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Kenya Agricultural & Livestock Research Organization

THE KENYA CEREALS ENHANCEMENT PROGRAMME – CLIMATE RESILIENT AGRICULTURAL LIVELIHOODS

(KCEP-CRAL)

GREEN GRAM EXTENSION MANUAL

SUPPORTED BY FUNDS FROM EU

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Disclaimer

The information presented in this manual is for advisory use only. Readers using the manual should verify details that relate to their agro-climatic zones from their area agricultural extension officers.

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KALRO Secretariat
P O Box 57811-00200
Nairobi, KENYA
Email: directorgeneral@kalro.org Tel. No(s): +254-722206986/733333223

Edited by: Esilaba, A.O., D. Nyongesa, M. Okoti, M. Otipa and L. Wasilwa

Compiling Authors: Macharia D., Waithaka M., Otipa M., Amata, R., Too A., Esilaba A. O., Nyongesa D., Okoti M., Mutuma E., Kathuku-Gitonga A.N., Mutisya D., Njunie M., Muli B., Karanja J. K., Wasike V. W. and Wasilwa L.

Production Editors: Mukundi K. T, P. Maina and K. Nyabundi

Design and layout: Nyaola E. and J. Njeru

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We also thank the researchers, farmers and stakeholders who participated in the project for their support in setting up trials, collecting and processing the data and thus generating large amounts of knowledge and information that KCEP-CRAL has packaged and shared through scientific papers, in seminars and in reports among others. The support of technical officers, laboratory personnel, administrative and support staff is also appreciated as it contributed to the success that the project achieved.

FOREWORD

Kenya Agricultural and Livestock Research Organization (KALRO) is one of the key partners in the Kenya Cereals Enhancement Programme - Climate Resilient Agricultural Livelihoods Window (KCEP-CRAL) Programme funded by the European Union (EU) and implemented by the International Fund for Agricultural Development (IFAD). KALRO participation in this programme is based on proven experience and expertise in agricultural research. Within the programme, KALRO handles the research component, conducting on station and on farm trials, develops farmer recommendations together with training materials for extension staff and service providers and conducts the training. The implementation of KCEP-CRAL is in thirteen (13) counties namely Nakuru, Nandi, Trans Nzoia, Kakamega, Bungoma, Kitui, Tharaka-Nithi, Embu, Machakos, Makueni, Taita Taveta, Kwale and Kilifi.

KCEP-CRAL focuses on the three leading rain-fed cereals (maize, sorghum and millet) and associated pulses (beans, green grams, cowpeas and pigeon peas). The programme's overall objective is to contribute to the reduction of rural poverty and food insecurity of smallholder farmers.

Through this manual, the programme will provide a comprehensive guide to extension officers, service providers and lead farmers on how to successfully produce cereals and pulses in Kenya. The manual is a useful training and reference material for extension officers and other stakeholders seeking to enhance the capacity of farmers, increase commercialization for food security and promote gender inclusion and participation along the commodity value chains.

Initial lessons learnt in this project indicate that enhancing the capacity of the extension staff and service providers has improved uptake of new technologies for dry land farming. It has opened up more land for farming through use of conservation agriculture in areas that hitherto were not under agriculture. Besides easing the pressure on previously arable land, farmers in the project areas have been trained to use alternative disease and pest management regimes using Integrated Disease and Pest Management and Push pull technologies for persistent pests of economic importance.

On behalf of KALRO, I am grateful to the European Union for supporting this project through the IFAD and KCEP-CRAL of the Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MoALF&C). I also appreciate the excellent coordination of the whole process by the KCEP-CRAL Secretariat led by Dr Anthony O. Esilaba, MoALF&C and other partners, scientists in participating centres, Knowledge, Information and Outreach Unit team and secretarial staff. It is my hope and desire that in using this manual, the expectations of all stakeholders will be met.

Eliud K. Kireger (PhD , OGW)

DIRECTOR GENERAL, KALRO

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

°C	Degrees Celsius
EU	European Union
ha	Hectare
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
KALRO	Kenya Agriculture and Livestock Research Organization
KCEP-CRAL	Kenya Cereals Enhancement Programme - Climate Resilient Agricultural Livelihoods Window
kg	Kilograms
KS	Kenya seed variety
KVR	Katumani variety
l	litres
MASL	Metres above sea level
ml	Millilitres
mm	Millimetres
MoALF&C	Ministry of Agriculture, Livestock, Fisheries and Cooperatives

1 INTRODUCTION

Pulses, or grain legumes in general, are an essential source of supplementary protein. They provide energy, protein, essential minerals, vitamins and several compounds considered beneficial for good health. Their cultivation enriches soil by adding nitrogen and improves the physical, chemical and biological properties. They are also well suited to diverse environments and fit in various cropping systems owing to their wide adaptability, low input requirements, fast growth, nitrogen fixing and weed smothering ability. Their short growing period and photoperiod sensitivity make them suitable for crop intensification and diversification. Notwithstanding their high production potential, their productivity is generally low as they are cultivated on poor lands, with no or little inputs, and are susceptible to several abiotic and biotic stresses.

Green gram (*Vigna radiata L.*) also known as Mung bean and *Ndengu* in Kiswahili is one of the potential food and cash crop pulses that have been observed to perform well in the arid regions of Kenya. The crop is commonly grown in central, south Nyanza, eastern and coastal regions. The grain is characterized by good digestibility, flavour, high and easily digestible protein and absence of any flatulence. Its seed contains contain approximately 374 Kcal, 23.9% protein, 1.2% fat, 16.3% dietary fiber, 4.5-5.5% ash, 63% carbohydrates on dry weight basis. It is also a crucial source of vitamins A and B complex. It also contains generous amounts of micro-nutrients such as iron and zinc which are deficient in diets among the poor, particularly pregnant women and children in Africa.

Green gram in Kenya is mainly grown by smallholder farmers, where it is often cultivated in unfavourable conditions and with minimum inputs. The production is severely constrained by low yielding varieties, disease and insect pests, 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, researchers and other stakeholders in Kenya to grow green gram more sustainably and profitably.

1.1 Ecological requirements

1.1.1 Altitude

Green gram perform best at altitudes between 50-1600 masl At higher elevations, of more than 1800 m, it has very poor pod set.

1.1.2 Rainfall

Green gram is drought tolerant with rainfall requirements ranging between 350-700 mm per annum. Adequate moisture is required from flowering to early and late pod fill to ensure good yield. Late planting which coincides with flowering during the high temperature-low moisture season, reduce yield. High humidity and excess rainfall late in the season may

result in disease challenges and harvesting losses due to delayed maturity. Heavy rainfall and cool temperatures lead to increased vegetative growth with reduced pod setting and development.

1.1.3 Soil Types

Green gram perform well on a wide range of soils, including red laterite soils, black cotton soils and sandy soils. However, a well-drained loamy to sandy loam soils is the best for its cultivation. Root growth gets restricted on heavy clay soils leading to poor yields. The crop does not tolerate saline soils and show severe iron chlorosis and other micronutrient deficiencies when grown on more alkaline soils.

1.1.4 pH

The best pH range is between 6.0 and 7.0. If it is below 6.3, lime should be added to raise pH to the desired level. For best results, lime should be applied and thoroughly incorporated in soil one year prior to growing green gram.

1.1.5 Temperature

Green gram is heat and drought tolerant and therefore can be grown in semi-arid environments. It is also responsive to day length. Short days result in early flowering, while long days result in delayed flowering. Different varieties vary in their photoperiod response. A warm humid climate with temperature ranging from 25- 35 ^{o} C is ideal for green gram production.

2 KEY OPERATIONS

Several farm operations are necessary in order to achieve the desired crop yields. These operations can be divided into pre-field or preparatory activities, on field operations, post-harvest handling and utilization. These different operations are discussed in this section.

2.1 Pre- Field Operations

2.1.1 Varietal Selection

The traditional green gram varieties/landraces under cultivation in Kenya are inferior. They are late maturing, require a long harvesting period, low yielding, prone to shattering, are small seeded and susceptible to several diseases. A number of improved varieties have been released in Kenya. The characteristics of these varieties are given in Table 1.

Table 1: Characteristics of released green gram varieties

Variety/ Description	Source	Seed Colour	Maturity	Yields (90 kg bags)
N22 or KVR 22 	Dryland Seed Company	- Golden yellow seeds - Semi-determinate plant - Tolerant to aphids, yellow mosaic and powdery mildew	- Flowers in 55 to 60 days - Matures in 80 to 90 days	4-7 bags per acre
N26 or KVR-26 (Nylon) 	KALRO Seed Unit	- Shiny green seeds - Determinate growth habit - Pods are black and contain shiny green grains - Flowers purple in color	- Flowers in 40 to 45 days - Matures in 60 to 65 days	6-8 bags per acre
KS20 (Uncle, Cotton) 	Kenya Seed Company	- Pods turn brown when dry - Grains are dull green in color - Flowers in 60-65 days. - Grains are bigger in size compared to N26.	- Matures in 80 to 90 days	7-10 bags per acre
Biashara	KALRO Seed Unit (Katumani)	- Shiny green seeds - Large seed size - 8-10 g/100 seeds	65 - 75 days	8 - 9

Variety/ Description	Source	Seed Colour	Maturity	Yields (90 kg bags)
Karembo	KALRO Seed Unit (Katumani)	- Green shiny grains - Large seed size - 8-10g/100 seeds	65 - 75 days	8 - 9
Ndengu Tosha	KALRO Seed Unit (Katumani)	- Green pod colour when dry and green shiny grains	65 - 70 days	8 - 10

2.1.2 Seed treatment against diseases and pests

For the prevention of soil and seed borne diseases and better yield, seeds should be treated with fungicides and insecticides. Additionally, it is important to regularly change the seed source.

2.1.3 Germination test

While the germination percentage of seeds is marked on every packet of seeds, farmers often encounter non-germination of seeds after planting. It is advisable to conduct a germination test before planting whole fields or farms. This is done by taking a few seeds of the green gram (e.g. a table spoonful) and soaking them in water overnight. The soaked seeds are then wrapped in polythene bag. On the third day, the seeds are examined to assess the number of sprouted seeds. Based on the number of seeds that sprout, the farmer will make a decision on whether to use the seeds or source for alternative seed.

A germination rate of 70-80% is an indication of high seed viability. This test also informs the farmer on whether to place excess seeds in the planting holes or not. If one batch of seed has 60% germination and another 90% germination, the farmer would need to plant more seeds per area from the former batch than the latter. Seeds with good germination capacity and uniformity in size will have good vigour. Seeds with good vigour will produce good quality seedlings that will grow and give good yields.

2.1.4 Site selection

In order to realize good yields, precautions should be taken in selecting the planting location. Farmers should avoid steep sloping land, swampy fields, heavy clays and fields with a lot of couch grass. It is important to look for sites with high soil fertility and also fields where green gram have been grown for no more than two seasons. Crop rotation should be practical where possible**.**

2.2 Field Operations

2.2.1 Land Preparation

A well-prepared seedbed is required for proper germination and establishment of the crop. Land should be ploughed during the dry spell to allow for aeration and to expose soil borne pests to die. Land should also be prepared early enough for planting to coincide with the rains. 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) or by hand held hoes.

2.2.2 pH

The best pH range is between 6.0 and 7.0. If it is below 6.0, lime should be added to raise pH to the desired level. For best results, lime should be applied and thoroughly incorporated one year prior to growing green gram.

2.2.3 Improving soil fertility

Fertilizer application is recommended based on soil test analysis and availability of the soil nutrients. A compound fertilizer containing nitrogen, phosphorus (P) and potassium (K) at a rate of one bag (50 kg)/ acre is applied and incorporated into the soil before sowing. Manure can be also be applied before fertilizer or alone at 5 tons per ha or 2 tons per acre (100 wheel barrows per acre. The manure should applied in the planting lines and mixed with the soil just before rains starts.

2.2.4 Planting, spacing and seed rate

Seeds for planting should be of high quality, healthy, undamaged and free from insect pests and fungi. Improved varieties should be obtained from an authorized source since poor quality seed will result in a poor crop and yield. For local varieties a source with good quality seed should be sought. Before sowing, shrunken, shriveled, fungal infested and diseased infected seeds must be removed and only good seeds sown.

Seeds should be planted 3-5 cm deep in a well-drained seedbed with fine tilth to avoid staggered germination. If the surface layers are dry, this depth can be increased to 7.5 cm but only if the soils do not crust easily because crusts reduce stand counts. When using oxen plough for planting, the seed should be placed at the side of the furrow.

2.2.5 Spacing

Green gram can be planted alone or intercropped with other crops like maize. When planted alone on a flat bed or ridges, the spacing should be at 45 cm between rows and 15 cm within rows (plant to plants spacing as shown in Figure 1. When inter cropping, the green gram rows are planted in the middle of the accompanying crop and the intra row spacing is maintained at 15 cm. Three seeds should be sown per hole and later thinned to two at first weeding.

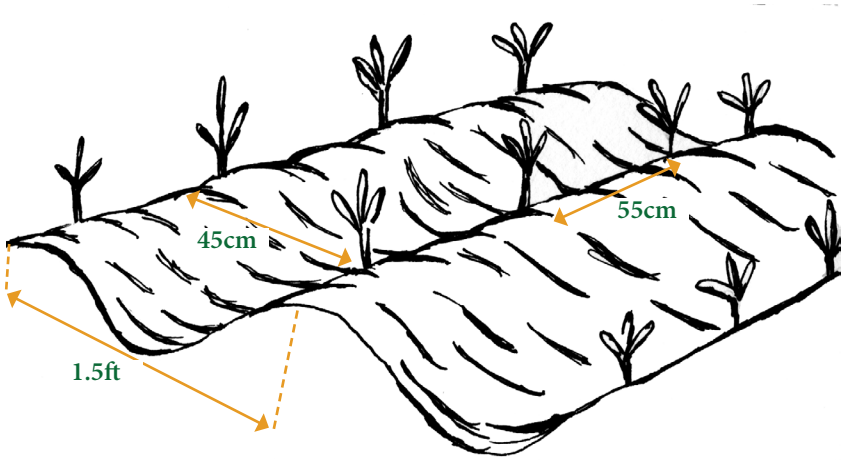


Figure 1: Spacing of green gram

2.2.6 Seed rate

The seed rate varies with seed size and season. A seed rate of 22-26 kg/ha or 8- 15 kg/acre or 4-8 '*gorogoro*' per acre 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. The box below gives an example of how to compute seed rate.

Calculating seed rate

Method 1

Seed rate = Target plant density per Ha

Seed/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%

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

= 24 kg/ha

Source: Gentry. J. 2010. Mungbean management guide. 2nd Edition

Method 2

Calculate the quantity of N 26 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:

= 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 kgha-1

Source: Dasgupta, S.K. and Oswalt, D.L. 1992. Agronomic practices for experimentation. Skill Development Series no. 2. Pages. 40. Human Resource Development Program, ICRISAT

2.2.7 Weeding

Weed control in green gram is essential to reduce competition between the crop and the weed, especially at an early growth stage. 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 weedings at 25 and 40 days after planting/germination are beneficial to keep the weeds under control. Late emerging weeds will have a smaller effect on yield than would early emerging weeds. Weed-free crop of green gram harbours lower major insect pest populations, while weedy crop is conducive for pest population buildup. Common weeds that pose problem to green gram include couch grass, star grass, amaranths, wandering Jew (*Commelina benghalensis*) among others. The most common weeding method is hand weeding but in some areas, farmers use oxen to remove the very early weeds.

Weeds can also be controlled using herbicides (pre-emergence herbicides). A non-selective contact pre-emergence herbicide e.g Roundup (Glyphosate) can be applied to kill all weeds before the land is ploughed. Fifteen days before sowing, the field needs to be pre irrigated with sufficient water to germinate most of the weeds. When weed germinate, Roundup is applied. In order to control later emerging weeds, manual weeding is done 30 days after sowing.

3 CROP PROTECTION

3.1 Importance of Pest and Disease Identification

Under different conditions, losses of 10-45% have been reported in green gram due to common blight while 80% has been reported due to angular leaf spot disease. Farmers lave limited access to technical skills and knowledge on how to control most pests and diseases in green gram thereby increasing insurgence.

There is need to innovatively find simpler ways to assist farmers and key stakeholders to correctly identify and manage pests and diseases that affect green gram production. This can be done by continually developing and providing information training manuals and extension materials to crucial stakeholders involved in green gram production. This manual envisages that the trained extension staff will in turn train farmers, share expertise and expedite the adoption of new pest and disease management techniques.

3.2 Management of Pest and Diseases using Integrated Pest and Disease Management (IPDM)

Integrated pest management (IPM) is the use of a combination of various strategies for the control of pests and diseases. These practices include the use of plant resistance, physical, cultural, biological, chemical and quarantine (exclusion of diseases from non affected areas) options to maintain pest populations below economic injury levels, with minimal impacts on non-target organisms, food safety, terrestrial and aquatic environments. In IPM it is important to conduct scouting, monitoring of pests and establishment of action thresholds to guide application of management strategies. Current projections point to low usage of IPM in Kenya by smallholders in many regions thereby making it necessary to promote its use to limit over use of pesticides and enhance food and environmental safety.

3.3 Scouting for Pests, Diseases and Weeds

The purpose of scouting is to gain an understanding of insects, diseases, weeds and beneficial insect activity in the green gram crop. Effective monitoring includes assessing their numbers and incidences in the field. Scouting is a critical component of implementing an IPM programme. When scouting, get in the farm and take a close look. If you have a large block of a green gram crop, walk in a Z, V, W or zigzag pattern through the field. Look at 50 leaves in a field but in small patches you may look at every plant. Make sure you turn the leaves over. The protected, damp areas under plants are often insect and disease's favourite homes. Check in all wet areas or other troubled spots for symptoms as well as the pests and diseases. Scout the green gram crop once a week in order to identify problems before they get out of control. Once you find insects, diseases or weeds, control them as advised.

3.4 Arthropod Pests

Various arthropod pests affect green gram both in the field and during storage. The field pests include cutworms (*Agrotis* spp.), Root-knot nematodes (*Meloidogyne spp*), whiteflies (*Bemicia tabaci),* leaf miner (*Lyriomyza* spp), aphids (*Aphis fabae*), Flower thrips

(*Megalurothrips sjostedti*), African bollworm (*Helicoverpa armigera) Stink bug (Coptosoma cribraria), Pod bugs: (Riptortus pedestri),Grass blue butterfly (Euchrysops cnejus,Spiny), pod borer (Etiella zinckenella),*and red spider mites (*Tetranychus* sp.). Storage pests affecting green gram include bruchids among others. Losses of up to 30-100% are caused by arthropod pests and rodents.

3.4.1 Cut worm *(Agrotis spp.)*

Symptoms

Damage is on young seedlings which are cut near the ground (Figure 2). Black larvae are found in the soil near the cut plant.

Figure 2: Black larvae are found in the soil next to the damaged plant

Management

A minor pest but where population is high, the larvae can be baited with straw mixed with an insecticide and molasses and sprayed within the field. Plough to expose caterpillars to predators and to desiccation by the sun. Apply ash around the plant. Use neem based botanical insecticides such as Nimbecidine at 50 ml in 20 L of water. Use Lambda Cyhalothrin 25 g/kg based products such as Battalion 2.5 EC, Cyportox 25 EC or Duduthrin 1.15 EC according to manufacturers' recommendations.

3.4.2 Root-knot nematode

Symptoms

Formation of galls on host root system is the primary symptom infected plants occur in patches in the field. Roots branch abundantly starting from the gall tissue causing a 'beard root' symptom with infected roots become knotty in severely infected plants the root system is reduced and the rootlets greatly damaged. The damaged roots are seriously hampered in their function of uptake and transport of water and nutrients. Consequently, plants wilt during the hot part of the day, especially under dry conditions are often stunted.

Figure 3: Galls on host root system become knotty causing a 'beard root'

(Source: Infonet - biovision.org)

Management

Practice crop rotation with crops such as maize, millet and sorghum. Solarize fields before planting by ploughing during hot months to expose nomatodes to the sun's heat which kills them. Clean farm tools and footwear to remove adhering contaminated soil and crop debris. Maintain high levels of manure in soil, uproot affected plants and bury or burn. Use biopesticides such as Achook, Neemray, Super or Nimbecidine according to manufacturers' recommendations.

3.4.3 Flower thrips (Megalurothrips sjostedti)

Symptoms

They suck sap from petioles, leaves and flowers. Damaged petioles and leaves have tiny holes surrounded by discoloured areas (Figure 4). Affected flowers are brown, dried, or completely distorted. The flowers drop prematurely. Thrips also feed on pollen leading to decreased pollination and seed set, low pod production and deformed pods.

Figure 4: Flower thrips on the surface of a leaf

(Source: Infonet- biovision)

Management

Plough and harrow before planting. This reduces subsequent thrips attacks by killing pupae in the soil. Conserve natural enemies particularly predators as these are important in natural control of thrips. Maintain natural enemies including predatory bugs (*Orius* spp. and *Anthocoris* spp.) and predatory thrips. Early detection is particularly important at the onset of flowering; Spray using neem based biopesticides such as Achook 0.15% EC and Nimbecidine according to the manufacturers' recommendations. In severe infestation, spray using spinosad based products such as Tracer 480. Synthetic pesticides such as Alfacyper MEC, Alfatox 10 EC or Acetak Top 700 WC, may be used according to the manufacturers' guidelines.

3.4.4 Aphids (*Aphis craccivora* Koch)

Symptoms

Infested young leaves become twisted and in severe cases plants wilt and die. (Figure 5). Excretion of honeydew as the aphids suck sap from the plant, leading to growth of sooty mould. Aphids are also vectors of viral diseases.

Figure 5: Aphids cause twisting, wilting and death young leaves

(Source: Infonet-biovision.org)

Management

Early planting to escape effects of severe infestation by aphids. Scout regularly for aphids and destroy and bury infested plant materials. This reduces aphids in the field. Destroy volunteer crops as some serve as alternative hosts for the pest. Practise crop rotation with non legumes, use yellow sticky and water traps. Spray soapy water solution (10-15 tablespoon full of liquid soap in 20 L of water), Use neem based botanical insecticides such as Nimbecidine at 50 ml in 20 L of water.

3.4.5 Pod-borers (African bollworm, Legume Pod-Borer, Lima Pod Borer)

Symptoms

Damage is prevalent on leaves resulting to defoliation in early stages. At later stages, only the larvae's head is thrust inside the pods while the rest of the body hangs out (Figure 6).

Figure 6: Larva on a green gram pod

(Source: Infonet-biovision.org)

Management

Monitor the crops frequently as there is only a brief period from egg hatching to entering into buds or pods. Handpick and destroy the caterpillars. Bio-pesticides such as Bt (Bio-T-Plus) or Baciguard 16WDG and neem (Achook 0.15% EC and Nimbecidine) products. Neem products usually give good control of pod borers, provided they are applied to the young caterpillars before they enter into the pods.

3.4.6 Pod sucking bugs

Symptoms

They suck sap from pods and seeds and cause various levels of damage depending on the stage of growth of seeds at the time of attack. Feeding may cause necrosis, pod malformation, premature drying, shriveling of seeds, loss of germination ability and formation of empty pods.

Figure 7: Pod sucking bugs on the leaf surface

(Source: Infonet-biovision.org)

Management

Bugs can be collected by hand regularly and killed, especially during flowering and pod formation. Conserve natural enemies such as the assassin bugs, spiders, praying mantises and ants which are important natural enemies of bugs that kill or deter bugs. Spray Neem based

products such as Achook 0.15% EC and Nimbecidine products to repel bugs. If necessary, spraying should be done in the morning when the immature stages are exposed.

3.4.7 Red Spider mites *(Tetranychus spp.)*

Symptoms

Spider mites slow plant growth, flowering, number and length of pods, and number of seeds per pod. Mite damage may be particularly severe during the dry season. (Figure 8).

Figure 8: Red spider mites (Left) damage crop especially in dry weather
(Source: Infonet-biovision.org)

Management

Avoid planting next to infested fields and frequent use of broad-spectrum pesticides, particularly pyrethroids as this may lead to spider mite outbreaks. Use overhead irrigation or wash plants with a strong jet of water to knock off mites and to destroy their webs. Be sure to spray the underneath of the leaves. However, this should be done early in the day to allow the foliage to dry wetness of the foliage for an extended period is conducive to development of fungal disease. Incase of severe infestation, abamectin based miticides such as Adventure 5G, Agrimech 18 EC and Amazing Top 100 may be sprayed according to the manufacturers' recommendations.

3.4.8 Whitefly *(Bemisia tabaci)*

Symptoms

Damage on the pod appears as black spots. Pods are poorly filled with shriveled grains inside. Larvae and the adults pierce and suck the sap from leaves, which may cause reduced plant growth (Figure 9). Yellowing of leaves and wilting of the plant occurs when pest is present in large numbers. They produce honeydew, leading to growth of sooty mould on leaves and pods thus resulting to reduced photosynthesis .

Figure 9: Whiteflies sucking sap from leaves
(Source: Infonet-biovision.org)

Management

Conserve natural enemies and parasitoids; spray neem based botanical insecticides such as Nimbecidine at 50 ml in 20 litres of water. Intercrop with onions and garlic to repel whiteflies. In case of severe infestation, spray with Cypermethrin based insecticides such as Alfatox 10 EC or Acetamind products such as Acetak Top 700 WG according to manufactireres' instructions.

3.4.9 Bruchids

Symptoms

They are small beetles (3-5 mm) which are grey or brown to reddish-brown in colour. Infested green gram show small dark circular windows on their skins (Figure 10). Inside the seed, a whitish larvae or pupae can be found. Development of eggs takes place inside the green gram for about one month before the emergence of the adult. The larvae feed on the seeds destroying them or reducing their germination capacity. The adult emerges from the seeds leaving small round holes on the green gram seeds. Heavy infestation can result in a large number of holed seeds, with adults moving across the stored green gram.

Figure 10: Bruchid attack on green gram (Callosobruchus chinesnsis Linneus)
(Source: Infonet-biovision.org)

Management

Harvest early to avoid infestations in the field. Clean store and burn all the trash vegetable oil such as cotton seed or coconut oil. Solar drying of green gram before storage is essential. Do not store newly harvested green gram with old ones. Before storage, treat or mix stored seed with a mixture of pesticidal plant parts (e.g. neem, lantana, pyrethrum among others). Dress the seeds with neem seed oil at a rate of 5ml/kg. Dust grain with Pirimiphos methyl based products such as Acrellic dust according to manufactureres' recommenations.

3.4.10 Spiny pod borer *(Etiella zinckenella)*

Symptoms

Damage results into dropping of flowers and young pods. Older pods are marked with a brown spot where larvae entered. Larvae are greenish initially, turning pink before pupation. It has five black spots on the prothorax. Adults are brownish grey moths. The prothoraxis is orange in colour while fore wings have a white stripe along the anterior margin (Figure 11).

Figure 11: Greenish larvae turning pink and brownish grey and an adult moth

Source: http://agritech.tnau.ac.-in/crop_protection/greengram_disease/greengram_d5.html

Management

Deep ploughing within 2-3 years to eliminate quicent pupa is recommended. Early sowing of short duration varieties is recommended. Grow tall sorghum as a companion crop to serve as biological bird perches. Collect and destroy larvae. Install pheromone traps at a distance of 50 m @ 5 traps/ha for each insect pest. Conserve natural enemies like *Tetrastichus sp*., *Bracon hebetor,Phanerotoma sp. And P. hendecasisella.* Spray biopesticides such as Achook 0.15% or nimbecidine according to the manufacturers' recommenations.

3.5 Diseases Infecting Green gram during Production

Various diseases affect green gram in the field. These include Anthracnose (*Colletotrichum lindemuthianum),* Bacterial Leaf Blight (*Xanthomonas phaseoli),* Cercospora leaf spot (*Cercospora canescens),* Leaf crinkle disease (*Leaf Curl Virus),*Macrophomina Blight (*Macrophomina phaseolina),*Yellow mosaic (*Mungbean yellow mosaic virus),* Powdery Mildew (*Erysiphe polygoni),* Root Rot (*Macrophomine spp: Fusarium spp*), Leaf Blight (*Rhizoctonia solani) and* Rust (*Uromyces phaseoli).*

3.5.1 Anthracnose *(Colletotrichum lindemuthianum)*

Symptoms

The fungus attacks all aerial part parts and at any stage of plant growth. Symptoms are circular, sunken spots with dark centreand bright red orange spaces on leaves and pods as seen in Figure 12. In severe infections, affected parts wither off. Seedlings are affected soon after seed germination.

Figure 12: Circular, black, sunken spots on leaves and pods

(Source: Infonet-biovision.org)

Management

Use certified seeds, practice crop rotation with non-legumes. Work in uninfected parts of the field first before the infected area. Avoid unnecessary movement in infected areas to minimize spread of the disease, disinfect farm implements after working from one field before proceeding to the other. Spray with Flutriafol 125/L based product such as Jupiter 125 CS or Bifenoconazole based products such as Domain 25% at 250 g/L. Seed dressing with Carbendazim 2 g/kg of seed.

3.5.2 Bacterial Leaf Blight *(Xanthomonas phaseoli)*

Symptoms

The disease symptoms are characterized by many brown, dry and raised spots on the leaf surface as shown in Figure 13. In severe cases the brown spots coalesce, the leaves become yellow and fall off prematurely. The lower surface of the leaf appears red in colour due to the formation of raised spots.

Figure 13: Brown, dry and raised spots on the leaf surface

Management
Use disease free seed and destroy plant debris by burning or burying. Practice crop rotation with non-legumes for 2-3 seasons. Apply a protective copper based fungicide such as coprocaffero, 1 sacop or champflo SC).

3.5.3 Cercospora leaf spot *(Cercospora canescens)*

Symptoms

This is an important disease of green gram and usually occurs in a severe form, causing heavy losses. Symptoms include smallspots produced in high numbers with pale brown centre and reddish brown margin, (Figure 14). Similar spots also occur on branches and pods. Under favourable environmental conditions, severe leaf spotting and defoliation occurs at the time of flowering and pod formation.

Figure 14: Leaves and stem affected by cerospora leaf spot

(Source: Infonet-biovision.org)

Management

Practise crop rotation with non legumes for 2-3 seasons. Uproot and destroy severely affected plants by burying. Spray using mancozeb products such as Pennozeb, Biothene. Where severe alternate with Azoxystrobin products such as Target Top or Amistar Top 325 SC.

3.5.4 Macrophomina Blight *(Macrophomina)*

Symptoms

A watery rot appears at the base of the stem, plants are stunted and leaves are dark green, mottled and reduced in size (Figure 15). Normal leaves on the affected plants drop suddenly and dry. Flowering and podding are greatly reduced. When the affected plants are split/open vertically from the collar downwards, reddish discoloration of the internal tissues is clearly visible while the internal root tissues appear white. The severity of the disease increases with the increase in temperatures. Fungus survives in the upper layers of the soil and enters the plant through the stem.

Figure 15: Stunted plants with reduced podding and flowering (Source: Infonet-biovision.org)

Management

Deep ploughing during land preparation is essential. Practise crop with fnon legumes for 2-3 years. Amend soil with farmyard manure @ 12.5 tonnes/ha. Destroy diseased plant debris by burning instead of burying them in the soil. Treat seesds with Trichoderma based products such as T. viride at 4g/kg or pseudomorinas fluorescens at 10g/kg of seed.

3.5.5 Yellow mosaic (Mungbean yellow mosaic virus)

Symptoms

Initial symptoms are mild scattered yellow spots which appear on young leaves and gradually increase in size. Ultimately some leaves turn completely yellow. Infected leaves also show necrotic patches. Diseased plants are stunted, mature late and produce very few flowers and pods (Figure 16). Pods of infected plants are reduced in size and turn yellow in colour. The disease is transmitted by whiteflies (*Bemisia tabaci).*

Figure 16: Stunted plants with reduced podding and flowering caused by yellow mosaic
(Source: Infonet-biovision.org)

Management
Use certified seed. Rogue out the infected plants and destroy by burning or burying. Spray biopesticide such as Nimbecidine and Achook 1.5 EC to control whiteflies. Spray methyl demeton 25 EC 500 ml/ha or Thiamethoxam 75 WS 1g/3 lit and repeat after 15 days, if necessary.

3.5.6 Powdery Mildew *(Erysiphe polygoni)*

Symptoms
White powdery spots are observed on leaves, stems and pods. Pods of infected plants are reduced in size and turn yellow in colour. The white powdery spots coalesce to form a powdery coating on leaves, stems and pods. At advanced stages, the colour of the powdery mass turns dirty white. Leaves later dry up, fall and the plant dies.

Figure 17: Stunted plants with reduced podding and flowering
(Source: www.apsnet.org and www.depi.vic.au)

Management

Practise crop rotation with non-legumes for 2-3 seasons. Plant early and observe high field hygiene, uproot and destroy severely infected plants to reduce inoculum in the field. Avoid overhead irrigation to reduce humidity and splash which promotes disease spread. Apply sulphur based protective fungicides at a rate of 30 g/10ltrs water, e.g. Jet, Cosavet DF, Flosul Plus, Wetsulf WP or spray with Triadimefon based products at a rate of 40 gm/20ltrs water at 10-14 day intervals, e.g. Bayleton WP 25, and Edimefon 25 WP. Spray the crop with baking soda at 1 teaspoon per litre of water before the disease becomes severe.

3.5.7 Root Rot and Leaf Blight *(Rhizoctonia solani)*

Symptom

Initial symptoms are mild scattered yellow spots on young leaves. The spots gradually increase in size and ultimately some leaves turn completely yellow (Figure 18). Infected leaves also show necrotic patches, diseased plants are stunted, mature late and produce very few flowers and pods.

Figure 18: Mild scattered yellow spots that lead to yellowing of leaves

Management

Practice crop rotation with non legumes for 2-3 seasons. Uproot and destroy severely affected plants and burn. Spray using Mancozeb products such as Penncozeb and Biothone and alternate with Azoxystrobin products such as Target Top 325 SC or Amistar Top 325 SC.

3.5.8 Rust *(Uromyces phaseoli)*

Symptom

Symptoms appear as circular reddish brown raised spots (pustules) which occur more commonly on the underside of the leaves, less abundant on pods and sparingly on stems. When leaves are severely infected, both the surfaces are fully covered by rust spots (Figure 19). Shriveling occurs followed by defoliation resulting in yield losses.

Figure 19: Brown rusty spots covering both surfaces of leaves

(Source: Infonet-biovision.org)

Management

Plant early using certified seeds. Practice crop rotation with non-legumes for a period of 2-3 seasons. Uproot and destroy severely affected plants, including weeds and volunteer crops by burning or burying them deep. Do not walk through your field during wet weather to prevent the spread of the disease from one plant to another. Prevention can be done by spraying copper based products such as copper oxychloride (cuprocaffaro micro 37.5 at a rate of 50 gm/20 litres water or Isacop 50WP at a rate of 60 g/20 litres of water) once initial symptoms are observed.

3.6 Major Weeds affecting Green gram Production

Symptoms

Weeds cause losses in green gram production through competition leading to losses of up to 100% experienced where left uncontrolled. Weeds affecting green gram include couch grass, *Tagetes minuta, Bidens pilosa* , wondering jew, gallant soldier, *Oxalis* spp etc.

3.6.1 Couch grass *(Cynodon dactylon)*

Symptoms

It is a spreading perennial grass with vigorous mat-forming stolons (Figure 20). It reproduces and spreads mostly by means of rhizomes but also propagates by seed. This grass is considered as one of the most serious weeds in the world.

Figure 20: Couch grass *(Cynodon dactylon)*
(Source: Charles T. Bryson, USDA)

Management
Couch grass should be controlled before planting green gram, since it is not be possible to grow a profitable green gram crop in a couch grass dominated field. Plough then harrow with a tooth harrow during the dry season in order to uproot the rhizomes and expose them to dry in the sun completely on top of the soil. If possible, collect and burn dry rhizomes. Burning them will increase the success of couch grass control. Introduce shade producing cover crops, within a crop rotational system. Post emergence herbicides that control grass weeds such as Lenuron or Pendimethalin based products may be used before planting green gram.

3.6.2 Mexican marigold *(Tagetes minuta)*

It is present in tropical and subtropical land and in every crop in those countries (Figure 21). It is common in East Africa and is occasionally troublesome as a weed of arable land and perennial crops.

Figure 21: Heavy production of seeds make this weed a troublesome weed
(Source: Infonet-biovision.org)

Management

Mexican marigold should be controlled before flowering. The weed may be managed through weeding before seedling, mulching and growth cover crops. Where flowering/ seeds have occured, burning them will increase the success of control. In addition introduction of shade within a crop rotational system helps in smothering this weed. Plants may be managed through weeding and planting cover crops.

3.6.3 Blue Morning Glory *(Ipomoea indica)*

Symptoms

This is a twining and climber growing plant that grows up to 15 m high, but sometimes attaches on low vegetation or creeping along the ground. Stems are fairly densely covered. (Figure 22). Occasionally the plant exudes a white milky sap when broken. The alternately arranged leaves (5-18 cm long and 3.5-16 cm wide) are borne on stalks (petioles) 2-18 cm long. They range from heart-shaped (cordate) to three-lobed and have pointed tips. Both leaf surfaces are softly hairy, and especially the undersides.

The plant has funnel-shaped (tubular) flowers that are bright blue or bluish-purple in colour with a paler pink or whitish-pink central tube.

Figure 22: Creepy and twining plant that can be a climber or creeper on the ground
(Source: Infonet-biovision.org)

Management

The weed should be managed at an early stage before fully establishing and spreading during weeding. Plants can be hand pulled and roots dug out roots (all year round). Roots and stems should be buried deeply to avoid sprouting.

3.6.4 Angel's Trumpet (*Datura metel*)

Symptoms

They are shrubs growing upto 1.4 m tall and somewhat variable in appearance. Its stems are slightly furry, with dark violet young shoots. The plant has hairless leaves, oval to broad oval, smooth and are often dark violet in colour. Its flowers are immensely varied, and can be single or double. Flower colour ranges from white to cream, yellow, red, and violet. They are pleasantly scented particularly in the night (Figure 23).

Figure 23: Shrubby deep rooted weed

(Source: Infonet-biovision.org)

Management

This weed can be managed through weeding, mulching and growth of cover crops. Plants should be cut and roots buried deeply. The remaining plant material left to rot down on site. Burning them will increase the success of control.

4 POST-HARVEST HANDLING AND MANAGEMENT

Smallholder grain farmers in Kenya face two key interrelated challenges after harvesting their crop:

(i) Poor grain handling and management results in 30% of post-harvest losses. This impacts negatively on national shortage in food supply. These losses are believed to be one of the major reasons why Kenya continues to be insufficient in food supply even when crop yields and land under cultivation have been increasing.

(ii) Marketing of grain at low prices, forcing households to buy grains for family consumption when prices increase. This is due to lack of knowledge on appropriate handling and storage methods so as to sell the grains during the off season at higher prices.

The component on postharvest management and marketing will support farmers in securing high returns from investments on grain productivity enhancement (Component 1 of KCEP) through:

(i) Adoption of improved on-farm grain handling practices to minimise post-harvest losses;

(ii) Enhanced access to profitable grain markets, enabling marketing of produce at more favourable terms. Activities include, investment in community storage facilities to allow target farmers stock their produce to attract wholesale buyers and wait for favourable terms of trade. This will enable farmers to leverage their stock for credit access.

The expected outcomes of this component are that target groups will be supported in:

(i) Reducing post-harvest losses from the current estimated 30%, to industry accepted levels of below 5%; and

(ii) Using certified warehouses to bulk and sell their produce at a price 30% higher than prevailing farm gate prices.

To achieve these, management strategies for controlling postharvest losses are recommended.

4.1 Postharvest Losses

Post-harvest period is the duration between physiological maturity of a crop and the time for its final consumption. Post-harvest loses refer to the degradation of quantity and quality of a food product from harvest to consumption (Figure 24). Food losses occur when edible dry matter or nutritional value that was originally intended for human consumption is reduced. The losses affect farmers globally thereby reducing profitability. It is estimated that food losses of up to 30 % are attributed to poor post-harvest management, translating to more than US$4 billion loses per annum.

Postharvest loses are attributed to improper handling, biological spoilage, insects, birds and rodents. These loses are common in developed countries and are a concern to farmers and those involved in the selling of food products. In cereals and pulses, deterioration occurs with increase in moisture levels and improper storage. To address these, management strategies for controlling postharvest losses are recommended.

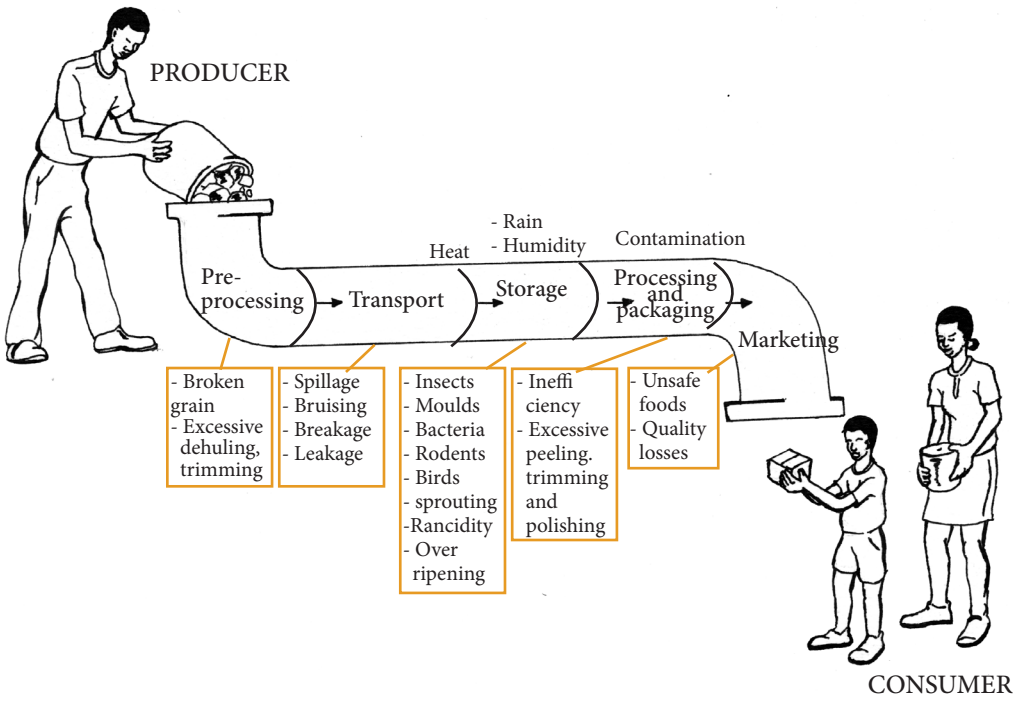


Figure 24: The Food pipeline

(Source: http://www.fao.org/docrep/w0078e/w0078e04.htm)

4.2 Quality Standards for Green gram in Kenya

Kenya has put in place quality standards for green gram (Table 2). The rejected grade of green gram are those that are sour, weathered, insect damaged, contain insect webbing or animal filth, with unknown foreign substance, broken glass or metal fragments. These are regarded as unfit for consumption.

Table 2: Specific requirements for grading dry green gram for human consumption

Characteristics		Maximum Limits			
		Grade 1	Grade 2	Grade 3	Method of test
Moisture % max m/m		14.0	14.0	14.0	ISO 24557
Purity % max m/m		99.0	99.0	99.0	ISO 605
Defective, % max m/m		2.0	4.0	6.0	
Immature grain % max m/m		2.0 %	3.0	4.0	
Contrasting classes		0.5 %	1.0	2.0	
Classes that blend max % m/m		5.0 %	10.0	15.0	
Germination, excluding hard seeds		90 %	n/a	n/a	
Sprout test		Suitable	n/a	n/a	
Foreign material, % max m/m	Organic	0.65	0.65	0.65	
	Inorganic	0.25	0.25	0.25	
	Filth	0.1	0.1	0.1	
Other edible grains% max m/m any edible grain (including oilseeds) other than green gram.		0.1	0.5	3.0	
Insect/pest damaged % max m/m, grains per cent by count clean-cut weevil bored.		1	2	3	
Total Aflatoxin (AFB1+AFG1+AFG2), (ppb)		10			ISO 16050
Aflatoxin B1 only, (ppb)		5			
Fumonism, (ppm)		2			AOAAC 2001.04

Source: Green gram Handbook, Sahelian Solutions Foundation

5 POSTHARVEST SYSTEM FOR DRY Green gram IN KENYA

The postharvest processes of green gram are described below:

5.1 Harvesting

During harvesting, proper care should be taken to minimize quantitative and qualitative losses. The harvested green gram should be kept separately from one variety to another to ensure true to type variety (grains).

5.1.1 Time of harvesting

Harvesting should be done at the right time that is at maturity and when 95 % of the pods have turned black and dry (Figure 25). At this stage, the pods are thin, brittle and prone to shattering during harvest hence a problem during harvesting. Harvesting before the maturity of crop, usually results in lower yields, higher proportion of immature seeds, poor grain quality and more chances of infestation during storage. Delay in harvest would lead to shattering of pods and infection by diseases, pests and other losses caused by birds and rodents. Avoid harvesting during adverse weather conditions such as rains and overcast weather.

Figure 25: Green gram crop with pods turning black for harvest

5.1.2 Method of harvesting

This is done in 2 to 5 hand-pickings at weekly intervals. Pick individual pods, or uproot the whole plant and dry it for about 2 days, prior to threshing and cleaning. Use the right kind of harvest equipment (sickle). The harvested bundles should be kept in one direction to ensure efficient threshing.

Note: In some varieties, pods start by drying at the base of the fruiting branch rather than on the top.

5.2 Drying

Dry the pods until they are ready for threshing (Figure 26). The harvesting bundles should be stacked in a dry, clean place to facilitate circulation of the air. They may also be kept on the threshing floor, if the weather permits. Following threshing, drying the grain for 2 to 3 days under the sun is recommended to lower the grain moisture content.

Drying the green gram well before storage avoids attack by bruchid weevils. Adding Neem leaves or actellic supper (50 g to one 90 kg bag) protects against bruchids.

Figure 26: Dry pods ready for threshing

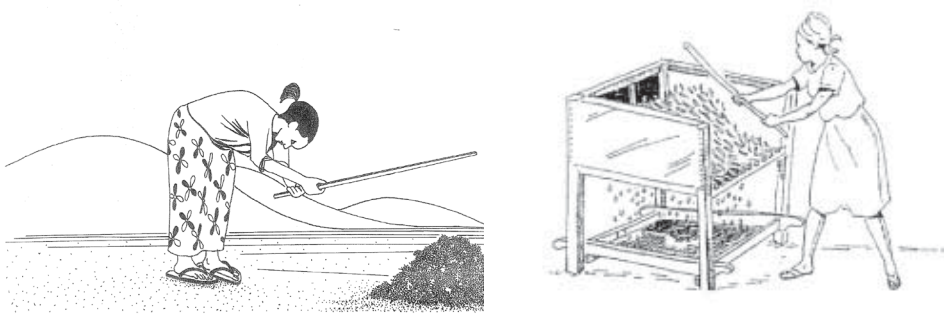
5.3 Threshing

Threshing green gram should be done when the pods are dried. If threshed immediately after harvesting, the seeds will be damaged due to high moisture content. Dry pods can be threshed on a threshing rack. This protects them from damage (broken or cracked grain) and dirt and prevents it from scattering. A threshing rack consists of wooden strips arranged on a platform with a wire mesh tray on the bottom to catch the threshed grain Figure 27 (b).

A polythene paper can also be spread to avoid dirt and foreign materials. Threshing is done using either mechanical or manual methods. Mechanical methods include the use of a pulse thresher, which is a faster and easier method. Manual threshing is done by hitting the pods inside a bag with a strong stick or when placed on a tarpaulin mat Figure 27 (a).

5.4 Winnowing and Sorting

Dry green gram grains are winnowed to remove chaff, dust, foreign matter such as stones, broken grains, shrivelled, mouldy, insect damaged, rotten discoloured or faded, and any remaining plant parts grains. Winnowing is then done using a winnowing tray (*'uteo'*) to separate the dry grain from the soil matter before sorting (Figure 28). Sorting should be properly done as this attracts a better price than unsorted green gram grains.



(a) (b)

Figure 27 (a) and (b): Threshing dry green gram manually on a mat or on threshing rack

Figure 28: Winnowing of threshed green gram grains

5.5 Drying of threshed green gram grains

After threshing and winnowing, the grain must be re-dried. It is important to protect the grain from dirt, rain, insects and other animals. Dry the threshed grain on mats or wire mesh trays on a raised platform.

5.5.1 Determining dry grain

To determine that the green gram grains are dry enough, they can be tested by crushing a few grains with the teeth or pinching with fingers (Figure 29). If the seed crushes easily, then that is an indication that the moisture content is still too high and the harvests should be further dried.

Use of electronic meters operating on dry cells or electricity can be utilized to determine the moisture content (Figure 30). These moisture meters are quick, portable, simple to use and fairly accurate. The meters are very expensive for smallholder farmers, and would normally be used at warehouses and by farmers' groups that handle a lot of grain. However, the extension staff have been provided with the meters to help farmers determine if safe moisture content (≤ 12%) is achieved before storage. A sample size of about 150 grams

of the grains is scooped with a hand and poured into the moisture meter then closed. The device is given a few seconds to do the detection of moisture and temperature. The digital electronic machines will display the readings on the screen once the detection is over. The recommended grain moisture for green gram should be 12% or below for longer storage.

A more objective approach is to use the '***salt method'***. This is quick and easy but will only indicate that grain is above or below 15% moisture content (Table 3). Dry salt will absorb moisture from grain legumes. This principle can be used to help determine whether a grain sample has a moisture content of above or below 15%.

The salt must first be dried by spreading it out on some plastic sheeting in the hot sun and leaving it for at least 3-4 hours until it is hard. It should be turned at intervals during this time. It can also be dried in an oven. The dry salt should be placed in a sealed container until it is ready for use.

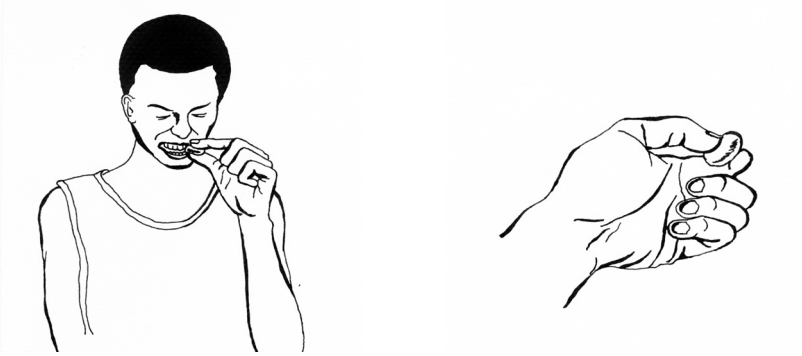


Figure 29: Checking when the grains are dry for threshing, using the teeth or pinching with fingers

Figure 30: Multi-grain moisture tester for the detection of moisture content in grains

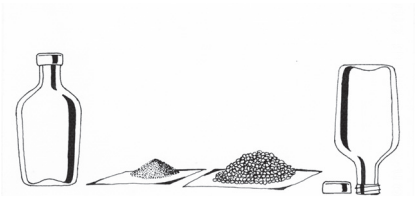
(Source: http://www.ruralking.com/dickey-john-mini-gac-grain-moisture-tester-minigac1.html)

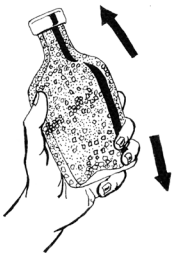
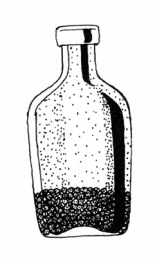
5.6 Transportation from field

The harvest can be transported on headloads if the homestead is not far from the market, while larger quantities are transported by pick-ups, bicycle, motor bikes, wheel burrow and oxen or donkey carts (Figure 31).

Figure 31: Movement of harvested crop from the field to the homestead on oxen

Table 3: The 'salt method' of checking grain moisture content

	**Materials required** - A clean dry glass bottle of about 750 ml capacity, with a cap that makes it airtight. - Some common salt - 250-350 g of the grain to be tested
	Take one sample (a handful is enough) from the middle of each bag of green gram grain. It is best to remove a sample using a special instrument called a sampling spear.
	Make sure that the jar you are using is clean and completely dry.
	- Fill one third of the dry bottle with the grain sample (250-300g). - Add the salt in the jar (enough salt to fill up a quarter of the jar). - Close the bottle tightly with its cap.

	- Shake the bottle vigorously for 1 minute to mix the salt and grain. - Allow the grain to settle for about 15 minutes.
	- If after 15 minutes the salt sticks to the side of the bottle then the moisture content of the grain is above about 15% and so the grain is not safe for storage. - If the salt does not stick to the bottle then the moisture content is below 15% and so is safe for storage.

5.7 Storage of green gram

Adequate storage measures are to be adopted for green gram for longer or shorter storage duration either for consumption or as seed for sowing during the next cropping season. This is the most important stage in overall crop protection otherwise all efforts put while raising the crop would go in vain.

Green gram with a moisture content of 12% and below can be stored in regular bins, fumigated to control weevils. Grains with a moisture content above 12% can be dried under the sun. The storage structures should be well ventilated/aerated stores and free from moisture. They should be leak proof to avoid dampness, clean and disinfected. Dusting the grains is also recommended prior to storage. Several structures can be used depending on the quantity of green gram to be stored. These include covered containers (tins), drums, pots, sealed containers or bags (Figure 32). Gunny bags can also be used (Figure 33).

Figure 32: Storage of dry green gram in air tight storage containers and hermetic bags

Figure 33: Gunny sack for the storage of dry green gram, Courtesy: Karanja (2016)

Large structures such as stores and barns are also other storage facilities where grain may be stored while packages in bags as shown in Figure 34.

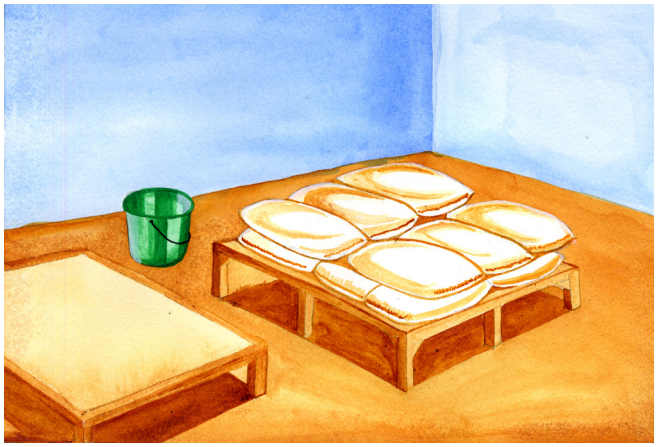


Figure 34: Storage of green gram in a large structure

5.7.1 Precautions during storage

a) Use of hermetic bags does not guarantee long term storage since it is vulnerable to storage pest hence requires complementary treatment of the grains as a safeguard.

b) Do not mix the newly harvested seed with stocks from previous harvests. Store the bags at least one metre away from the walls and on a raised platform.

c) Store the bags in a non-leaking storehouse to avoid contact with moisture.

d) The store should be clean and well ventilated.

e) Stored green gram seed should be placed out in the sun occasionally (once every month) in order to reduce moisture content and to kill off pests.

f) Green gram seeds for the following season's planting can be mixed with dried leaves of marigold, tephrosia, neem or any other locally tried plant, in order to keep storage pests away.

g) During storage the grains can be dusted by the chemicals including Actellic dust, Sumi combi, Skana super and blue cross following manufacturers' application manual.

5.7.2 Storage pests

Bruchids and weevils are major storage pests for green gram and pulses in general. Before storage, dust the green gram with Actellic at rate of 50 g per 90 kg bag. Store them as dry as possible in air-tight bins, drums or well secured gunny bags.

6 MARKETING OF DRY GREEN GRAM

6.1 Transportation to the market

Following harvest, the grains are transported to a shed where cleaning, grading and bagging is done. No specialized transport is required for green gram, however, movement should be safe. Transportation of green gram is mainly done by head loads, bullock or camel cart, tractor-trolleys, trucks, railways and ships depending upon the availability of transportation means, quantity of the produce and the stage of marketing (Figure 35).

Figure 35: Transportation of green gram grain harvest to the market using various modes

6.2 Packaging

The packaging materials used for green gram include airtight bins, storage silos, hermetic bags, Jute bags, polythene impregnated jute bags, cloth bags or ordinary 90kg bags. It is recommended that packaging material have the following qualities:

a) It must protect quality and quantity.

b) It must prevent spoilage during transit and storage.

c) It must have information about quality, variety, date of packing, weight, and price.

d) It must be convenient to stack.

e) It must be food-grade packaging materials.

6.3 Marketing Strategy

6.3.1 Grading

Grading green gram as shown in Table 2 above is beneficial to the farmers, traders and consumers. It enables farmers to have quality in their produce leading to high demand, thereby attracting high selling price (Figure 36). Ungraded beans are the ones which do not fall within the quality standard groups while rejected beans are those dusty and materially weathered (Table 2).

Packaging and bulking should be done in 90 kg polythene bags, checked and certified. During packaging, make sure the scales are working and that they have a recent calibration (according to regulations).

Figure 36: High quality grain fetch better markets

6.3.2 Promotion

Promotion of green gram is done through exhibitions at platforms and events that bring various actors within the value chain. These include farmer field days, and market events that bring together input suppliers, traders, extension service providers, financial institutions, private companies and government agencies. During these events, product samples are presented and demonstrated to potential buyers.

Market service providers include:

(i) Financers (banks, micro-financiers and SACCOs)

(ii) Market information services

(iii) Transporters

Green gram marketers include:

(i) Traders (retail and wholesale)

(ii) Exporters

(iii) Vendors (collectors, assemblers)

(iv) Supermarkets

(v) Farmer associations / groups

Based on the quality and quantity of produce, cooperatives are linked to a category of buyers including:

(i) Exporters - such as Capital reef, Mombasa and other exporting companies in Nairobi.

(ii) Intermediate buyers - such as Kamili, spice world.

(iii) Local buyers - such as Daystar, Amkem investment.

7 PROCESSING OF DRY Green gram

7.1 Value addition and utilization

Mature seed/grains or flour are used in a variety of dishes such as soups, porridge, snacks, or bread. In Kenya it is most commonly consumed as whole seeds boiled with cereals such as maize or sorghum. Green gram are utilized in several food products, as whole seed or in processed form. The boiled seeds can also be fried with meat, vegetables and eaten alongside with “ugali” and “chapati”. Wet or dry milling can be done, and the flour can be further processed for addition into bread or biscuits. Grains can also be dehusked and split (Figure 36), or can be polished to give the dehusked and split grains a small quantity of oil treatment. The plant residues or weathered or cracked seeds are fed to livestock and fresh vines used as fodder, green manure or used as a cover crop.

Figure 37: Split green gram

In preparing pulses for consumption, soaking in water is recommended. This can be followed by cooking or fermentation.

Green gram sprouts are utilized as salads. Once beans are pre-germinated, they are mixed with other vegetables because they are a good source of vitamins. Boiling green gram alone and eaten along with Ugali, cooked rice and/or substitute animal proteins. Green gram flour can be used as accompaniments for making snacks such as bhajia, or incorporated into baking snacks.

Examples of green gram recipes are described below:

Green gram sprouts

1. Soak a cup of green gram in water for at least 12 hours.
2. Wash well and put it in a muslin cloth and tie it like a bundle.
3. Hang it for another 10 to 12 hours in a warm place.

4. When you open the bundle you will see all the grams are sprouted well. (If you are living in a cold place, then it will take more time and you can sprinkle little water over the bundle and keep it for more time. Alternatively you can put the soaked gram in a hot pack and keep it).
5. Green gram sprouts are consumed directly with lemon and salt as a healthy snack or added to salad.

Green gram (Ndengu) stew

1. Sort green gram to remove sand and other foreign matter. Rinse ½ cup Green gram grains a couple of times and then soak in enough water for an hour.
2. Boil the soaked grains in enough water until soft and can be easily mashed
3. Chop 1 medium onion, 1 large tomato and 1 to 2 green chillies crush the ginger and garlic to a paste in the mortar-pestle.
4. Heat 2 table spoonful oil in a pan and then add the chopped onions. Saute the onions till light golden.
5. Add 1 tea spoonful ginger-garlic paste and chopped green chillies. Stir and saute till the raw aroma of ginger-garlic goes away.
6. Add the green gram 2 ½ to 3 cups water and salt to taste. Stir very well.
7. Cover and simmer for 10 to 12 minutes.
8. Serve hot with rice, chapati, Ugali, cassava or sweet potatoes.

Figure 38: Fried green gram, boiled green gram as a salad and potato snack (Bhajia) made from green gram flour

8 TAKE HOME MESSAGES

The main points to remember in green gram production are:

- Ensure timely land preparation and timely planting to take advantage of rain and control diseases.
- Plant clean certified seeds to prevent seed-borne diseases.
- Use disease free vegetative propagated planting materials from reliable dealers.
- Scout once to twice a week for pests and diseases for timely management.
- Uproot and destroy severely infected plants by burning.
- Maintain a weed free field to reduce competition and alternative hosts for diseases.
- Ensure timely harvesting and proper post-harvest handling for long shelf life.

The main points to remember in green gram crop protection are:

- Plant clean seeds for high germination, uniform growth and maturity.
- Do timely land preparation and timely planting to take advantage of rain and control diseases.
- Plant crop in rows for proper population for optimal yield and ease of pest and disease control
- Maintain a weed free field to reduce competition and disease build up.
- Timely harvesting and proper post-harvest handling for long shelf life.

The main points to remember in green gram postharvest management are:

- Timely harvesting should be done at a proper maturity stage to ensure they are dry, optimum grain quality for consumer acceptance.
- Delay in harvest will lead to shattering of pods and infection by diseases, pests and sometimes seeds vigour will be lost due to untimely rains.
- Ensure moisture content is below the recommended levels by drying the harvested bundles under the sun, and stack in a dry and clean place to facilitate circulation of the air around.
- Keep green gram separately from one variety to another to get true to type variety (grains).
- Apply pest control measures during storage by treating or dusting the grains with appropriate chemicals.
- Ensure proper storage techniques by storing in insect- and rodent-proof bags to avoid infestation.
- For long shelf-life, storage areas should be kept clean and well-ventilated.

9 REFERENCES

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Available extension manuals cover basic cereals (maize, millet and sorghum), pulses (beans, cow peas, pigeon peas and green gram), soil climate smart agriculture and Farming as a Business as listed:

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3. Green Gram Extension Manual
4. Pigeon Pea Extension Manual
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Kenya Agricultural and Livestock Research Organization
P.O Box 57811-00200 Nairobi, Kenya
Tel. +254 709 104 000
www.kalro.org