THE KENYA CEREAL ENHANCEMENT PROGRAMME (KCEP)

ADAPTATION AND DISSEMINATION OF AVAILABLE TECHNOLOGIES FOR SMALLHOLDER ADOPTION

KALRO-KCEP COMMON DRY BEANS PRODUCTION TRAINING AND EXTENSION MANUAL

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Overview

The purpose of this module is to train extension officers, lead farmers and service providers on bean production along the value chain, with enhancement of gender participation for improved livelihoods.

Training Objectives

1. To train the extension officers and other stakeholders to enhance the productivity on beans
2. To enhance and empower the capacity of farmers on the bean value chain for food security.
3. To increase commercialization of beans.
4. To promote gender inclusion and participation in bean production along the value chain.

Outcomes

1. The extension officers and other stakeholders trained for enhanced productivity of beans
2. The capacity of farmers on the bean value chain for food security enhanced and empowered
3. Commercialization of beans increased
4. Gender inclusion and participation I bean production along the value chain promoted.

Abbreviation/Acronym

AEZ	Agro-ecological zones
MoA	Ministry of Agriculture
MoALF	Ministry of Agriculture Livestock Development & Fisheries
KALRO	Kenya Agriculture and Livestock Research Organization
KARI	Kenya Agriculture Research Institute
GLP	Grain Legume Research Project
Kg	Kilogram
Gm	Grammes
Ha	Hectare
MT	Metric tonne
°C	Degrees Celcius

Introduction/ Background

Beans are leguminous annual crops that originated in Central America. In Kenya beans are the most important pulses. They rank second to maize in importance as food crops. The crop provides a cheap source of protein, and is rich in the essential amino acid element lysine which is found in fewer quantities in maize and other grains (du Plessis *et al.*, 2009). The production is mainly at subsistence level by small-scale farmers with limited commercialization. Beans can be grown in pure stand or intercropped with other crops.

1.1 Ecological requirement

Ecological factors considered include altitude, rainfall and soil/ambient temperature.

1.1.1 Altitude

The crop grows from an altitude of 600 to 2700m.a.s.l. In Kenya beans grow best in altitude above 600m.a.s.l because below this, high temperatures cause flower and pod dropping leading to poor fruit set and hence reduced yield. There are also high incidences of diseases like; bean rust, and bean anthracnose below this altitude. Altitude between 900-2100 is ideal. Beyond this altitude there is the problem of frost damage.

1.1.2 Rainfall

The crop is mostly cultivated under rain fed conditions. It requires a minimum of 400 to 500 mm of rain during the growing season, but an annual total of 600 to 1500 mm is considered as ideal. Beans require well-distributed rainfall. Too much rain and long spells of drought lead to reduced yields. Beans are not drought tolerant hence they require moist soil throughout the growing period. Excessive rainfall during flowering causes flower drop and increased disease incidences. Medium rainfall is thus required during flowering and pod set. Dry weather is required during harvesting.

1.1.3 Soil type

Beans grow on a wide range of soil types but best growth is obtained in well-drained soils with high organic matter. Beans grow well in soils with a depth of at least 90 cm that have no mineral and water deficiencies. With sandy soils, problems of low fertility or nematode damage can occur. Beans can grow in soil with a pH range 5.0- 7.5. Below pH 4.5, plant growth is impaired through limitation of development of the Rhizobium bacteria that are responsible for the nitrogen fixation. The crop also performs poorly in compacted, too alkaline or poorly drained soils.

1.1.4 Temperature

The bean crop thrives in a warm climate at optimal temperatures of 18 to 24 °C. The maximum temperature during flowering should not exceed 30 °C. High temperatures during the flowering stage lead to dropping of flowers and a low pod set, resulting in yield loss. Day temperatures below 20 °C will delay maturity and seed formation causing pods to mature empty. The crop is very sensitive to frost, and minimum temperatures should not go below 13 °C.

Key Operations

1.2 Pre-field operations

1.2.1 Varietal Selection

There are many varieties recommended for five KCEP implementing counties in Western region.

Table 1: Bean varieties

Variety name/code	Owner(s)	Maintainer Source Production and seed	Optimal altitude Range (masl)	Duration to maturity (months)	Grain Yield (t ha-1)	Special Attributes
Mwitemania (GLP x 92)	KALRO/KSC	KALRO/KSC	900-1600	2-3	1.2-1.5	Drought tolerant
Rosecoco (GLP 2)	KALRO/KSC	KALRO/KSC	1500-2000	2 - 3	1.8 - 2	High yield, Wide adaptation. Attractive seed colour Good taste
Mwezi Moja (GLP1004)	KALRO/KSC	KALRO/KSC	1200-1600	2 - 3	1.2-1.5	Good performance in dry areas Early maturity Tolerant to drought and bean fly
Canadian Wonder (GLP-24)	KALRO/KSC	KALRO/KSC	1200-1800	3 - 3.5	1.3-1.8	Moderately resistant to angular leaf spot
GLP-585 Red haricot	KALRO	KALRO	1500-2000	2.5 - 3	1 - 1.5	Suitable for high rainfall areas Resistant to bean common mosaic virus
KK 15	KALRO	KALRO-Kakamega	1200-1800	2 – 3	1.5-1.8	Tolerant to root rot
KK 8	KALRO	KALRO-Kakamega	1200-1800	2 – 3	1.5-1.8	Tolerant to root rot
KK 22 (RWR 719)	KALRO	KALRO-Kakamega	1500-1800	2.5 - 3	1.8-2	Tolerant to root rot
Chelalang'	Egerton	Egerton	900-1600	2.5 - 3	1 - 1.5	High yielding
Ciankui	Egerton	Egerton	900-1600	2.5 - 3	1 - 1.5	High yielding

1.2.2 Seed Selection and Treatment

For successful production of beans, use certified seed. This production cost factor is slight when compared to probable yield losses due to disease or poor stand. Low-quality causes poor and uneven stand, resulting in uneven maturity, harvesting problems and yield losses.

Benefits of using certified seed are:

- High in germination percentage.
- Guaranteed true to type and ensures uniformity.
- Guaranteed free of weed seeds and foreign matter.

Farmers may select from his stock of bean harvest. Beans should be well sorted and only the best should be used for planting.

Good quality bean seed has the following properties:

- A high germination rate;
- Pure: all seeds are of the same variety and of the same size;
- Clean: not mixed with foreign matter such as stones or dirt, or other seeds;
- Not damaged: broken, shriveled,, or insect damaged;
- Not rotten or mouldy, discolored; may be diseased.

1.2.3 Seed Dressing

Selected seeds must be dressed with insecticides such as Thiram or Fenasan D at the rate of 3g per kg of seed or Aldrin 2.5 % at 5g/kg seed. This protects them against pests and fungal diseases. Treated seed is unfit for human consumption and should be planted immediately. Do not inhale or allow contact with the skin, wash hands with soap immediately after handling treated seeds.

1.2.4 Rhizobial Inoculation

The legume crops have a unique capacity of utilizing atmospheric nitrogen through nitrogen fixing bacteria in the root nodules. However the naturally occurring (local) strains of *Rhizobium* may not be efficient. It is, therefore, recommended to artificially inoculate the seeds with an appropriate strain of *Rhizobium*. The artificial inoculation is cheap and it increases the efficiency of the plant to fix nitrogen.

About 60 g of molasses are dissolved thoroughly in half-litre of water. To this solution, a culture packet is mixed so as to form slurry. A 10 kg seed (free from dust) is mixed thoroughly with the slurry of the culture with clean hands taking care that all the seeds are equally coated with the product. The treated seed is spread on a polythene sheet or a clean cloth and placed in the shade to dry. The coated seeds are sown the same day and immediately covered with soil so as to avoid direct exposure of the coated seeds to sunlight.

Inoculum contains bacteria that must be kept alive. All packages of inoculum have an expiration date. After this date, the bacteria may not be alive and the inoculum should not be bought or used. Heat and direct sunlight kill bacteria in stored inoculum, even while packaged. Since a short period of heat can reduce the number of live Rhizobia, the package should be kept in a cool place and out of direct sunlight - even when taking it home from the store (keep it off the dashboard). The preferred storage place for inoculum is the refrigerator (do not freeze). Inoculant should not be mixed with either pesticide or fertilizer.

1.2.5 Testing for germination

While the germination (%) of seeds is supposed to be on every packet, farmers often get non-germinating seeds and this results in disappointment after planting. It is therefore advisable to conduct a simple germination test. This is done through taking a few bean seeds (e.g. a table spoonful) and soaking in water overnight. The soaked seeds are then wrapped in polythene bag and 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 not. This test also informs the farmers on whether to over seed in the planting

holes. If the seed has 60% germination rate compared to one with 90% germination rate, you will need to plant more seed of the former than the latter

1.2.6 Site selection

To ensure high bean yields, select highly productive land suitable for bean production. For example, you should avoid steeply sloping land, land that is near a swamp, very sandy soil and areas with shallow surface soil and a lot of couch grass. Look for signs that indicate high or very low soil fertility.

1.3 Field Operations

1.3.1 Land Preparation

Land preparation should be done early enough so that the field is free of weeds and ready for planting at the onset of rains. Seedbed should have fine tilth. The seedbed must be deep, level and firm because this ensures better surface contact between the seed and the soil, increasing the absorption of moisture. A level seedbed also facilitates planting to a uniform depth.

1.3.2 Soil Fertility

Organic fertilizers

The use of 15-20 tons/ha of farmyard manure is highly recommended especially in areas where soils are low in organic matter content. Well-decomposed animal manure or compost should be applied under dry conditions, and then mixed with the topsoil. This should be done about one week prior to planting.

Inorganic fertilizers

About 200kg DAP or 23:23:0, or Mavuno per ha. The fertilizer should be thoroughly mixed with soil before covering the seed.

1.3.3 Planting

Planting time

The most suitable planting date is determined by the following factors

- Correct soil temperature.
- Probability of heavy rain which may lead to soil crusting and restrict seedling emergence.
- Possibility of high temperatures later in the season, which may cause blossom drop.
- Length of the growing season (high temperatures during flowering, rain during harvest and frost damage should be avoided).

Beans should be planted at the onset of rains. Delay in planting may result in reduced yields or crop failure.

Spacing

Beans in mono cropping should be planted in rows at 50 cm x 10 cm (one seed per hill). The soil texture and its moisture content determine planting depth. Generally the seeds are placed 2.5 to 5.0 cm below the soil surface. If animal drawn implements will do weeding then rows

should be spaced at least 60 cm. In intercropping, plant maize at the recommended spacing for the agro-ecological zone. Interplant two equidistant bean rows between the maize rows at 15 cm within the row, one seed per hill. The other alternative is to have one bean row between maize rows, two seeds per hill.

Seed rates

The amount of seed required for a given area will vary from variety to variety depending on the size of the seed. The bigger the size of the seed the more the quantity of the seed required. It ranges between 25-50 kg/ha.

1.3.4 Weeding

Beans should be kept free from weeds. Timely and thorough weeding is absolutely essential. This is achieved by a first weeding 2-3 weeks after emergence followed by a second weeding 3 weeks later (just before flowering) in mono-cropping. In intercropping, one weeding 3 weeks after planting may be sufficient except in high rainfall areas where a second selective weeding 3 weeks later may be necessary. Care should be taken to avoid damaging the shallow roots especially during the first weeding. Avoid cultivation during flowering time to avoid flower shedding and when the field is wet to avoid spread of diseases and soil compaction. Herbicides can be used to control weeds for example Dual Gold or Basagran.

1.3.5 Crop rotation

This practice is recommended to avoid pest and disease build up. Rotation is mainly done with cassava, maize, sorghum or any other non leguminaceae crop.

1.3.6 Controlling Pests and Diseases

Diseases and pests may have been partially responsible for the unstable production that has been experienced in the past. Incidence and severity vary between seasons because of environmental and management practices. Integrated disease and pest management, using all suitable control measures, is recommended. The bean pests and diseases and their control measures are as given in Table 1 and Table 2.

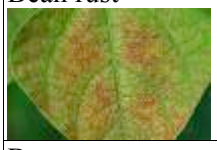
Pests

Table 1: Bean Pest types, Symptoms and Control Measures

Name	Symptom	Control
Cut worm 	Cut young seedling near the ground, Black larvae found in the soil near the cut plant; The larvae curls up when disturbed.	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.
Bean fly 	Dying of the taproot; Young seedling wilt and die within a short time; older plants become stunted; presence of small shiny black flies with clear wings; early signs of attack are punctures on the primary leaves around the base; stem thickens and usually crack at the soil level.	Early planting; destroy volunteer crops; Crop rotation; seed dressing; plant tolerant varieties.
Bean aphid 	Soft black insects found clustered around the stem, young shoots and pods; they suck plant sap and causes stunting; in severe cases plants wilt and die.	Early planting; destroy volunteer crops; crop rotation; under heavy infestation spray with insecticide.
African boll worm 	Large roundish holes in the green pods; the caterpillar also feeds on the flowers and terminal buds.	Spray with insecticide as soon as young caterpillars are seen.
Flower Thrips 	Small slender yellow to black insects found concealed in flowers and jump when disturbed; water soaked spots on pods which result in curling of the pods. Flower abortion may occur.	Spray with suitable insecticide.
Bean bruchid 	Infested beans show small dark circular widows on their skins; inside the seed a whitish larvae or pupae can be found.	Dress the seeds with suitable insecticide.

Diseases

Table 2: Bean Diseases, Symptoms and Control Measures

Name/photo	Symptom	Control
Halo blight 	Small watery brown spots on leaves which later become surrounded with yellow ring; the whole leave may turn yellow; on the pods small greasy spots are observed	Crop rotation; field hygiene; use certified seeds; rouge and destroy infected plants; plant resistant varieties
Common blight 	Water socked spots appear on leaves and pods; the spots are much larger than those on hallow blight and occur on the leaf margins	Plant certified seed; rogue and destroy infected plants; crop rotations
Anthracnose 	Sunken dark brown spots on the pods; spots have black orange powder; on the other side of the leaf reddish brown spots may appear on the leaf veins	Use certified seed; crop rotations; field hygiene; seed dressing
Angular leaf spots 	Grey spots appear on the leaves and later turn brown; the spots are enclosed by leaf vein g, the giving the spot typical angular shape; the stem and pods round spots may appear; in severe cases the leaves fall	Use certified seed; crop rotations; field hygiene; seed dressing
Bean rust 	Minute symptoms slightly raised white spots which turn into characteristic rusty reddish brown pustules on leaves; in severe cases stems and pods can be affected and leaves may fall off early	Use certified seed; crop rotations; field hygiene; seed dressing
Bean root rot 	Round discoloration of tap root which later turn brown; yellowing of plants	Crop-rotations; seed dressing, resistant varieties

1.3.7 Harvesting

Dry beans should be harvested when all the pods have turned yellow, but before they have become so dry that the pods begin to shatter or rot away especially in mixed stands. Dry beans have a moisture content of about 50 % at physiological maturity. The beans, however, are only ready for harvesting when the moisture content drops to 16 %, the ideal being 15 %. Seeds may split during threshing when the moisture content is less than 12 %. It is also difficult to clean without further seed split or broken seed coats.

1.4 Postharvest handling

1.4.1 Testing moisture content before threshing, winnowing and sorting

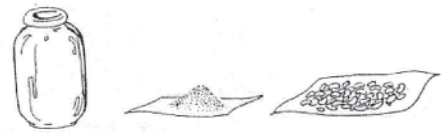
	Before beans can be threshed, they must be dried in the pod. If you start threshing immediately after harvesting, you will damage the seed because it is too moist to be threshed. You should test the moisture of the seed before threshing using your teeth or pinching with your fingers.
	Spread out the bean plants after harvest and let them dry in the sun before threshing. Threshing on the ground or in a gunny bag can easily damage the seed. Broken or cracked seed is more likely to be attacked by insects and mould and may not germinate. Threshing on a threshing rack protects the seed from damage and dirt and prevents it from scattering. A threshing rack consists of strips of wood arranged on a platform with a wire mesh tray on the bottom to catch the threshed seed.
	Winnowing should be done to remove chaff, dust foreign matter such as stones, remove all grains that are broken, shriveled, mouldy, insect damaged, rotten discoloured or faded.

(Source: Soniia, 1998)

1.4.2 Seed drying

After the seed has been threshed, it must be dried again to about 10% moisture content. Protect the seed from rain, insects, animals and dirt. Threshed seed should be dried on mats, plastic sheets or wire mesh trays raised on a platform. Spread the seed thinly on the drying surface to allow air to pass through it. Turn the seed regularly to avoid overheating.

1.4.3 Testing moisture content of grains before storage

	The salt test is also a good way to determine the moisture of threshed seed: For this test you will need a clean, dry jar with a lid, some salt and a sample of bean seed.
	Take one sample (a handful is enough) from the middle of each bag of bean seed. 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.

	Put the salt in the jar (enough salt to fill up a quarter of the jar) and add a sample of seed (enough to fill half of the jar). Put the lid on the jar.
	Shake the jar well and then allow the seed to settle for about 10 minutes.
	If after 10 minutes you can see damp salt stuck to the sides of the jar, the seed is too moist. This means that the moisture is above the required 13- 15%. If the jar is dry and there is no salt stuck to the sides of the jar, the seed is dry.

(Source: Soniia, 1998)

1.4.4 Grain and Seed dressing and storage

Bruchids are major storage pests. Before storage, dust beans with Actellic Super at rate of 50g per 90 kg bag. Store beans as dry as possible in air-tight bins, drums or well secured gunny bags.

1.4.5 Storage

Store the seeds in clean or disinfected bags. Do not mix the newly harvested grain with stocks from previous harvests. Store the bags at least 1 meter away from the walls and on a raised platform. Store the bags in a non-leaking storehouse to avoid contact with moisture. The grains can also be kept in airtight drums or in hermetic bags. However, if seeds are to be used for planting, they should not be stored in airtight containers to maintain viability, gunny bags are recommended. The store should be clean and well ventilated.

1.4.6 Utilization and value addition

The grains are utilized in variable ways;

- Boiling beans-maize mixture to soft (*Githeri*).
- Boiling beans-maize mashing with potato and greens (*mukimo*).
- Boiling beans alone with testa or without and marsh or not and used to eat with *Ugali*, and cooked rice.
- Pre-cooking plus tomato sauce and canned (bean variety Mexican 142).

Take home messages

The main points to remember in bean production 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.
- Keep proper population for optimal yield and reduced disease incidence.
- Maintain a weed free field to reduce competition and disease build up.
- Timely harvesting and proper post harvest handling for long shelf life.
- Prevent and control of pest and diseases in all stages to minimize loss (quantity and quality).

Further Readings

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