pest. The insect secretes honey dew on which sooty mould grows resulting in blackening of leaves, drastically reducing photosynthetic rate and eventually drying of leaves. Whitefly is a vector of number of viral diseases especially Mungbean Yellow Mosaic Disease (MYMD).

**Management:** Management of heavy whitefly infestations is very difficult. Whiteflies are not well controlled with any available insecticides. However, if you choose to use insecticides, insecticidal soaps or oils such as neem oil, may reduce but not eliminate whitefly populations. Use yellow sticky traps at the rate of 10-12 traps/ha to trap whiteflies. Traps should be hung slightly above the canopy level and ensure that fields are weed free.

![Figure 8. Colonies of whitefly on the under surface of leaves (Photo credit: Ampofo. J. K. O)](image)

2.10.1.4. Thrips

Adult thrips (*Megalurothrips sjostedti*) are shiny black, minute insects and are the most important pests of grain legumes such as mungbean, cowpea and pigeonpea. Thrips feed on leaves, flower buds and flowers (Figure 9).

**Damage:** Thrips damage both leaves and flowers. The thrips damage in seedling is seen when the first trifoliate leaves open. Damaged leaves are severely distorted and discolored. Severely infested plants do not produce flowers. When the thrips population is very high, open flowers are distorted, malformed, and discolored. Thrips feeding particularly on anthers and filaments may lead to premature loss of pollen and decrease in pollination and seed set. Flowers fall prematurely and under heavy thrips infestation there is total crop loss.

**Management:** Adequate soil moisture levels or timely irrigation results in low buildup of thrips. To control thrips, crop must be sprayed at flower initiation stage with Spinosad @ 0.6 ml/l of water. Treat seeds with thiomethoxam 70 WS (0.2%) at the time of sowing. Spray thiomethoxam 25 WG 0.02% or neem seed kernel extract (NSKE) @ 50 g/l or neem oil 3000 ppm @ 20 ml/l, when high thrips population is observed in the field.
2.10.1.5. Flower beetle (Blister Beetle)

Blister beetles also known as pollen beetles belong to several species of the genera *Mylabris* and *Coryna* and cause considerable damage to the grain legume flowers. Blister beetles are easily recognized by the characteristic bright-coloured elytra with broad black, yellow, or red bands (Figure 10 a). They are about 15 to 28 mm long and often appear in large numbers.

**Damage:** Blister beetles feed on the petals and pollen of flowers and a large infestation can reduce pod setting and yield drastically (Figure 10 b). Eggs are laid in the soil and the early instar larvae feed on grasshopper eggs. The adults exude a yellowish fluid that causes irritation or blisters to the skin. The beetles, mostly visit only flowers that are open for just a day, and this habit and the mobility of the beetles make it difficult to obtain control with insecticides.

**Management:** Most insecticides are not very effective against these beetles, but synthetic pyrethroids such as cypermethrin work reasonably well. The beetles can be controlled manually by hand picking or collecting with an insect net and crushing them since they are slow moving but care should be taken to protect the skin.
2.10.1.6. Pod borers

a. *Helicoverpa armigera*

*Helicoverpa armigera* also known as African bollworm is a polyphagous pest infesting several agricultural crops both in the tropics and sub-tropics. The main hosts include mungbean, cowpea, pigeonpea, chickpea, sorghum, cotton and tomato. Mature larvae are about 4 cm long and vary in color between yellowish-green, green, brown and black. But they all have a characteristic marking of pale and dark bands on each side of the body.

**Damage:** The older larvae feed from outside and characteristically leave part of the body exposed. The feeding hole is usually clean and circular with faecal frass usually deposited away from the hole. The young larvae feed within flower buds, flowers and pods (Figure 12). Damaged flowers abort and do not set pods. The pods may have shrivelled or half eaten seeds or bear no seeds at all. Crops are better able to compensate for early than late pod damage. However under water limiting conditions, significant early damage may delay or stagger podding with subsequent yield and quality losses. Damage to well-developed pods also results in staining of uneaten seeds due to water entering the pods.
b. *Maruca vitrata* (=*testululis*)

This is also commonly referred to as the spotted pod borer or the legume pod borer and is widely distributed throughout the tropics and sub-tropics, where it causes extreme damage in several leguminous crops. The immature larvae are dull to yellow-white and often reach a length of 18 mm. Each segment has dark spots, which form a distinct series along the length of the body. This pattern is quite obvious on the upper surface. The larval head is dark brown to black in colour. The adult moth has three white spotted brown forewings and greyish–white hind wings with distal brown markings. The eggs are laid singly in the sepals, petals, on buds or on the pods.

**Damage:** Larvae prefer concealment when feeding. They characteristically attack pods at the points of contact between a pod and a leaf or stem or a pod and a pod and form webs to attach the parts at the points of contact for protection against natural enemies. The larvae feed from inside flower buds, flowers and pods and often plug the entry hole with faecal frass to protect themselves against natural enemies. The characteristic symptom of *Maruca* larvae infestation is webbing together of flowers, pods, and leaves with frass often on pods and shoot tips. *Maruca* damage causes flower discoloration and shedding. Damaged pods possess small darkened entry holes frequently ringed with frass. The leaves and pods are stuck together by webbing with signs of surface feeding. Entry holes left by larvae also let in water, which stains the remaining seeds (Figure 13 a,b).

**Management:** Deep dry season or summer ploughing helps to expose and destroying the pupating larvae. Spray spinosad @ 0.6 ml/L or indoxacarb @ 2 ml /L or neem seed kernel extract (NSKE) or crude neem 5% @ 50 g/L or neem oil 3000 ppm @ 20 ml/L or *Bacillus thuringiensis* 5 WG @ 1.0 g/L of water. Sex pheromone lures of *Helicoverpa* and *Maruca* can be used for monitoring. The insecticides give good control, particularly if applied soon after the eggs hatch. For the case of *Maruca*, the webs protect them from contact insecticides therefore careful application is required.

![Figure 13. (a) Maruca web between pod and leaf and (b) Maruca feeding inside the pod in mungbean (Photo credit: WorldVeg)](image-url)
2.10.7. Pod sucking bugs

Pod bugs are widely distributed throughout Africa. They attack beans, other leguminous crops and trees, okra as well as most horticultural crops. The common pod bugs in Uganda include; Clavigralla (=Acanthomyia) gibbosa, C. schadabi, C. elegata, C. hystricodes, Riptortus dentipes, Anoplocnemis curvipes, Nezara viridula.

a. *Anoplocnemis* spp:

The giant coreid bug (*Anoplocnemis* spp.) is a major pest in tropical Africa. Full grown bugs are black in colour and about 3 cm long. Grey to black coloured eggs are laid in chains and hatch in about 7-11 days. There are five nymphal instars and total nymphal period varies from 29-54 days. The life of an adult ranges from 24-84 days. Eggs are usually laid on leguminous trees or weeds, but seldom on cowpeas or mungbeans. Adults are strong fliers (Figure 14).

![Figure 14. Adult giant coreid bug - female (Photo credit: Ampofo. J. K. O)](image)

b. *Riptortus* spp. :

This is a serious pest widely distributed in tropical Africa. The adult bug is cylindrical, light brown with characteristic white or yellow lines on the side of the body (Figure 15). Eggs are laid either in short rows or are scattered. They are mostly laid on leguminous plants and weeds. There are five nymphal instars. Adults are strong fliers.

![Figure 15. Riptortus bugs - adult (Photo credit: WorldVeg)](image)
c. *Clavigralla* (Syn.: *Acanthomyia*) spp:

Spiny brown bug, *Clavigralla gibbosa* (Figure 16) is widely distributed and attacks a wide range of leguminosae plants. Adults are stout, about 10 mm long, furry and brown, having a pair of elongated spines projecting interiorly on pro-thorax. A single female may lay about 250 eggs. Nymphs are sluggish and form colonies on pods and peduncles. *C. schadabi* and *C. elongata* are narrower, grey in colour and have a pair of elongated spines on the “shoulders”; *C. hystricodes* is black and has a short body.

![Figure 16. Spiny brown bug: Clavigralla (Acanthomyia)](Photo credit: Ampofo. J. K. O)

**d. Nezara sp.**

This is commonly known as the green stink bug and is widely spread in the tropics and subtropics. It is primarily a pest of soybean, but also does extensive damage to mungbean, pigeonpea and cowpea. A single female may lay 100 to 250 eggs in four to six batches. The egg period is about 5 to 10 days. Nymphs are shiny with bright spots. There are five nymphal instars and the nymphal period is 3 to 7 weeks. Adults are green in colour and triangular in shape (Figure 17). The adult life period is about 15 to 20 days. The entire life cycle may take 40 to 60 days.

![Figure 17. Nezara- adult](Photo credit: WorldVeg)
Damage: The nature of damage caused by pod sucking bugs is similar: They pierce the pod walls and suck sap from the developing seeds. This leaves tiny depressions or dimples on the pod wall. Attacked seeds rot or shrivel and lose viability or ability to germinate and are not acceptable as food. The whole pod may shrivel. In addition, Anoplocnemis spp. sucks the sap from young shoots, causing them to wilt. Fungal spores are sometimes transmitted through the mouthparts during feeding, resulting in rotting of the seeds. Seeds damaged in older pods are blemished, difficult to grade and have reduced grain quality. Bug-damaged seeds are frequently discolored, either as a direct result of tissue breakdown or water that enters through holes developed in pods.

Management: Use of pesticide sprays such as monocrotophos, dimethoate, cypermethrin have been found effective but they need to be applied against the early instar nymphs. Botanical pesticides such as neem seed kernel extract and other concoctions such as fermented cow urine may also repel the adults and nymphs.

2.10.2. Storage insect pests

2.10.2.1. Cowpea weevil

The cowpea weevil/bruchids (Callosobruchus maculatus) commonly termed as pulse beetle (Figure 18) is a storage pest of worldwide importance. The C. maculatus attacks several pulse crops such as mungbean, cowpea and pigeonpea. Severe infestations can lead to grain losses of up to 100 percent within six months of storage. This pest attacks mungbean both in the field and in storage, with the greater losses occurring in stored grains. The adult is a small square-shouldered beetle with dark markings on the wing cases. Adults live for 5 to 8 days. Elongate, oval and scale-like eggs are laid on the seed surface. Egg laying period is about one week. After hatching, the grubs enter the seed and complete their development within them. Larval (grub) period is about 2 to 5 week. The mature grub is white in colour with a brown head, and is about 0.5 cm long. Pupa is oval in shape and is of white colour. Depending on the temperature, pupal period lasts for 1 to 4 weeks. Adults emerge from the seed through characteristic holes made by the larvae (Figure 19). The nutritional quality of the grains deteriorates as a result of bruchid infestation, rendering them unmarketable. Multiple generations can destroy most of the entire grain, leaving a foul-flavoured flour.

Figure 18. Adult cowpea weevil: (a) male and (b) female
(Photocredit: Brown and Downhower)
Management: Early harvesting before pods shatter/split to avoid field infestation. Clean storage area properly, dry the seeds well (9-10 % moisture), and apply non-toxic chemicals such as vegetable oils. For large-scale seed storage, fumigation with phosphine or other suitable fumigants can be adopted. Treating the mungbean grains with clays, sand, kaolin and ash has proven effective in controlling bruchid infestation in storage. Vegetable oils (e.g., olive oil or mustard oil at the rate of 15 ml/kg of seed) can also be used to treat mungbean grains and seeds to protect from bruchid infestation. However, some vegetable oils may reduce the seed viability. Novel gadgets such as traps (e.g., pitfall trap and probe trap) can be used to monitor as well as mass-trap bruchids in storage. Storage of mungbean grains or seeds in air-tight containers is an effective way to eliminate bruchids, as they are unable to survive without air. Triple-bagging mungbean grains for storage substantially reduces bruchid infestation.

2.11. Mungbean diseases and their management

2.11.1. Fungal diseases

a. Powdery mildew

Powdery mildew caused by fungus *Podosphaera fusca* is a major disease of mungbean causing severe yield loss. The disease has world-wide importance, occurring wherever mungbean is grown. The pathogen attacks angiosperm species of several families, such as *Asteraceae, Cucurbitaceae, Lamiaceae, Scrophulariaceae, Solanaceae, Verbenaceae* and *Leguminaceae*. Significant yield loss (40-90%) can occur if powdery mildew develops before or at flowering, particularly if the crop is under moisture stress.

**Symptoms:** Infected plants have a greyish-white powdery growth on the surface of leaves, stems and pods (Figure 20). Disease initiates as faint dark spots, which develop into small white powdery spots, coalescing to form white powdery coating. At the advanced stages, the color of the powdery mass turns dirty white. The disease induces forced maturity of the infected plant causing heavy yield losses and its intensity increases in stress condition.

**Disease development:** The pathogen overwinters and survives on the host tissue (plant debris) in the form of cleistothecia. The fungus is favoured by cooler conditions, and is often widespread in late-planted crops. Disease intensity depends upon the cultivar, growing period and environmental conditions.
Management: Sowing of resistant or moderately resistant varieties where available e.g NAROGRAM2. Spray neem seed kernel extract (NSKE) @ 50 g/L or neem oil @ 20 ml/L or water soluble sulphur 80 WP @ 4 g/L or carbendazim 50 WP @ 1 g/L twice at 10 days interval from initial disease appearance. Good agronomic practices such as control of volunteer seedlings and other host crops and weeds prior to sowing will significantly reduce the levels of in-crop inoculum. Delayed sowing of mungbean with wider spacing considerably reduces the disease severity.

Figure 20. Powdery mildew symptoms on mungbean leaves (Photo credit: WorldVeg)

b. Scab

This is fungal disease caused by several *Sphaceloma* spp. especially *S. glycine* and is mostly favoured by warm, wet weather. Round to elliptical lesions occur on the leaves, petioles and stems. The lesions are greyish-white at the centre, while the margins are reddish-brown (Figure 21).

Management: Dressing seeds with fungicides such as thiram, dithane and captan. Roguing and burning of diseased plants. Sowing of resistant varieties if available. Practicing a 2–3 year rotation with non-host crops like cereals.

Figure 21. Scab lesions on mungbean leaves (Photo credit: Mbeyagala. K. E)
c. Cercospora leaf spot

Cercospora leaf spot is a fungal disease caused by *Cercospora canescens*. The disease is recognized by the appearance of circular to irregular leaf spots with greyish white centres and reddish brown to dark brown margins, characterized by frog eye shaped spots (Figure 22). Under severe conditions, the plants are completely defoliated with poor pod development.

**Management:** Treat the seeds with thiram or captan @ 2.5 g/kg seed before sowing. Spray carbendazim 50 WP @ 2 g/L or mancozeb 45 WP @ 4 g/L or dithane M-45 @ 3.2 g/L of water. Subsequent sprays should be done after 10 to 15 days, if required. Remove all the infected plants and burn them. Do not sow the seeds in the field which was affected last year by this disease.

![Figure 22. Cercospora leaf spot symptoms on mungbean leaves (Photo credit: Worldveg)](image)

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d. Charcoal rot (Ashey stem blight)/dry root rot and *Macrophomina* blight

The disease is caused by the fungus *Macrophomina phaseolina*. This disease is found throughout the tropics and subtropics and has a wide host range. It is most damaging in areas of unreliable rainfall and high temperature.

**Symptoms:** The disease infects the cotyledons and the hypocotyls at soil level producing black, sunken cankers which have a sharp margin and concentric rings. The plant’s growing tip may be killed and the stem may break at the cankers. It also causes damping-off and seedling blight. Young plants have black wounds and stems have ash-like wounds on diseased bean stems, thus the name “ashy stem blight”. Black charcoal-like flakes/specks (microsclerotia) occur on old on the surface and below the epidermis on the outer tissue of the stem and root, pods and seeds. Infection on older plants may cause stunting, leaf chlorosis, wilting, premature defoliation, rotting of the stem and roots and plant death (Figure 23). The infection is more pronounced on one side of the plant. Damaged seeds shrivel and lose colour. Charcoal rot generally occurs after flowering during a period of heat or moisture stress and results from infection of roots by soil-borne microsclerotia. The pathogen is most favoured at a temperature of 27-35°C and 15% moisture. Seed infection occurs during rain periods when microsclerotia are splashed from the soil surface on developing pods.
Management: Grow dry root rot resistant varieties, if available. Sowing of seeds where sufficient soil moisture is available and avoid the field were charcoal rot is the major problem. Basal application of zinc sulphate @ 25 kg/ha or neem cake @ 150 kg/ha or soil application of Pseudomonas fluorescens or Trichoderma spp. @ 6 kg/ha + 125 kg of well decomposed manure at the time of sowing. Seed treatment with captan 75 WP or thiram 80% WP @ 3 g/kg seed or with Trichoderma spp. @ 5 – 10 g/kg seed before sowing. Uproot and destroy the diseased plants so that sclerotia of Macrophomina do not form or survive. Crop rotation with non-host cereal crops.

Figure 23. Dry root rot infection in mungbean (Photo credit: WorldVeg.)

2.11.2. Bacterial diseases

a. Tan spot

Tan spot is caused by the bacterium Curtobacterium flaccumfaciens. The disease occurs worldwide and infects several crops such as Vigna radiata (mungbean), Glycine max (soybean), Lablab purpureus (hycacinth bean), Phaseolus lunatus (lima bean), Phaseolus vulgaris (common bean), Vigna angularis (adzuki bean) and Vigna unguiculata (cowpea).

Symptoms: The disease is characterised by large, irregular, dry, papery lesions on leaves that coalesce to form large brown dead areas, commonly with yellow margins around the dead areas (Figure 24). These areas usually tear and fall out, giving the leaf a ragged appearance. Infected flowers usually die. Early infection results in stunting, yellowing, and poor set seed. Tan spot is seed borne, and while it may develop in the seedling stage, the disease is more commonly seen from the second trifoliate leaf stage onwards. The bacterium is spread from infected seedlings to other plants in the crop by wind-blown rain or hail and mechanical damage (machinery and abrasion from dust storms). Symptoms develop rapidly if the crop is subjected to adverse growing conditions such as heat or moisture stress.

Management: Grow resistance varieties such as NAROGRAM1 and NAROGRAM2. Controlling of volunteer mungbean seedlings and plants of other host crops such as cowpea, soybean and weeds prior to sowing significantly reduces the levels of in-crop inoculum. Destroy infected plant residues (leaves, stems, pods) to reduce sources of inoculum. Use low risk seed and practising good crop rotation will minimise its impact.
b. Halo blight

This a seed borne bacterial disease caused by *Pseudomonas savastanoi* pv. *phaseolicola*, *Pseudomonas syringae* pv. *phaseolicola*. The disease is more prevalent in mid-to high altitude areas. It is favoured by cool temperatures (16-20 °C) and moist, cloudy conditions. It multiplies rapidly in the presence of dew. It is not common in regions or seasons with high temperatures.

**Symptoms:** On young leaves, there is an extensive yellow green halo surrounding a smaller area of brown shiny tissue. Infected branches and petioles bear greasy spots which develop a reddish discolouration. The stem may rot at the first node where cotyledons were attached and cause the plant to break. The spots soon turn reddish brown (Figure 25). Infected pods exhibit water-soaked lesions which also develop a reddish discolouration. Under humid conditions, whitish to yellow bacterial exudates appear on the lesions. Seed may become shrivelled and discoloured or rotten. But sometimes no visible symptoms may be seen at all. The disease is spread by water splash, windblown rain and contact among plants due to movement of equipment and/or workers, especially when the foliage is wet.

**Management:** Crop rotation with a non-host crop for at least for 2-3 years. Deep ploughing to bury and destroy the pathogen infected debris. Sowing of resistant varieties if available. Avoiding movement of workers in the field when wet. Removal of all infected seedlings from the field immediately when sighted. Suppression by spraying crops with registered copper based fungicides.
2.11.3. Viral disease

a. Mungbean Yellow Mosaic Disease (MYMD)

This disease is caused by a gemini virus, *Mungbean Yellow Mosaic Virus* (MYMV) which is transmitted by whitefly (*Bemisia tabaci*). MYMV attacks several hosts such as mungbean, *Vigna mungo* (black gram), *Cajanus cajan* (pigeonpea) and *Glycine max* (soyabean).

**Symptoms:** Symptoms include small yellow specks along the veinlets of leaves which spread over the lamina to produce yellow mosaic symptoms (Figure 26); the pods become thin and curl upwards. Leaf size is generally not affected, but sometimes the green areas are slightly raised and the leaves show a slight puckering and reduction in size. The leaves become papery white and thin. Yellowing leads to less flowering and pod development. Early infection often leads to death of plants.

**Management:** Grow MYMD resistant varieties. Diseased plants should be rogued out to prevent further spread of the disease. Use yellow sticky traps @ 10-12 traps/ha for whitefly. Soak 1 kg of seed in 200 ml of water either mixed with 3 mL of imidacloprid 17.8 SL or 5 g of thiomethoxam 25 WG for 45 minutes to one hour and shade dry before sowing. If whitefly incidence is observed, spray imidacloprid 17.8 SL @ 0.1 ml/L or neem oil @ 20 ml/L or oxydemeton methyl 25 EC @ 3 ml/L of water (repeat after 15 days, if necessary).

![Figure 26. Symptoms of MYMV on mungbean leaves (Photo credit: WorldVeg)](image)

3. Harvesting and post-harvest handling

3.1. Harvesting

Pod maturity is generally not uniform because the plants flower over an extended period. Therefore, it is sometimes difficult to decide suitable time to harvest the crop. Nevertheless, harvesting should begin when two thirds of the pods are mature or begin to darken. Harvesting too early can result in the loss of immature pods while harvesting too late can result in losses from pod shattering. Harvesting is done either manually or by machines (combine harvester). When harvesting is done manually, mungbean stalks may be cut with a handsaw or uprooted. Alternatively, mature pods may simply be handpicked. For mechanical harvesting the plants should defoliate (using defoliants/or desiccants) and dry before harvesting. Diquat or glyphosate can be used to desiccate plants before harvesting. Seeds splitting and damage during harvesting can be minimized by harvesting the crop at the optimum seed moisture content (14 to 16%), avoiding harvesting during the noon when the temperatures are too high and by proper harvester settings.
3.2. Drying and threshing

The harvested mungbean stalks containing pods should be sun-dried for about 3-4 days (Figure 27). Threshing must be done as soon as the pods are dry (Figure 28). Beat pods with a stick until pods are opened, or put dry pods in a jute bag, place the bag on the floor, and walk on it. Remove any foreign materials by winnowing. Sun-dry for 3–5 days. Drying of seed to 9-10% moisture level is very important for good storage. Use a seed moisture meter (Figure 29a) for accurate determination of the moisture content. Use of solar dryers would be a better option for quicker drying (Figure 29b). Collect only good seeds (free from diseases, seed coat cracking, split, or immature).

Figure 27. Drying harvested mungbean pods on a tarpaulin (Photo credit: Mbeyagala. K. E)

Figure 28. Threshing of mungbean on a tarpaulin (Photo credit: Mbeyagala. K. E)
3.3. Storage

Dried seeds can be safely stored for at least three years. Place seeds in jars, manila envelopes, cloth or mesh bags, plastic containers, triple layer bags or foil envelopes. The best containers are air-tight, such as a sealed glass jar, metal can, and triple layer bags or foil envelope (Figure 30 and Figure 31). Protect seed from sunlight. Store seeds in a cool (below 15°C is ideal), dry location. Place the seeds in a refrigerator for long-term storage. For short-term storage, keep the seeds in a cool, shady and dry place on raised platforms.

Figure 30. Storage of seed/grain in sealed plastic drums (Photo credit: WorldVeg)
Figure 31. Storage of mungbean seed in triple layer bags (Photo credit: Mbeyagala. K. E)
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