EAST AFRICAN MALTINGS LIMITED

SORGHUM GROWING GUIDE FOR FARMERS AND EXTENSION AGENTS

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Abbreviations

ASAL	**Arid and Semi Arid Lands**
CAN	**Calcium Ammonium Nitrate**
DAP	**Di-ammonium Phosphate**
EABL	**East African breweries Ltd**
EAML	**East African Maltings Ltd**
GoK	**Government of Kenya**
Ha	**Hectare**
KARI	**Kenya Agricultural Research Institute**
MAP	**Mono Ammonium Phosphate**
MC	**Moisture Content**
MT	**Metric Tonnes**
NPK	**Nitrogen Phosphorus Potassium**
PH	**Potential Hydrogen**

1.0 INTRODUCTION

Sorghum originated in Africa, particularly the Sudan region of the Horn of Africa. Today, grain sorghum is the fifth most important cereal in the world. In Kenya, it is grown on about 171,000ha across the country. Due to its wide adaptation, it is grown in most parts of the country especially the semi areas regions. Nyanza Province leads in production, followed by Western and Eastern in that order. Other areas are in North Rift valley, Coast, North Eastern and Central provinces. Sorghum is used for food, fodder, Starch extraction and production of alcoholic beverages.

Because of its superior drought tolerance, better economic returns may be expected from grain sorghum than from maize in marginal and arid areas. As rainfall reliability and distribution become more and more challenging, sorghum can be an alternative cash crop in dry lands of Kenya.

2.0 ADAPTABTIBILY

The superior drought tolerance of grain sorghum in comparison with most other crops, especially maize, may be attributed to the following factors:

(a) Grain sorghum has the ability to “mark time” during a period of stress (developmental elasticity). In this way moisture uptake is reduced and physiological development is delayed. After good rains the crop recovers rapidly and development is resumed. If the main stem has been severely damaged by stress, the plant will compensate by ratooning producing factional tillers

(b) The stems and leaves of sorghum are covered with a waxy layer and have a corky cuticle which helps reduce water loss thereby withstanding desiccation during periods of low soil moisture.

(c) Leaves have the ability to roll thereby reducing surface area effectively slowing down transpiration rate.

(d) The sorghum rooting system is more dense and continuously growing (regenerative) during the crop growing period making it more effective in exploring for soil moisture even under low soil moisture pressures compared to that of most cereals and especially maize.

(e) Compared to maize, sorghum plant has a smaller leaf area, heavy and waxy cuticles covers the leaves surface making them better adapted to high temperatures and effective in controlling transpiration during warm conditions. Furthermore, sorghum is a more effective translocator of nutrients from source (leaves) to sink (panicle) during grain filling stage

under stress condition compared to most cereals making it more tolerant to post flowering stress.

(f) Grain sorghum has the ability to compensate by producing effective tillers in the event of damage to main plant and also by producing larger panicles in case of low plants population or improved production conditions.

2.1 Climatic Requirements

(a) Grain sorghum is well adapted in areas with rainfall of 250-1250mm per growing season. However, a low night temperatures of below 15^{o}c or minimums of 18^{o}c greatly affect seed setting.

(b) Germination takes 3-4days after planting on well watered soil conditions. Low soil temperatures below 20^{o}c tend to slow germination. Sorghum is more sensitive to low soil temperatures than maize.

(c) Ideal growing temperature is 23 - 35ºC with a minimum of 18ºC and maximum above 45^{o}c. However, grain sorghum can withstand high temperatures better than most other crops,

Low Temperatures during pollen development-Boot stage

- During the Boot stage (a period when flag-leaf is swollen), just before the developing panicle becomes visible, the sorghum plant is sensitive to low temperatures. This is the period during which pollen is fully developing. Studies in this regard have shown that at temperatures of approximately 10ºC the normal development of pollen grains is affected to such an extent that sterile pollen is produced. Low temperature at this stage of the panicle development does not affect the female component of the flower.

- Sorghums timing should be done in such a manner as to avoid crop flowing during months of June, July and August in areas which experience low temperatures during these months.

2.2 Low Temperatures during the Grain Fill Period

Low temperatures during grain filling stage has the following effect on performance of sorghum crop

- Lowers yield potential and prolong period of grain filling:

- Sorghum plant requires a maximum daily temperature of 25 - 35ºC (Turkana and much of north eastern Province sorghum germplasm requires 35-45^{o}C growing condition) for optimal grain production. Low temperatures reduce yields, it is therefore important that planting dates are chosen in such a way as to attain filling stage when conditions are favorable conditions.

- ***Heat Unit***

Sorghum requires high heat unit for proper development. If adequate heat is not attained, plants get stunted, grassy in growth character and yields are greatly reduced

2.3 Light Intensity and Sorghum Production

The second important aspect, which affects yield potential and is often overlooked, is the number of sunlight hours, which occur during the growing season.

In this regard two growth stages are of importance:

- ***Boot stage – full panicle emergence)***

Reduction in the number of sunlight hours can cause the development of fewer grain kernels, which in-turn affects ultimate yields.

- ***Milk stage to Soft Dough Stage***

During this period sufficient sunlight is required to ensure good grain mass. Excessive cloudiness during this stage affects grain mass considerably. It is under these conditions that realized crop yields get reduced and become poorer than expected.

2.5 Soil Requirements

(a) Sorghum adapts to a wide range of soils provided the soil fertility is reasonable. Good yields may be produced on soils with a pH of 4.5 - 8.5 and it can withstand a certain amount of salinity.

(b) Sorghum can be grown with greater success than maize on less fertile soils, shallow soils, heavy turf soils and soils subject to water-logging. (Note that this is not because the crop doesn't need good growing conditions, but due to its good ability to scavenge for nutrient and regenerate after water logging to give a good yield).

(c) Heavy soils produce the best yields in good seasons, but during times of stress sandier soils are better; however, during a normal drought, sorghum will still produce satisfactory yields on soils with high clay content.

(d) Sorghum is more sensitive to aluminium toxicity than maize and should not be planted on very acid soils.

(e) Striga has the ability to reduce sorghum yield by up to 100%. Only sorghum varieties showing tolerance or resistance to striga should be grown in Striga prone areas common in lake regions of general western Kenya and parts of north coast Kenya. Farmer preferred sorghum varieties in these areas have varying rates of tolerance (carrying capacity) to Striga and gives appreciable yield performance under above normal Striga infestation. KARI sorghum improvement program is currently at advanced stages of testing striga resistant varieties for striga prone environments.

3.0 CULTURAL PRACTICES

3.1 Seedbed Preparation

A fine seedbed is preferred because the seeds are small. Where there are large soil moulds, a harrowing after ploughing is recommended.

A tractor prepared sorghum seedbed.

- Oxen plough and jumbles can be used to attain good seedbeds. However, it is important that adequate depth is attained to ensure good soil moisture storage and to allow for sorghums extensive root system development.

3.2.1 Growing season

For Nyanza, Western, Rift Valley including Turkana, North Eastern and coastal region, Long rain season (March-July) is the recommended season for sorghum production because it's the main crop growing season with the highest chance of success. Eastern province and lowlands of central province, Short rains season (Oct-December) is recommended because the rains are more reliable in both amount and distribution and temperatures conducive for crop development and good quality grain. While temperature is not an issue in coast province, parts of the province especially Taita Taveta, and Tana River districts the short rain are the better option due to unreliability of long rains.

3.2.2 Planting Time

Dry Planting.

Short Rain sorghum production in dry low lands of Eastern Kenya, Dry planting is recommended due to the brief nature of the season and occurrence of dry spells during the growing rainy season which occasionally exposes the late planted crops to post-flowering moisture stress. Sorghum has a better seedling stress tolerance and its recovery ability enables it to bring between early season dry spells. The dry planting should be done during the first weeks of October. This ensures that the crop get established (germinate) with the first adequate rain shower. Dry planting requires that planting depths be deeper (4cm) to avoid false germination signals associated with erratic initial rain on-set in semi-arid dry lowlands.

Wet Planting

Wet planting is recommended for areas where rainy season is long enough for a sorghum growing crop (90-120 days) such as in western and coastal regions of Kenya. Planting may commence immediately the soil moisture is adequate (35-40mm) to support germination and before soil temperatures decline to below 20ºC. It should be timed so as to ensure flowering occurs when the environment is relatively warm and grain filling occurs when atmosphere is low in humidity for realization of quality grain.

Seed Placement

3.3 Plant Population

Sorghum planting recommendation is **75cm x 20cm** giving an optimum plant population of **66,000 plants per hectare**. At bordering low plant populations the crop effectively compensates by producing effective basal tillers (ratoons). However, too low population, below 60,000 plants/ha, must be avoided because sufficient compensatory power is unattainable and poor canopy may lead to built up of excess weed problem.

3.4 Cultivars

East African Breweries will only purchase white-grained sorghum.
The reason being: -

- White varieties contain more carbohydrates > 70% than other varieties which is important to the brewer.

- They contain less fats and proteins than other varieties (Brewing requires as little proteins and fats as possible).
- Red varieties contain polyphenols and tannins that are absent in white varieties. Polyphenols and tannins affect the quality of beer in terms of colour and taste.

Other considerations while choosing the cultivar are:-

(a) The adaptability of the cultivar with regard to soil and climatic conditions in the area.
(b) The length of growing season in the area.
(c) Important agronomic characteristics of the cultivars such as :
    - Threshability , Compactness of ears, Malting characteristics
    - Resistance to disease and pests, panicle exertion under stress and cold tolerance

The following varieties have been found suitable for EABL market: -

1. Gadam (KARI)
2. Sila (Syngenta)
3. KARI Mtama 1 (KARI)
4. Gadam (KARI/Western seed company)

3.5 Spacing and Seed Requirements

Spacing between Rows	Spacing in Row	Seed Requirements per Ha	Plant Population
60cm	20cm	5-10 kg	83,000
90cm	15cm	4-6 kg	74,074
75cm	20cm	3.5 -5 kg	67,000

60cm from row to row and 20cm from plant to plant within the row. A plant population of 83,000 plants per ha can be obtained. Row cropping makes thinning, weeding, spraying and harvesting easier. Thin to one plant per hole when the plants are 15cm tall. This gives the plants good establishment. The spacing between the rows will depend on the yield potential of the area in question.

Row planting enhances chances of attaining maximum plant population

3.6 Plant Depth & Conditions at Planting

Grain sorghum must be planted shallow, especially on heavy soils, but the seed must be placed in moist soil, otherwise germination suffers. The planting depth will vary between 3cm - 5cm.

3.7 Fertilization

The nutrient requirements of grain sorghum are equivalent to those of maize, and more or less the same quantities of N, P and K are removed from the soil by these two crops. Sorghum can utilize soil nutrients more efficiently than maize, however. The recommendations for maize therefore may also be applied to sorghum – except for slight adjustments under certain conditions. As in the case of maize, the fertilization programme must be based on the projected yield and a reliable soil analysis.

3.8 Planter Calibration

For commercial farmers willing to grow a big area, wheat planters that are common with farmers can be used. Close alternate seed dispensing charters in the planter to get a spacing of 75cm between rows. Mix seed with fertilizer (DAP/NPK) at a ratio of 1:5 to get a seed rate of 4kgs per acre or 1:6 to get a seed rate of 3kgs per acre. Mix the seed and fertilizer thoroughly to get a uniform mix.

Fertilizer application is important for good yields

Lime

Lime is recommended where the pH of the soil is less than 4.6 [pH 5.6 (H_2O)] or where the acid saturation in the soil is higher than 15% the efficiency of fertilizers increases as the soil acidity is reduced. The choice between dolomitic and calcitic lime will depend on the Mg-content of the soil. Liming of soils with an aluminium problem is essential for successful sorghum production.

Lime must be spread evenly and worked well into the soil, preferably at least two months before planting.

It is estimated that fertilizer use will give increase yields ranging from 2,500 to 3,000 kg/ha. This amount of grain will contain up to 36kg of nitrogen and 6kg of phosphorus. The farmer therefore must return more than this amount to the soil by applying fertilizers. The most effective application depends on the soil and its moisture status. Nitrogen requirement for sorghum is 40kg/ha. This is split into two applications of 20kg each. The first one is applied during seedbed preparation or planting and the second application is done 20 to 30 days after germination. Under very dry conditions, nitrogenous fertilizers are not effective. Other tests have shown that generally economic responses are obtained with 80kg of nitrogen together with 40kg of phosphorus (P_2O_5) per ha.

Each farm has its own nutrient requirements depending on it's history, texture and structure. It is therefore recommended that soil analysis tests be done to quantify nutrient requirements.

Fertilizer Types

- N.P.K
- DAP
- Mavuno fertilizer
- CAN-As a top-dresser
- MAP

4.0 CROP PROTECTION

4.1 Weed Control

As the sorghum plant grows very slowly in the early stages, weeds can easily suffocate it. The young sorghum seedling is not capable of competing with weeds. Therefore, it is important, that weeds are effectively controlled, particularly in the early stages.

(a) A well-prepared seedbed largely prevents weeds from becoming a problem after planting.

(b) Mechanical weed control from just before emergence until just before the piping stage – using a rotary cultivator and a tined cultivator with tines or sweeps – is usually effective, however, sometimes the use of a rotary cultivator before the plants have reached the 5 – 8 cm stage may result in a reduction of the plant population, as the seed is planted shallowly and is therefore easily damaged. The tined cultivator may damage the roots if used too close to the row, especially in the later stages.

(c) Use of hoes when the plant is 5-8 cm.

(d) Animal drawn power- Use of donkeys and bulls especially in parts of eastern and rift valley is common. The plant should be 5-10 cm tall and the animals should be trained. Their snouts should also be covered to avoid destruction of the young crop.

(e) Various chemical herbicides produce effective weed control in sorghum.

(f) It is extremely important that the manufacturer's instructions regarding the use of herbicides are carefully followed.

4.2. Insect pest Control

a) **Cutworms**
Manifested by drying seedlings at 2-3 weeks after germination. Control measures are the same as for maize. Cutworms are not such a serious problem in sorghum, however.

b) **Maize Stalkborer & Sorghum Stalkborer**

Both these pests can attack sorghum and cause serious damage. Sorghum stalkborer larvae differ from those of the maize stalkborer in that they are slightly smaller, pale white in colour, with pigmented spots.

The control measures for both pests are the same, although the sorghum stalkborer is more difficult to control. They have similar life cycles, but the sorghum stalkborer can complete more life cycles per annum than the maize stalkborer.

Late plantings, in particular, may be severely affected and yields may be completely destroyed. Chemical control measures are absolutely essential for the timely control of both pests.

c) **Aphids**

Sorghum is affected by three types of aphids, the most important being honeydew aphid. The other two are known as the wheat aphid and the maize aphid.

A Mature honey-dew aphid has a life expectancy of approximately 30 days, and that during this time one aphid may reproduce up to 100 young ones which in turn reach maturity within 6 days. All aphids are capable of asexual reproduction, known as parthenogenesis.

The aphid feeds mainly on the underside of the leaves, and lives off the sap of the plant. They absorb mainly the protein and nitrogen particles of the sap and excrete excess sugars known as honey-dew, a sticky, gummy secretion which appears on the leaves. A fungus grows on this honey-dew, giving infected plants a typical black colour.

Chemical control measures must be applied as soon as the plants start exhibiting honey-dew in patches.

d) **American Bollworm**

Eggs of the American Bollworm are laid singly on the plant and the larvae feed on the ears. Usually infestation occurs shortly before the flowering stage. The colour of the larvae varies from nearly black, brownish to green and even pink, but may be easily identified by the dirty-white line on both sides of its body on which the respiration openings are clearly visible. They usually hide in the ear and damage to the grain may continue until it has hardened.

Chemical control is recommended as soon as the pest is observed. In cultivars with very compact ears spraying may often be less effective, as the chemical only penetrates the ear with difficulty.

e) **Sorghum Midge**

This pest feeds on the developing florets and result in poor seed development.
No chemical control measures are recommended and where the sorghum midge is a problem, the crop must be planted early.

4.3 Birds Control

White varieties of sorghum are highly susceptible to birds menace. The best method for controlling bird's damage is to plant in farmer clusters so that the risk is borne by many farmers. It has been proved through research that a specific region has a distinct number of birds. Apart from the "residential birds" quelea quelea invasion can have devastating effects. When this occurs, government intervention through the Desert Locust Control Unit can be explored. Bird scaring is done to curb damage and lasts for a period of 20-30 days.

Disease Control

a) **Pre- and Post-Emergence Seedling Wilt**

The disease complex is caused by a large number of harmful fungi. Germinating seedlings die before emergence, while those that do emerge wilt and usually also die.
The affected seedlings have a purplish colour and are stunted, as the causal organisms affect the mesocotyl and primary root system. The roots rot and the development of the secondary root system is delayed. As soon as the latter do develop, the plants recover fairly rapidly.

The disease is particularly prevalent in early plantings and where heavy rains have fallen immediately after planting. Although most plants may die as the

disease is usually localized, particularly where water has been standing in the planter furrows.
Certain herbicides can aggravate the disease, while seed treatment with a fungicide has a limited preventative effect.

b) **Grain Sorghum Leaf Spot (various organisms)**
This disease occurs particularly in the wet regions, and is caused by a variety of organisms, which manifest themselves together on the leaves. They may be transmitted on the seed and can cause considerably damage under conditions favourable for its development.

Symptoms vary from light green spots to large reddish-purple discolourations and from small round, slightly elongated light brown spots to large necrotic areas where the spots merge together. Leaf spots usually appear first on the lower leaves and then spread to the top leaves later. On the leaf itself the spots are initiated on the tips and then spread back on the leaf margins. The disease may also affect the young kernels and results in small, shrunken seeds. The infection of the grain is of particular importance in seed production.
At this stage no effective seed treatment against grain sorghum leaf spot has been registered. Therefore the use of resistant cultivars, offers the best preventative measure at present.

c) **Bacterial Stripe (*Xanthomonas holicicola)***

This disease is known as “red death”. Wet or high humidity conditions favour the incidence and development thereof and in wet years yield losses can be considerable. Symptoms may be observed as early as the 2-leaf stage. Light reddish-purple stripes increase in size as the disease develops and eventually form dead, necrotic areas bounded by a thick dark margin. Severely affected plants stay dwarfed and usually do not produce any grain.

Little is known about the transmission and control of Bacterial Stripe. Transmission through the seed is not considered to be a serious source of infection though, and indications are that the disease can be easily controlled by the use of resistant cultivars.

d) **Helminthosporium Blight *(Helminthosporium turcicum)***

As in maize – where it is also known as northern leaf blight – this disease usually only occurs under moist conditions. Severe infections before flowering can cause considerable damage, but yield losses are negligible if infection is slight or occurs late.

The disease starts with the formation of small red or white spots on the leaves which develop rapidly and later become oval-shaped spots with sharp points and reddish-purple margins. As the size of the spots increases, they merge and can consequently damage a large potion of the leaves. The disease begins on the lower leaves and later spreads to the top leaves. The only effective control measure is the use of resistant cultivars.

e) **Anthracnose *(Collectorichum graminicola)***

Anthracnose is a fungus disease affecting the leaves as well as the stems of grain sorghum. If only the leaves are infected, the plants may be weakened to some extent, but the resultant effect on the yield is seldom serious. However, when the stems are infected as well, particularly just under the ear, the consequences may be serious. Apart from the yield loss the plants lodge, with complicates mechanical harvesting.

The causal fungi penetrate the leaves during the young stages and red-brown, red or purple spots appear on the leaf surface. The diameter of the spots is usually approximately 3 mm but may be up to 25 mm. Infected stems also turn red or purple and when they are cut open the tissue inside the stems will also be discoloured.
The only effective control measure is the use of resistant cultivars. Crop rotation may keep the disease in check as the spores over-winter in the plant.

f) **Rust *(Puccinia purpurea)***
Rust usually only develops when the plants are maturing and seldom have a serious effect on the yield. Brown and brown-red spots appear on the leaves. These spots burst open later and release the typical brown-red spores which easily rub off the leaves.
Control measures are seldom necessary.

g) **Ergot *(Sphacelia sorghi)***
Ergot is a fungal disease also known as “sugary disease”. Cool wet climatic conditions favour infection and the development of the disease. Individual flowering on the sorghum ear are susceptible to infection before fertilization of the ovary.

The fungus then develops with the unfertilized ovary forming a mass of hyphae (fungal body). This is followed by maturation of the fungus during which period millions of spores are produced. This latter period is associated with a sticky pinkish-white secretion, which later darkens and becomes reddish-brown or even black. It drips readily from the ears and forms a white deposit on the soil surface. This in-turn often creates an ideal medium for the development of secondary organisms.

If conditions remain favourable infection of the disease occurs during the secretion period. Millions of spores present within this secretion are then spread to adjacent flowers by wind, rain and insects. This accounts for the rapid spread of the disease. As the fungus matures under these favourable conditions, the hard, so-called “ergots” are formed in the ears. These are the over-wintering bodies of the fungus which provide for infection the following year, should conditions be favourable therefore. Ergot is the most important sorghum disease and is mostly associated with cool wet conditions and late plantings.

h) **Covered Kernal Smut**
This is a fungal seed-borne disease affecting the grains in the kernel. Infection therefore starts before sorghum seedlings emerge from the soil. Previously disease-free seed can be contaminated at harvesting. The disease can therefore increase rapidly causing high levels of yield loss and staple food deficits. The disease can be controlled using cultural and chemical methods.

•**Cultural** –The act of harvesting, carrying the harvested heads to the homestead, drying and threshing all encourage the spores to be released. Planting seed should be harvested from the fields before harvesting of the rest of the heads begin. Maintenance of a clean seedbed and destruction of diseased plants should be done far away from the field. Selection of clean heads should be done as far as possible from the infected heads in the cropping field

•**Chemical** –Treat sorghum seed before planting with recommended seed dressing chemicals and Plant certified seed.

A plant infected with kernel smut

h) **Head Smut (*Sphacilotheca reiliana*)**

The same fungus causing cob- and tassel-smut in maize may also infect grain sorghum. The disease is known as Head Smut and the whole panicle is destroyed. At first the spores are covered with a thin

white membrane. The membrane eventually bursts open and millions of black spores are released. The use of resistant cultivars offers the only effective control measure.

A plant infected with head smut

j) **Physiological Leaf Discolouration**

Often a red to purplish discolouration of the leaves is observed in sorghums, which is similar to the symptoms of certain diseases such as rusts (Anthracnose) amongst others.
Physiological leaf discolouration may be caused by the following:

- **Chemical Spraying**

Certain cultivars are more susceptible to so-called “chemical-burn” than others. Weather conditions before and during spraying may also have an effect. A general purplish discolouration of the leaves or sheath takes place and is usually limited to the top surface of the upper leaves. Sometimes the discolouration may also be in the form of small reddish-purple spots. The sorghum plant is most susceptible to chemical burn, at flowering.

• **Physical Damage**

Physical damage by chemicals or insects may also result in a discolouration of the leaves or stem sheath.

In general, physiological leaf discolouration seldom causes any yield loss. Experts are of the opinion that the sorghum plant may lose 50 % of its leaf surface without any detrimental effect on the yield.

5.0 HARVESTING

Harvest when grains are hard and don't produce milk when crashed between fingers. The grains can be let dry in the field. Dry the sorghum heads to moisture content of 11-14 per cent. Storing the grains at higher moisture levels will lead to molding and increased insect damage.

Methods of grain drying

- Leave seed to dry in field before harvesting
- On black plastic sheeting
- Drying on concrete floor
- Sun dryers
- Solar dryers

Salt dry test (simple MC test for grain)

On the farm use the **Salt moisture test** to confirm safe moisture content

- Put salt to dry in sun
- Put in water proof paper and cool
- Take clean dry glass and put seed and the dry salt.
- Shake together for a few minutes and let settle
- If the seed is not dry, salt grains will stick to sides of glass
- If seed is dry to below 14% moisture content then no salt grains will stick on the sides of the glass.

6.0 YIELDS

Sorghum yields will depend on agronomic husbandry practiced, climatic conditions and varieties planted.

In marginal areas with proper agronomic practices, yields of 2.5 - 4 mt/ha, can be achieved.

In higher potential areas grain sorghum can produce yields similar to maize, namely 4 - 8 mt/ha, depending on climatic and soil conditions.

Under irrigation, like maize, yields of 8 - 12.5 mt/ha can be achieved. 75 cm rows are recommended in this case.