KENYA AGRICULTURAL AND LIVESTOCK RESEARCH ORGANIZATION

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FACTSHEET FOR TECHNOLOGY INNOVATORS WORKING WITH SMALL HOLDER FARMERS IN KENYA

Sorghum Growing in Kenya

Sorghum

Introduction

Sorghum (*Sorghum bicolor*) is the fifth most important cereal grown in the world. It is an indigenous crop to Kenya and a basic staple food crop for many rural communities in the country, especially in more drought-prone areas. It is important for food, animal fodder, bio-fuel and production of alcohol and beverages. The crop is adapted to a wide range of environments, able to perform better than most crops under extreme climatic conditions, from very dry spells to excessively moist conditions, and under varied temperatures and soil types. Sorghum can grow anywhere from sea level to 2,500 meters above sea level and requires a minimum rainfall of 250 mm per year and a minimum temperature of 10°C.

Sorghum tolerance to drought

It can survive drought conditions for some weeks by rolling up its leaves and thus decreasing transpiration. The major advantage of sorghum as a drought tolerant crop is that it can become dormant under adverse conditions and can resume growth after relatively severe drought. Early

drought (pre-flowering drought) stops growth before floral initiation and the plant remains vegetative; it will resume leaf production and flower when conditions again become favorable for growth. Late drought stops (post-flowering drought) leaf development but not floral initiation.Signs of drought intolerance in sorghum include leaf rolling, death of lower leaves (senescence), stunted growth and low yields.

Choice of sorghum varieties

KARI Mtama-1

KARI Mtama-1
Colour: White
Yield: 17 bags (90 kg) per acre
Days to flowering: 58-65
Maturity: 3.5-4 months

Gadam

Gadam
Colour: Chalky white
Yield:14 bags (90 kg) per acre
Days to flowering: 45-52
Maturity: 3 months

Serena

Serena
Colour: Brown
Yield: 9-10 bags (90 kg) per acre
Days to flowering: 65-77
Maturity: 3-4 months

Seredo

Colour: Chalky white
Yield: 14 bags (90 kg) per acre
Days to flowering: 45-52
Maturity: 3 months

Seredo

Planting of sorghum

Planting field should be prepared well in advance, and it is recommended that land be ploughed immediately after harvesting the previous crop. Dry planting is highly recommended. Thus, plant before or at the onset of rains by either drilling in the furrows made by oxen plough or tractor, or hill plant in the holes made by *Jembe* or *Panga*. After the onset of the rains, plant shallow but press the soil so that the seed may be in contact with moist soil. Planting depth ranges between 2.5 cm to 4.0 cm, but when dry planted, the depth should be 5 cm.

Soil and water conservation measures

Bench terraces

Terraces can be the *fanya juu* or bench terrace. The *Fanya juu* terraces are constructed by heaping soil up-slope to make an embankment which forms a runoff barrier leaving a trench used for retaining or collecting runoff. The canal is 0.6 m deep and 0.6 m wide. The soil embankment is about 0.7 m from the surface. Runoff from external catchments is led into the canals for retention to allow more time for water to infiltrate into soil. This technique is recommended for areas with slopes greater than 5%.

The bench terraces are similar to *Fanya juu* terraces but do not have a retention ditch at the lower side of the terrace and are spaced closer than the *Fanya juu* so that with continuous maintenance by placing soil on the embankment, a bench is formed by lower terrace embankment with the lower side of the terrace above this one. Rainwater is uniformly spread within the terrace unlike the *Fanya juu* terrace where rainwater is collected at lower side.

Zai pits

These are planting pits with 30 cm diameter and 15-20 cm depth. Manure or compost is placed at the bottom of the pit and mixed with soil before planting. During digging the soil is thrown down-slope to form a small embankment. The pits are made at a spacing of one meter row to row and 30 cm pit to pit. Pits should not be perpendicular to each other to avoid possible erosion in case of excess rainfall.

Integration of rainwater harvesting with soil fertility improvement like use of manure 2t/ha plus water harvesting in semi-circular hoops can increase sorghum grain yield from 0.36t/ha to 1.96t/ha.

Tied ridges

These are made to increase surface storage and to allow more time for rainwater to infiltrate the soil. Oxen made furrows are manually tied at 3-5 m intervals. The lower furrow is tied starting from the point between the above tied furrows such that tying is not perpendicular to prevent possible erosion in the farm to give a pattern similar to house construction using bricks. The cross ties are usually of lower height than the furrow so that if they fill, the overflow is along the furrow but not down the slope. This technology is recommended for land having a slope greater than 2% so that the furrows retain rain water that would be lost as runoff if the structures were not in place.

Micro-catchment

Sorghum grain can be increased by planting in micro-catchment plots with some part of the field acting as a runoff catchment of cultivated field of sorghum. This runoff enriches soil water in the cultivated sorghum field leading to increased sorghum growth and yield.

Deep tillage

Deep tillage is achieved by ploughing the soil to 20cm depth (greater than 6 inches depth) to allow percolation and retention of rainwater in the soil. This improves soil water holding capacity which could not have been achieved without this kind of cultivation.

Use of deep tillage increases sorghum grain yields. Deep tillage allows rain water to enter into the soil and be retained in at deeper soil profiles for longer than in a shallow tilled soils.

Sorghum plant nutrition

Plant nutrition

High yielding crops of sorghum require adequate nutrition and should any nutrient be found lacking, appropriate fertilizers need to be applied. Rates of fertilizer will vary depending on locality, soil type, previous crop and fertilizer history. The nutrients that most frequently limit production are nitrogen (N) and phosphorus (P). Sulphur (S), potassium (K) and zinc (Zn) may also be limiting in some soils or under some growing conditions.

Crop Uptake

For each tonne of yield, the sorghum plant requires defined quantities of nutrients. Nitrogen (N) and potassium (K) are nutrients required in the greatest quantities followed by sulphur (S), phosphorus (P), calcium (Ca) and magnesium (Mg). The timing of nutrient demand in sorghum is similar to other cereals with N and K occurring ahead of dry matter accumulation and phosphorus uptake. Sorghum takes up 75% of its nitrogen requirement in the vegetative period prior to floral initiation (about 6 leaves open). A shortage of nitrogen during this period significantly reduces growth in stems and leaves and consequently in the number of flowers produced and so leads to a reduction in yield.

For the remaining nitrogen demand, take up between flowering and maturity is most important, for a shortage of plant available nitrogen during this period results in large reductions in the protein content of the grain. Fifty percent of its potassium requirements are during the vegetative period prior to floral initiation, while the uptake of phosphorus peaks at early flowering, with 45% of the total phosphorus demand being taken up during booting and flowering.

Soil fertility management

Most soils in sorghum and millet production areas are deficient in macronutrients such as nitrogen and phosphorus which are essential for adequate crop growth. This can be managed through application of organic manures, and Inorganic or chemical fertilizers.

Organic of manures/Inorganic fertilizers

Use of manure

Manure improves soil organic matter, which improves soil structure and moisture retention. Well-decomposed manure should be placed in the furrows before onset of rains and mixed with the soil before seed planting. Farmers may apply good farm yard manure at the rate of two tons per acre is recommended to increase macronutrients in the soil.

Mix soil and manure and a smooth seedbed.

Manure at correct rates for proper plant growth.

Inorganic fertilizers

This requires use of the right type of fertilizer placement and rate. At planting apply one bag (50 kg) per acre of compound fertilizer like NPK (20:20:0, 23:23:0), DAP or 17: 17:17). Top dress with one bag (50 kg) of CAN per acre. The fertilizer is normally drilled along the planting furrows and mixed with soil; the seed is planted and then covered with soil.

Growth enhancers and micronutrient fertilizers

In the semi-arid zones yield of sorghum can be enhanced by use of commercial growth hormone, a 2-4% zinc micronutrient top dress and modest amounts of fertilizer at planting (DAP 50 kg/acre) and additional topdressing with (CAN 50 kg/acre). The sorghum grain yield range from 2 to 4 (90 kg) bags in seasons of low rainfall and 2 to 17 bags in seasons of good rainfall

Management of acid soils

Soil testing is recommended before planting, however, liming is recommended if soils are acidic. Soil testing will give some soil reaction pH which is a measure of soil acidity or alkalinity depending on the soil pH range. The desired management of acid soil depends on the soil pH and the ratio of Calcium to Magnesium. The ideal ratio being 2:1 to decide on whether corrective measure will require lime or dolomitic lime stone application.

Management of saline soils

Saline soils are either have excess soluble salts, excess sodium or both in levels that affect plant water and nutrient uptake leading to decline in crop yield. There are some areas in semi-arid land with soil salinity problems. The advantage is that, the soils are well drained and salt effect is decreased by the rainfall received in these areas.

The recommended management is application of manure or compost and frequent soil testing to ensure soil electrical conductivity is below 1 mS/m.

Sorghum routine management practices

Land preparation

Steps during land preparation

- Plough a fallow land, if planted as second season crop one plough is sufficient.
- Practice contour farming technique.
- Add manure and fertilizers to the soil in the right amounts to provide the required plant nutrients for vigorous crop growth.
- Maintain adequate soil health, soil nutrients, soil depth and moisture holding capacity.
- Soil testing and analysis is necessary for tailored soil amendments and nutrient replenishment.

Planting

Plant at the onset of rain and intercropping should be done with an appropriate cover crop. Direct planting of seeds is done by sowing directly into furrows as a drill at a spacing of 45 x 60 or 75cm x 20cm for mono-crop and 90 cm x 30 cm for inter-crop with legume or maize. Drill then thin to 12-20 cm between plants in furrows, 3-4 weeks after emergence. In dry condition seeds should be placed at 5 cm depth and 2.5-4.0 cm in moist soil. Traditional planting broadcasting can also be applied.

Spacing and plant population per hectare

Seed rate; 7-12 Kg per Ha and the seed rate vary depending on environmental conditions. The lower seed rate is applicable in very dry conditions.

Intercropping

Sorghum is often grown in association with pulses such as pigeon peas and green gram. The row arrangement for the cereal and legume could be a single alternate where a legume falls between two rows of sorghum spaced at 90 cm. Two rows of pulses could also be also be alternated with two rows of sorghum.

Crop rotation

Crop rotation is recommended to reduce build-up of sorghum diseases and insect pests and soil fertility improvement. Rotating of sorghum with other cereal crops like maize and millet should be avoided, especially due to Maize Lethal Necrosis Disease (MLND) and that there is no soil quality improvement when a cereal is planted following another cereal. Cereals like sorghum are rotated with legumes because legumes improve soil quality through biological nitrogen fixation and organic matter addition through litter decomposition. Some legumes improve the soil quality better than others and therefore need to know the right legume to rotate with sorghum.

Weeding

Weeds reduce sorghum yields by competing for moisture, nutrients, space and light. Weeds are also an alternative host to pests and diseases. The first weeding should be done within 1 to 2 weeks after emergence. Two weeding's are recommended. The second weeding is done before topdressing fertilizer is applied about 3 weeks after germination. Chemical weeding can also be done in large-scale farms using recommended herbicides. Ensure all weeds are controlled timely and through rotation with legumes.

Thinning

Thinning should be done when the soil is moist. This ensures minimal disturbance of the roots of the remaining plants for healthy growth. Thin sorghum seedlings and leave 1 plant per hill. It should be done 1-2 weeks after emergence in semi-arid areas (at 3-4th leaf stage). This is best done after first weeding in order to accommodate appropriate plant density adjustments in case some plants are

damaged during weeding. Leaving 2 plants adjacent to it compensates for a gap within the row. Sorghum thinning is done so early to avoid waste of fertilizer to plants that farmer will thin later. To achieve good yields, the vegetative regrowth (tillers) are thinned to ensure 2-3 plants per stool. This ensures formation of large panicles and high sorghum yields

Rogueing

This is the removal of plants that has characteristics, which are different from the needed variety. Plants taller than the general height of the plant population, whose flower colour deviates from that of majority of other plants, or with grain colour that is different from the majority of plants should be removed.

Sorghum ratooning

What is sorghum ratooning (cutback)

It is a process where sorghum stalks are cut back just above ground level after harvest to stimulate growth of New shoots and hence a new crop.

Why ratoon Sorghum?

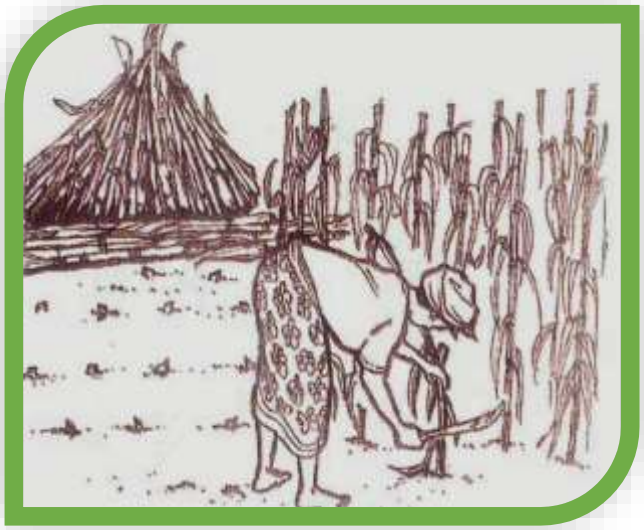
A ratoon crop does not require seeds for planting in the long rain season. A ratoon crops matures 20-30 days earlier compared to a newly planted crop. When the rains fail or are poor, the farmer who ratoons harvests something while the one who plants a new crop might harvest nothing.

Step 1: Harvesting initial crop

Harvest the initial crop by cutting the head and leave the stalk standing.

Step 2: Cutting back stalks

Within one week of harvesting, cut back the sorghum stalks above ground level and new shoots will grow. Do not delay cutting until stalks dry.



Step 3: Field management

After ratooning, remove the cut sorghum stalks from the field to reduce stalk borer infestation. Weed the new sorghum crop and mulch the soil surface to retain soil moisture.

Step 4: Harvesting the ratoon

When the grains are ready, harvest same way as the first crop. Ratooning sorghum within one week after harvesting. Produces an extra 4 bags/acre of sorghum compared to late rationing or no rationing.

Protection of sorghum against insect pests

Shoot fly

As soon as the sorghum seedling have emerged, established or one week after germination look out for shoot fly. The yellowish or white maggots bore into the hearts of the shoots and cause characteristic dead heart

Control of shoot fly

- Dry plant or plant early within 7-10 days of onset of rains
- Seed dress with imidacloprid 70

- Increase seed rate 3 to 5 kg/ha
- Spray suitable insecticide e.g. Marshal within 1-2 week after germination and after next 2 weeks

Stalk borer

The caterpillars feed inside the stalks killing the growing points (die back), stunted plant growth, poorly developed ear Heads and complete drying-up of plants in severe infestations. The damage and or presence and symptoms of Chilopartellus or Buseolla fusca appear as three dots along the middle part of leaf length. As for symptoms of bollworm (Helicoverpa armigera) larvae on the leaves, the leaves show long tattered damage with stunted growth for the slow maturing plants.

Control of stalk borer

- Destruction or proper storage of crop residues
- Plant early and improve soil fertility and plant vigour
- Scout for borer infestation and apply suitable chemical such as bull dock star at 1-2 kg/acre, spray with Marshal at 80mLs per acre or dress with pepper and ash mixtures in the funnels 6 weeks after germination.
- One or two occurrence of dead hearts of sorghum could either be severe attach of the growth bud by either shoot fly or any of the stem borer species.

Pest surveillance

To manage the stalk borer, shoot fly and other insect pests, it's important to undertake routine surveillance.

Pest surveillance 1

a) Appearance of bollworm damage. The leaves appear as tattered with evident stunted growth.
b) Appearance of stem borer damage of three-line dots of fed leaves. Appearance of "dead heart" of growing bud is evidence of shoot fly or stem borer larvae.

Pest surveillance 2

Two weeks later there is need to carry out surveillance to find out if other pests or resurgence of initial is taking place.
If no more insect pests then next surveillance will be undertaken at flowering stage.

Pest surveillance 3

If bollworm larvae attack ripening grain at soft dough spray of a contact insecticide like Duduthrin® (Lambdacyhalothrin 17.5g/L as active ingredient of synthetic pyrethroid insecticide applied once at the rate of 200ml /ha

Sorghum harvest, processing and storage

Sorghum harvest at soft dough stage

Birds start visiting the sorghum crop at early soft dough stage. As the grain starts attaining cream white colour bird damage increase exponentially as the grain ripen to hard dough. This presents the most laborious period of sorghum production as the farmer move from one point to another to chase birds away (Photo 12). Harvest of sorghum at soft dough offers opportunity to salvage yield at over 90%.

Sorghum harvest at physiological maturity

A sorghum crop is physiologically mature when the grain is hard and does not produce milk when crushed between the fingers. At this stage the heads can be harvested for drying. Alternatively the farmer can wait for the heads to dry in the field and harvest.

Sun drying, threshing and winnowing sorghum

Sorghum processing

Sun-dried sorghum ears are subjected to hand threshing and winnowed. Winnowing of grain follows after it dries to 10-12% moisture content and safe from aflatoxin infection from the soil. The dry grain can be dusted with insecticide against weevils and safely stored in suitable bags.

Sun drying grain on ears

Winnowing the grain

Harvesting, Dusting and storage

Harvest the crop when the grain is hard and does not produce milk when crushed between the fingers. The heads are broken off by hand and sun dried. The heads are harvested, threshed and dried to less than 13% moisture content. To control storage pests the grain should be dusted with effective storage chemicals (e.g. super actellic) at 50g per bag. Farmers can also use neem (also add scientific name) tree leaves or treat with wood-ash (4-6 kg of ash per bag). Weevils are the main storage pests. The grain is then stored in cool well ventilated stores that don't leak water.

Sorghum plants treated with growth enhancer and micronutrient fertilizer

Economics of using growth booster and mineral supplement in sorghum production

Farming interventions require information on economic returns to investment. Farmers need to grow a sorghum crop that is economically viable. This is especially applicable to sorghum farming in semi-arid eastern Kenya where occasionally several challenges occur.

Economic benefits on sorghum grain production

Current sorghum grain production in semi-arid eastern Kenya is 2-4 bags/acre below breakeven of 5 bags/acre. This production level can be enhanced by use of growth booster and zinc mineral. These increases sorghum production to 3bags/acre in poor season rains and to 18 bags/acre over farmer practice in above average rain season. Economic analysis based on every one shilling spent on production gives back two shillings. This show that use of growth booster and mineral zinc is a viable technology for sorghum production. However use of 50kg DAP/acre at planting plus top-dress with 50kg CAN/acre with sorghum spacing of 90 cm x 20 cm, pest management and bird scaring is recommended.

Economics of sorghum cultivation using growth booster and mineral zinc supplement in semi-arid eastern Kenya

This analysis is based on cost of inputs and sorghum grain yield increase due to application of growth booster and or micronutrient zinc mineral supplement, current market price of grain sorghum of Ksh. 27/kg. Sorghum is planted with 50kg /acre DAP and top dressed with 50kg/acre CAN and growth booster sprayed while mineral zinc supplement is foliar applied or top dressed.

Input required per acre for sorghum Gadam production

Input	Unit	Qty	Unit price	Cost
Hormone	Litres	5	1,000	5,000
2%zinc	kg	0.96	50	48
Seed	kg	3.00	125	375
Fertilizer(DAP)	Bag(50kg)	1	4,000	4,000
Fertilizer (CAN)	Bag(50kg)	1	2,500	2,500
Land preparation	contract	1	2,000	2,000
Weeding Person	days	8	500	4,000
Bird scaring person	days	15	500	7,500
Total Cost				**25,423**

Net revenue per acre of Gadam sorghum treated with growth enhancer and micronutrients

Season	Yield (kg)	Price/ Kg(KES)	Revenue (KES)
Average rainfall (300mm)	1,612	27	43,524
Rainfall Below 300mm	43,524	25,423	18,101

Sources of growth booster and Zinc mineral supplement

Growth booster and mineral zinc supplement are available in the local market in Nairobi *Ngara*, Organix Company ltd and Amiran Kenya respectively. Growth booster is organic in origin while 2% zinc mineral supplement is Zinc sulphate fertilizer

Rates of application

Growth booster: Apply at 5litres/acre when sorghum is at 4-5 leaf stage by spraying alongside pesticides application in the left. 2%zinc mineral supplement: Top dress at 960g zinc sulphate/acre when sorghum is 4-5th leaf stage or at time of applying topdressing fertilizer nitrogen and incorporate into the soil.

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