THE KENYA CEREAL ENHANCEMENT PROGRAMME (KCEP)

ADAPTATION AND DISSEMINATION OF AVAILABLE TECHNOLOGIES FOR SMALLHOLDER ADOPTION

KALRO-KCEP MAIZE 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 maize production along the value chain, with enhancement of gender participation for improved livelihoods.

Training Objectives

- To train the extension officers and other stakeholders to enhance the productivity on maize.
- To enhance and empower the capacity of farmers on the maize value chain for food security.
- To increase commercialization of maize.
- To promote gender inclusion and participation in maize production along the value chain.

Outcomes

1. Extension officers and other stakeholders trained on maize production.
2. Capacity of farmers for food security along the maize value chain enhanced.
3. Commercialization of maize enhanced.
4. Gender inclusion and participation in maize along the value chain enhanced.

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Abbreviation/Acronym

AC	Acre
AEZ	Agro-ecological-zones
CAN	Calcium ammonium nitrate
DAP	Di-ammonium phosphate
FYM	Farmyard manure
Ha	Hectare
KALRO	Kenya Agricultural and Livestock Research Organization
KCEP	Kenya Cereal Enhancement Programme
KSC	Kenya Seed Company
NPK	Nitrogen, Phosphorus, Potassium
UH	Upper Highlands
LH	Lower Highlands
UM	Upper Midlands
WSC	Western Seed Company
GDP	Kenya's Gross Domestic Product
°C	Degrees Celcius

1 Introduction/ Background

Maize is a staple food and contributes to about 65% of daily per capita cereal consumption. It serves as subsistence and a commercial crop, and grows on an estimated 1.4 million hectares. Maize accounts for more than 20% of the total agricultural production and 25% of agricultural employment. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Maize products include baked, roasted and boiled fresh maize on the cob, porridges, pastes, beer, starch, oil and livestock feed from by-products of fresh and dry maize grain. The stalk provides an important source of livestock feeds as crop residue and silage.

1.1 Ecological requirement

Maize grows across a range of agro-ecological zones and most varieties differ in maturity, resistance/tolerance to pests and diseases.

1.1.1 Altitude

Maize is grown at all altitudes ranging from sea level at the Coast to 2,200 m above sea level. However, if planted in very low or high altitudes poor yields will be realised.

1.1.2 Rainfall

Rainfall requirements vary with different varieties. In general maize will do well in areas that receive 600-900mm of rainfall. The rainfall should be evenly distributed during the growing period. For higher yields, the crop should receive enough rainfall during the first five weeks after sowing and at flowering time. Otherwise any drought at flowering time will interfere with pollination and drastically lower the yields. Dry weather conditions are required during harvesting.

1.1.3 Soil type

Soils should be well drained, well aerated, deep and warm. The best soils for growing maize are silt loam with sufficient nutrients and a pH range of 5.0-7.0. Water logged soils should be avoided because if maize stands in water for more than two days it wither and die off. Soils should be routinely analyzed.

1.1.4 Temperature

The temperature requirements of maize vary with varieties. Cold conditions at high altitude will extend life cycle, whereas high temperatures will expose the crop to much respiration and lower the yields. The optimum temperature for good yields will be 30°C.

2 Key Operations

2.1 Pre-field operations

2.1.1 Varietal Selection

The choice of appropriate maize varieties for a given location is very important because every variety has extensively been tested and recommended based on climatic conditions, soil type, yield potential, resistance to pest and diseases or maturity period among others (Table 1). Some tolerant and resistant varieties include Hybrid 6218 is tolerant to leaf blight, Hybrid 6213 and 6210 are tolerant to grey leaf spot.

2.1.2 Seed selection and treatment

Farmers are advised to use certified seeds and practice best agronomic practices for best yields.

2.1.3 Testing for germination

While the germination percentage (%) of seeds is supposed to be indicated on every sold packet, farmers often get non-germinating seeds and this results in disappointment after planting. Therefore it is advisable to conduct a simple germination test. Counting a 100 seeds of a selected maize variety and put between moist old newspapers does this. After four days of incubation, the germinated seeds are counted and divided by the total seeds and expressed as a percentage. For example, if out of the 100 seeds 85 seeds germinate, germination percent will be 85%. A germination percentage of 85-100% is considered good for the maize seed. In case germination rate is lower, you may increase sowing density correspondingly to ensure appropriate plant density (for example plant 2-3 seeds) per hole.

2.1.4 Site selection

To ensure high maize yields, select highly productive land suitable that is suitable for maize production. For example, avoid steeply sloping land, or near a swamp, very sandy soils, and areas with shallow surface soil and places with couch grass.

Table 1: Maize varieties five KCEP implementing counties in Western Region

Varieties	Source	AEZ where grown	KCEP sites	Maturity (Days)	Yield potential 90 kg bags/acre
H 6213	Kenya Seed Company	Highlands	Trans Nzoia, Nandi, Nakuru, Kakamega Bungoma	160-210	50
H6210	Kenya Seed Company	Highlands	Trans Nzoia, Nandi Nakuru, Kakamega Bungoma	160-210	45
H629	Kenya Seed Company	Highlands	Trans Nzoia, Nandi Kakamega and Bungoma	160-210	43
KH600-23A	Agricultural Development Corporation (ADC)	Highlands		140-175	56
H614D	Kenya Seed Company	Highlands	Nandi, Nakuru and Bungoma	160-210	33
H627	Kenya Seed Company	Highlands	Bungoma	150-210	47
WH509	Western Seed Company	Moist Mid-Altitude	Bungoma	120-180	30-35
WH505	Western Seed Company	Moist Mid- altitudes	Bungoma	120-180	30-35
H516	Kenya Seed Company	Moist Mid altitude	Bungoma		20
PHB30G19	Pioneer Seed Company	Moist Mid-altitude	Nakuru	90-120	30
H517	Kenya Seed Company	Moist Mid-altitude	Bungoma	120-130	32
H624	Kenya Seed Company	Highlands	Nakuru	140-180	32

H6218	Kenya Seed Company	Highlands	Trans Nzoia, Nandi, Nakuru and Kakamega	150-200	56
PANNAR (691)	Pannar Seed Company	Highlands	Kakamega	150-200	25
WH507	Western Seed Company	Moist Mid-altitude	Bungoma	120-130	32
SIMBA61	Seed Company (SeedCo)	Moist Mid-altitude	Bungoma	120-130	32

2.2 Field Operations

2.2.1 Land preparation

A maize farm can be prepared using Conventional CA methods. Conservation Agriculture includes spraying with recommended herbicides and crop residue management. Conventional methods include hands, us of an ox-plough or a tractor. It's important to prepare the land early enough to allow weeds to dry and decompose.

Table 2: Land preparation practices/technologies employed in five KCEP implementing Counties in Western Region

	Land preparation practices/technologies		
County/ Sub-county	**Conventional land preparation:**	**Conventional land preparation-**	**Conservation Agriculture**
1. Bungoma County (Tongaren and Sirisia sub counties); 2. Kakamega County (Lugari and Lukuyani sub-counties); 3. Nandi County (Mosop and Chesumei sub-counties); 4. Trans Nzoia County (Kwanza and Cherangani sub-counties); 5. Nakuru County (Njoro and Molo sub- counties)	Plough twice and harrow once or plough once but at least 3 months before the anticipated time of planting + 2 harrows just before planting	One plough (disc or mould board) + 1 harrow	Use Glyphosate based herbicide at 2 l/acre during fallow and 1.2 l/acre at least 2 weeks before planting.

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2.2.2 Soil fertility management

Soil fertility can be managed through several strategies including, organic fertilizers/manures, and inorganic or chemical fertilizers.

Organic fertilizers/manures

Farmyard manure (FYM) can be applied either alone at a rate of 4 tonnes per acre. When FYM is used in combination with inorganic fertilizers half the recommended rates should be applied.

Inorganic/chemical fertilizers

Fertilizer recommendations are based on different agro-ecological zones and soil types. The main fertilizers used are Di-ammonium phosphate (DAP) at 50kg/acre (50kg bag/acre) (applied at planting), Calcium ammonium phosphate (CAN) at 92kg/acre (2 bags of 50kg each) top-dressed when the plants are knee-high. However, farmers should follow the recommendations agreed during the KCEP validation workshop until further notice.

Management of acid soils

Liming is recommended for acid soils. However, other fertilizers with a liming effect like MEA Mazao (100 kg/acre), Mavuno basal (100 kg/acre) and Mavuno for topdressing (75 kg/acre) are recommended for acidic soils.

2.2.3 Planting

Planting time

The time of planting is a very critical step in maize production. Planting should be done within the first two weeks of the onset of rains. Early planted maize allows the germinating seed to benefit from nitrogen flux effect, warm soil temperatures and good aeration and escape from insect pests and diseases. Maize planting depth ranges from 2.5-5 cm.

Spacing and plant population per hectare

The recommended spacing and planting density of maize for different zones is as shown in Table 3.

Table 3: Recommended spacing and planting density of maize for different zones

Region	Spacing	Density (plants per ha)
Highland	75x25cm 1 plant/hill (pure stand) 75 x 50cm 2 plants/hill (intercrop)	53,333 53,333
Medium	75 x 30cm 1 plant/hill (pure stand) 75 x 60cm 2 plants/hill (intercrop)	44,444 44,444
Dry land	90 x 30cm 1 plant/hill (pure stand) 90x 60cm 2 plants/hill (intercrop)	37,850 37,850

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2.2.4 Weeding

Weeds reduce maize yields by competing for moisture, nutrients, space and light. Weeds are also an alternative host to pests and diseases. The most critical stage of weed competition in the life of a maize plant is during the first four to six weeks after emergence of the crop. The most common practice in weed management are hand weeding and use of herbicides. Some of the recommended practices include: hand weeding that should be done at least three weeks after emergence of the plants followed by a second weeding at knee high. Other recommended approaches include the use of a dense legume cover crop to suppress weeds for example lablab (*Lablab purpureus*), velvet bean (*Mucuna pruriens*) or sunhemp (*Crotalaria juncea*) and desmodium. Farmers can regularly scout their fields and uproot *Striga* weed early enough before the seeds are produced.

2.2.5 Crop rotation

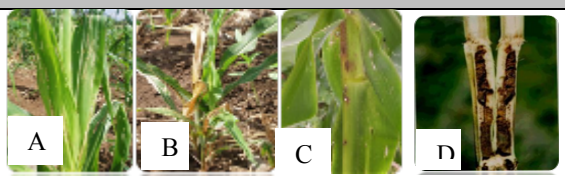
Crop rotation is highly recommended to reduce build-up of maize diseases and insect pests. Rotation is mainly done with beans, cowpeas and peas. Rotating of maize with other cereal crops like sorghum and millet should be avoided, especially in case of Maize Lethal Necrosis Disease (MLND).

2.2.6 Controlling pests and diseases

Diseases and pests are largely responsible for the low maize yields, however, the incidence and severity vary between seasons. Integrated pest and disease management is recommended. Some examples of common maize pests and diseases and their control measures are shown in Tables 4 and 5, respectively.

Pests

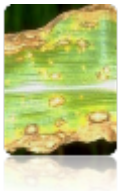
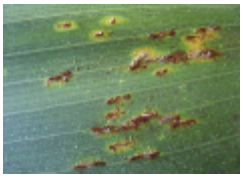
Table 4: Field pests, destructive stage, damaging symptoms and control

Pest	Symptoms	Control
FIELD PESTS:		
Maize stem borers  	 Caterpillars feed on young plants (a)and cause dead hearts (b). They later burrow into stems (c and d) affecting water and nutrient flow.	• Intercrop with non-host crops. • Intercrop with green leaf desmodium. • Plant trap crops around the plot. • Biological control with predators and parasites. • Use recommended insecticides.
Maize leafhoppers 	• Slender hoppers with two small black spots between eyes and hop away on disturbance • Hoppers feed on maize plants and transmit maize streak virus. Plants turn chlorotic and streaked and damage may be up to 100%	• Plant away from grassland or a previous irrigated crop. • Plant early to reduce risk of virus transmission. • Keep the fields free from grass weeds. • Remove residues of cereal crops. • Use recommended MSV resistant maize varieties. • Catch them with sticky green traps
Maize Aphids 	• Small, 1 to 4 mm long, soft-bodied dark green to bluish-green in color with two long antenna. • Feed on young leaves in dry periods. • Mottling stunted growth and dieback. Sooty black mold becomes evident.	• Mixed cropping, trap crops. • Use predators and parasites like ladybirds and hover fly. • Sprays with recommended Chemical in severe infestations.
Bollworms  	 • Polyphagous pest that damages many crops. • Bollworms feed on leaves, buds, growing points, flowers and fruit. • Damage reduces leaf area, which slows plant growth. Also feeds on flowers and fruit causes the main damage.	• Intercrop maize with other crops in heavy infestations. • Spray with approved insecticides

Cutworms 	• These are caterpillars that are found in the soil and damage young seedlings. • They cut off the plant at or below the ground level.	• Seed dressing with approved seed dressers. • Spread bait on the ground.

Diseases

Table 5: Selected maize diseases, symptoms and control strategies

Disease	Symptoms	Prevention/control
Downy mildew 	Leaves and leaf sheaths have white and yellow stripes, stunting of the whole plant, which produces no yield.	• Early planting. • Crop rotation. • Resistant varieties
Northern Corn (Turcicum) Leaf Blight 	A chlorotic "halo" develops into a necrotic lesion that grows into mature cigar-shaped lesions about 2 cm wide and 15 cm long. The symptoms appear first on lower leaves and increase in size and number as the plant develops.	• Planting resistant varieties. • Crop rotation. • Fungicides in the early stages of the disease.
Southern leaf blight 	Light brown leaf spots appear with a brown margin, of up to 25 mm long and 2-6 mm wide. The spots are at first restricted by the leaf veins, but later leaves dry out and die prematurely. Survival in soil occurs for up to 12 months.	• Use disease-free seed or treated seed with fungicides. • Destroy crop residues and volunteer plants. • Practice crop rotation. • Use tolerant/resistant varieties.
Gray leaf spot (GLS) 	Mature lesions, about 5cm long and 0.3 cm wide start from the lower leaves and increase in number usually after silking. The colour changes from light to gray lesions, which may grow together and kill the entire leaves.	• Observe field hygiene; • Use resistant/tolerant varieties; • Early planting; • Proper tillage; • Crop rotation for at least 2 years with non -host crops like potato, beans or pea; • Use recommended rates of fertilizers.
Common rust 	The disease is characterized by elongate raised bumps (pustules) scattered or clustered together on both leaf surfaces that are red to dark brown in color. The symptoms are mainly observed in the mid and upper canopy of the crop, especially during tasseling. Later the epidermis is ruptured and the lesions turn black and spores are released as the plant matures.	• Use resistant varieties. • Foliar application of fungicides. • Cultural practices.

Common smut 	The fungus attacks all parts of the plant that is leaves, stalks, tassels and ears even below the soil surface. It gains entry through wounds or thin walled cells of actively growing maize. Galls that replace individual kernels and are covered with white membranes characterize common smut. Later, the galls break open releasing black masses of spores that will infect maize in the following season.	• Observe field hygiene • Plant resistant varieties • Spray with fungicides • Avoid injuring the plants.
Head Smut 	The fungus penetrates the seedlings and grows inside the plant without showing symptoms, until the tasseling and silking stage.	• Plant resistant varieties. • Plant early, when temperatures are unfavorable for spore germination. • Treat seeds with systemic fungicides. • Maintain balanced soil fertility. • Where feasible, remove and burn smutted tassels and ears as they emerge to reduce inoculum spreading. • Crop rotation.
Maize lethal necrosis disease   	These include chlorotic mottle on the leaves, usually starting from the base of the young leaves in the whorl and extending upwards toward the leaf tips, mild to severe leaf mottling, dwarfing and premature aging. Necrosis of the young leaves in the whorl before expansion leading to a "dead heart". Lesions sometimes associated with unfurled leaves appear on the stem. Tassels with no pollen and finally there is poor grain filing.	• Integrated pest and disease management. • Use of certified seeds. • Observe field hygiene. • Manage the hosts and vectors. • Avoid volunteering crops/weeds in the farm. • Observe closed seasons. • Cop rotate with non-cereal crops.
Maize streak virus 	Narrow white to yellowish streaks on the leaves whorls. The central leaves die, resulting in a dry, withered parallel to the mid rib 'dead-heart' symptom.	• Use of resistant varieties. • Plant early in the season • Eradicate grass weeds. • Control vectors.

2.2.7 Harvesting

Green maize

Maize that is to be eaten green is ready for harvest when the grain hardens or when the silky flowering at the top of the maize cob turns black.

Dried maize

The recommended moisture content for dry maize is 13%.

2.3 Postharvest handling

2.3.1 Seed drying

Maize can be dried on cob or after shelling. Both shelled and unshelled maize can be dried in the sun on a cemented floor, mats, and tarpaulins, raised structure like cribs or specially constructed drying sheds. Maize should not be dried on bare ground because the grains will pick up moisture, dirt and insects. In case of open air-drying, the grain should be protected from rain, night dew, domestic animals and birds. Maize can also be dried in mobile motorized driers, which are now accessible to farmers and can dry up to 37 bags in two hours. The recommended moisture content for dry maize is below 13%.

Maize drying on bare ground (not recommended

Maize drying on tarpaulin or mobile drier (Recommended)

Figure 2: Methods for drying maize.

2.3.2 Shelling

Shelling should be done immediately after drying the cobs. Sort the cobs to remove diseased or rotten grains. Shelling can be done using a hand-held Sheller or motorized Sheller. Shelling of the grains should be done carefully, so that the grains do not get damaged. After shelling, the grains should be cleaned by removing any dirt and foreign matter, small and damaged seeds.

2.3.3 Grain and seed dressing and storage

Before storage, and consuming maize treat the grains with Super actellic @ 50g per bag/90kg. Store maize as dry as possible in air-tight bins or drum or well-secured gunny bags.

2.3.4 Proper storage

The dried shelled grains should be stored in metallic silos or packed in Hermatic bags (Agro-Z bags). Place the silos or bags on pallets in a clean and well-ventilated store.

Poor Maize storage condition

Sky plastic and small metal silos

Large-scale metal silos

Figure 3: Maize storage methods

2.4 Maize storage pests

Several post-harvest pests affect maize and some selected pests of economic importance are shown in Table 6 below:

Table 6: Storage pests, symptoms, damages caused and control strategies

Pest	Symptoms	Damage	Control
Larger Grain Borer (LGB) A beetle like insect that is a serious pest of maize.	 LGB will attack maize on the cob, both before and after harvest.	 Adults bore into maize husks, cobs producing large quantities of grain dust as they tunnel.	• Early harvesting, drying and storage in cleaned and dusted store and bags. • Use plant extracts such as Neem, pyrethrum and castor seed. • Use recommended chemicals.
Maize weevils The adults are small (2.5 to 4.0 mm long), black with a long, narrow snout.	 Female lays eggs inside the grain.	 Larva (grub) lives inside the grain hollowing it out leaving circular holes on the surface of the grain	• Early harvesting, drying and storage in cleaned and dusted store and bags. • Recommended Chemicals can also be used.
Rodents (Rats and mice)	Feed on maize grain.		• Use rat guard when building the in the granaries. • Use traps • Use baits.

2.5 Mould and aflatoxin control

Aflatoxin in maize is caused by moulds (*Aspergillus species*). Cooking or heating cannot destroy aflatoxins. The only way is to dry maize grain quickly after harvest to moisture levels of between 12 and 15% and ensure good ventilation.

2.6 Utilization and value addition

1. The grains are ground to produce maize flour and it is also consumed as a food grain fresh, ground, boiled or mixed with other foods.
2. The stalks, leaves, and other remains from the maize cobs are used to feed domestic animals especially dairy cattle.
3. The stalks and cobs are used to provide domestic fuel particularly in the rural areas. They are also used as organic manure.
4. The grains are used in manufacture of corn oil and animal feeds hence it is a vital raw material for industrialization.

3 Practical

3.1 How to determine the moisture content of maize

Moisture content can be determined by using a moisture meter. Where farmers have no moisture meter, they can use the biting grain method or the salt test.

Salt test

Put maize grains into a 750ml glass bottle (which should be about one third full). Add 2–3 tablespoons (20–30g) of dry salt and shake vigorously for 1 minute to mix the salt and grain, and then leave for 15 minutes. If the salt sticks to the side of the bottle, the moisture content of the grain is above 15% and is not safe for storage. If the salt does not stick to the bottle, the moisture content is below 15% and the grain is safe for storage.

4 Take home messages

1. Always plant certified seeds.
2. Carry out timely land preparation.
3. Always plant early.
4. Do timely weeding.
5. Always control pests and diseases.
6. Harvest at physiological maturity.
7. Dry to 13% moisture content.
8. Treat grains before storage.
9. Store in a clean dry place.

5 Further reading

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