SORGHUM PRODUCTION GUIDE

Sorghum is an important income and food security crop for those living in drought-prone regions of Uganda. Many races of the cereal are grown in almost all zones but the northern region is the highest producer followed by eastern, western and lastly the central. Much as the northern region is the highest producer of sorghum, the region experiences the lowest productivity indicating that production is due to increased area in cultivation.

Uses of sorghum in Uganda

- In Uganda, like in many countries in sub-Saharan Africa most of the sorghum produced (47%) is consumed at household level followed by selling grain.
- Sorghum being an important food security crop, a greater percentage is stored mostly for later use as food.
- Much of what is sold is used for making alcohol lager beer by East African Breweries and Nile Breweries.
- The grain is sometimes an ingredient of livestock feed while the stover is used for forage.
- The forage may be fed sole or mixed with brewer's mash.
- The mash is also a good laxative feed for lactating cattle which results in increased milk production.

Sorghum farmers' desirable attributes

- Despite the availability of high yielding improved sorghum varieties, more than 60% of sorghum farmers in Uganda grow land races much as they are low yielding.
- However, through participatory interaction with farmers desirable attributes were identified.
- This has led to developing sorghum genotypes with the attributes desired on the market in order to increase adoption rates.
- The market driven attributes include; tolerance to prevalent constraints especially striga, drought, disease and insect pests, low soil fertility.
- Like in most East African countries farmers in Uganda prefer brown to red grain sorghum because of the minimal damage from birds.
- The sorghum with brown and red color is associated with high tannin levels and less preferred by birds.
- In addition specialty sorghum such as SESO1 was developed for breweries for making lager beer brands such as eagle, senator, engule and chibuku.
- The panicles should be compact with bold grains.
- Other attributes preferred by farmers include; short glumes, palatability, easy to grind, resistance to lodging, stay green and sweet stems.

Ecological requirements for sorghum production

- Sorghum is adapted to a wide range of ecological conditions, surviving in the tropical, sub-tropical and temperate regions of the world.
- It is planted in areas considered to be too dry and hot for other cereals to survive because of its tolerance to drought and heat stress.
- The adaptability enables sorghum to grow from sea level to above 2000m above sea level.
- However, sorghum performs well under optimum conditions of deep well-drained fertile soils, moderate to high relatively stable rainfall distribution most of which should be received during the vegetative phase and temperate to warm weather (20-30°C).
- These conditions result in a yield potential of 3000-5000Kgha^{-1} if improved cultivars are used.
- Unfortunately, the high yield potential is not realized in Uganda because farmers grow low yield potential sorghum under low-input semi-arid conditions

Soils

- Sorghum grows well in a wide range of soils except in water logged places.
- It grows best on well drained fertile soils with moderate amount of organic matter at soil pH values between 6 and 7.5.
- At this pH range most nutrients are more easily assimilated by the plant roots.
- It has some tolerance to salt and aluminum toxicity.
- However, in Uganda sorghum is mainly grown on low potential, shallow soils with high clay-loam or sandy-loam texture.
- The soils are deficient of nitrogen and phosphorous and mainly acidic.
- Thus there is need to ameliorate the soils with by liming to lower the acidity in order to attain optimum productivity of sorghum.

Temperature

- Sorghum is a warm-weather crop, which requires high temperatures for good germination and growth.
- Low temperatures may prevent successful production of grain sorghum.
- Soil temperature at planting time is critical for grain sorghum.
- The recommended temperature for germination is 17-18°C while lower temperature prolongs germination.
- The best time to plant is when there is sufficient moisture in the soil.
- Temperature is important for normal growth and development of sorghum after germination.
- A temperature of 27 to 30°C is required for optimum growth and development though the crop can still survive below 21 °C, without a dramatic effect on growth and yield.

- Fortunately the temperature in most sorghum growing areas of Uganda is above 20^0C except in the southwestern regions with $<20^0$C, indicating that temperature is not a constraint to production.

Day length

- Sorghum is a short-day plant requiring long night hours before the reproductive stage.
- Thus varieties introduced from the temperate regions into tropical regions fail to develop seed because of photoperiodism.
- The optimum photoperiod, which will induce flower formation, is between 10 and 11 hours.
- Photoperiods longer than 12 hours stimulate vegetative growth.
- Sorghum plants are most sensitive to photoperiod during flower initiation.
- However, most of the improved varieties developed for Uganda's conditions are not sensitive to photoperiodism and can thus perform well in almost all parts of Uganda.

Rainfall

- Sorghum is known to be drought tolerant and can do well in areas with little rainfall but performs better in conditions where water is available.
- It can be grown under hot and dry conditions with its roots penetrating a greater volume of soil to obtain moisture.
- Water requirement increases and reaches its peak during flowering.
- In Uganda, sorghum grows under fluctuating rainfall conditions of approximately 82-130 mm per month.
- Some varieties have physiological mechanisms, such as stay green, for avoiding the effects of droughts.
- Stay green trait promotes adaptation to drought by producing waxy leaves and stems that protect the plant form desiccation.
- The leaves fold up and stomata close rapidly to limit water loss during warm and dry conditions.
- The stay green mechanism involves reducing tillering, increasing the size of lower leaves and constraining the size of the upper leaves and decreasing the number of leaves per culm.
- This results in reduced pre-flowering water demand, thereby increasing water availability during grain filling and, ultimately, grain yield.
- Sorghum also has the ability to remain in a virtually dormant stage and resume growth as soon as conditions become favorable.
- Even though the main stem can die, side shoots can develop and form seed when the water supply improves.

Sorghum varieties grown in Uganda

Sorghum varieties	Year of release	Days to maturity	Average grain yield (Kg/ha)	Grain colour	Unique attribute
NAROSORG-1	2017	110-120	3000-3200	Cream white	Medium maturity and excellent for brewing
NAROSORG-2	2017	100-110	2700-3000	Red	Good for yeast and not much affected by birds
NAROSORG-3	2017	110-120	3000	Chalky white	Midge resistant
NAROSORG-4	2017	90-100	2300-2500	Brown	Good for food and not much affected by birds
SESO-1	2011	90	3000	White	Early maturity and good for brewing
SESO-2	2011	100	2500	White	Forage and resistant to lodging
SESO-3	2011	95	3000	Brown	Good for food and not much affected by birds

Site Selection and Land Preparation

- Select a site with fewer trees to minimize bird damage.
- The site should have well drained fertile soils and free from high humidity and strong winds during ripening period.
- In swampy sites sorghum should be planted on ridges to avoid water logging.
- Timely land preparation for sorghum production should be ensured (at least one month before planting) for better emergence and seedling development.
- Land may be prepared using a hand hoe, ox-plough or a tractor.
- It should be ploughed twice to obtain a fine field for better crop establishment and good yield.
- Tractor-ploughed land has to be harrowed to a fine tilth to achieve better crop emergency.
- In dry areas it is important to adopt cultivation practices which maximize moisture conservation and preventing soil compaction.
- In high sorghum producing areas the cereal is planted in flat fields where land is prepared using ox-ploughs.
- However, in areas prone to flooding or water logging sorghum should be planted on ridges.

Planting time

- In Uganda most of the sorghum is planted in the second season (August-September) while some farmers plant in the first season (March-April).
- However, variation in planting time exists depending on the region and types of varieties grown.
- In the north and northeastern where unimodal rainfall and late maturing land races are grown sorghum is planted once in May and harvesting done in January the following year but in the southwestern highlands sowing is done mostly in December and January.
- It is advisable to plant timely at the onset of rains so that the crop reaches peak water requirement when adequate moisture is still available.
- Early planting also enables the crop escape drought and attack by the sorghum midge, stem borers and sorghum shoot fly.
- Most damage by shoot fly occurs within 14-20 days after germination, so spraying should be done within the first two weeks after germination.

Planting methods and seed rate

- Broadcasting is mainly practiced by farmers in Uganda.
- However, this method leads to wastage of seed and use of more labor for subsequent activities such as spraying, weeding and harvesting.
- The recommended seed rate is 10 $Kgha^{-1}$ (4 kg ac^{-1}) where 3-5 seeds are planted per hole under row planting.
- Row planting is strongly recommended for optimum yields and easy field operations such as weeding, bird scaring, harvesting, and also use ox-drawn equipment for weeding.
- Under sole row planting, a spacing of 60cm x 20cm for short varieties and 90 x 30cm for tall varieties is recommended to achieve optimum productivity.
- The sorghum may be planted in a mixed or sole cropping system.
- Most farmers practice sole cropping system while some farmers practice mixed cropping with cereals or legumes.
- Under mixed cropping, the sorghum-cowpea or sorghum-green gram intercropping systems, in a ratio 1 sorghum to 2 legume, are the most economically beneficial.

Weeding and thinning

- Weeds lower yields in sorghum so they should be controlled within the first 6 to 8 weeks after planting.
- Weeds vigorously compete with sorghum for nutrients and water during this period.
- Sorghum is normally weeded once in many parts of Uganda but it is recommended to weed at least twice.
- The first weeding should be done 2-3 weeks after germination while the second weeding should be done 6 weeks after germination depending on weed intensity.
- Weeding is done using hand hoe but animal traction is also effective.

- During weeding thinning and gap filling should also be done to a desirable plant population.
- This should be done immediately after or during the first weeding.
- Thin to 1 or 2 plants per hill for grain and seed production respectively.
- This should be carried out when there is adequate moisture in the soil to avoid stress.
- Gap filling should be carried out where necessary by transplanting within 2 weeks after emergence.

Fertilizer application

- In Uganda sorghum is grown in soils with low fertility but farmers do not use fertilizers to enhance productivity.
- Fertilizer or manure is important for early vegetative growth and rapid development.
- Sorghum uses relatively large amounts of nitrogen and moderate amounts of phosphorus and potassium.
- Organic fertilizer or manure can be broadcast in the field and incorporated in the soil or in bands along the planting furrows at rate of 5-10 ton ha^{-1}.
- For basal application, a compound fertilizer (DAP 20:20:0 or 23:23:0) at 20Kg N and 20Kg of P_2O_5 per acre may be applied in furrows.
- Top dressing with 20Kg N as straight fertilizer (CAN, UREA) may also be applied beside the crop in presence of adequate moisture to dissolve the fertilizer.
- However, due to high costs of fertilizer micro-dosing can be adopted where a rate of 6g (NPK; 15:15:15) plus 2g of DAP and 1g of urea is recommended by ICRISAT.

Crop rotation

- Sorghum normally comes late in the rotation, but also grows well in early rotation.
- Continuous cultivation in the same field with cereals increases striga infestation.
- Normally a cereal-legume (sorghum-groundnuts, cotton and cowpea) rotation is recommended and to a lesser extent the sorghum-root crops rotation is adopted by farmers.

Harvesting sorghum

- Depending on the variety, sorghum matures between 90-140 days and is ready for harvesting when the crop has reached physiological maturity.
- First season sorghum is harvested between July to August while second season sorghum is harvested from December to January.
- Harvesting is done by cutting the sorghum panicle just below the attachment with the peduncle.
- In Uganda harvesting sorghum is predominantly done by women using a sickle or knife.
- For seed production harvest only disease free heads.

Sorghum diseases

1. Covered kernel smut
    - Covered kernel smut disease (*Sporisorium sorghi*) affects the panicle damaging developing sorghum grains.
    - It manifests with cone-shaped capsules developed within the panicles.
    - They may cover some parts or the whole panicle with capsules containing spores that once broken spread to contaminate other sorghum plants causing further infection.

    Control

    - Use of sorghum disease free seed which is dressed with thiram or any other effective chemical.
    - Cutting off the infected panicle and bury in soil to prevent further spread of the disease.
    - Plough down to burry and destroy disease carrying crop residues.
    - Crop rotation with non-host crops especially legumes.
    - Use of resistant varieties.
    - Integrated disease management where a combination of the above strategies to reduce crop damage is adopted.
2. **Ergot**
    - Ergot disease, caused by *Sphacelia sorghi*, also known as sugary disease affects the panicle producing mycelium in the affected grain.
    - The affected spikelet produce honey dew which is concentrated suspension of conidia.
    - The disease affects sorghum at flowering and severe during rainy and humid conditions.
    - The disease is spread through infected seed with sclerotinia germinating and releasing spores that infect the sorghum spikelet ovary.
    - Insects and rain splash also spread the disease.

    Control

    - Adjusting planting dates to have sorghum flower at the time when there is low rainfall and low relative humidity.
    - Plant clean seed dressed with thiram or any effective chemical
    - Burn crop residue; deep plough soil at planting.
    - Crop rotation; and where possible spray fungicides such as mancozeb 80 Wp (2kg/Ha) or Cabendazim (500gm/Ha) at panicle emergence.
    - Repeat the spraying after a week, especially if rain occurs.

3. **Anthracnose**
    - Anthracnose disease caused by *Colletotrichum graminicola*, that commonly attacks sorghum leaves, stems and panicle.
    - Symptoms include brick red coloration in a lengthwise split stem.
    - Small circular leaf lesions develop into mature lesions with straw-colored centers that are reddish and blackish purple, and later coalesce into larger necrotic tissue.

    Control

    - Practicing crop rotation with leguminous crops to break the disease lifecycle.
    - Field sanitation where sorghum residues should be collected and destroyed before the onset of the rains to reduce disease spread.
    - Use of resistant or tolerant varieties.
    - Integrated disease management reduces damage due to anthracnose disease.
4. **Northern leaf blight**
    - Symptoms of Northern corn leaf blight disease include long elliptical shaped lesions with grey centers and tan to red boarders.
    - Control measures include; burning crop residues; deep ploughing at planting and crop rotation.
5. **Sorghum rust**
    - Rust disease, caused by *Puccinia purpurea*, manifests as brown blister-like pustules formed on the upper and lower side of the leaf.
    - The pustules rapture and release the powdery mass of reddish brown spores which are commonly dispersed by wind and animal contact.
    - Other hosts include: Citronella grass, Creeping wood sorrel, Columbus grass, Johnson grass and Sudan grass.

    Control

    - Practicing crop rotation with leguminous crops to break the disease lifecycle.
    - Field sanitation where sorghum residues should be collected and destroyed before the onset of the rains to remove the primary source of the disease.
    - Use of resistant or tolerant varieties.
6. **Striga (witch weed)**
    - Striga, commonly known as witch weed, is a parasitic weed the affecting many cereals including sorghum. It causes 20-80% grain yield loss under severe infestation.
    - The common striga in Uganda is *Striga hermontheca*.
    - Symptoms of striga damage to sorghum include stunted growth, yellowing and sometimes failure to bear panicles under severe infestation.
    - The damage occurs when striga parasitizes the sorghum plant by colonizing roots, taking up the water, mineral nutrients, and photosynthetic assimilates thereby retarding growth and development of the host.

- Striga plants produce thousands of small seeds in a season which remain viable in soils for up to 15-20 years and a few can grow in a season where host plants exist.

Control

- Striga weed is mainly managed and controlled Inter-planting sorghum with a "chaser" *Celosia argentea*.
- Practicing crop rotation with trap crops such as cotton.
- Use of resistant/tolerant sorghum varieties and regular weeding before the weed flowers.

Major insect pests that attack sorghum

1. **Stem/stalk borers**
    - Many types of stem borers affect sorghum in the field causing great yield loss.
    - However, four types stem borers are common in Uganda in particular where their larvae are the destructive stage.
    - These include the spotted stem borer, sugarcane borer, maize stalk borer and the pink borer.

    Control

    - Crop rotation
    - Early planting on the onset of rains
    - Planting Napier grass around the sorghum fields as a catch crop
    - Intercropping sorghum with none host crops such as beans and cowpeas
    - Spraying with an insecticide once every 2 weeks and integrated pest management is effective in reducing crop damage.
2. **Sorghum shoot fly**
    - The shoot fly, *Antherigona soccata*, is a widely distributed pest in the sorghum growing semi-arid agro-ecological zones of Uganda except in the cold highlands above 1800masl.
    - The female shoot flies lay cigar-shaped eggs singly on the lower surface of the leaves, at the 1-7 leaf stage from 5 to 25 days after seedling emergence.
    - The eggs hatch within 1- 2 days and the larvae moves and bores into the base of the shoot, damaging it to cause wilting and subsequent dead heart symptom.
    - The plant may produce tillers as a survival mechanism in response to damage.
    - Shoot fly population is normally high if sorghum is planed late (usually a month after the onset of rains).
    - During off season the shoot fly survives on alternative hosts such as finger millet and maize.

Control

- Use of shoot fly resistant varieties.
- Early planting at the onset.
- Use of systemic insecticides such as Carbofuran 5G granules applied at the root base of the plants.
- Alternatively, spraying the leaves and shoots of seedlings with imidacloprid 70 WS (2gms/ kg) or Endosulfan 35 EC.
- Use a botanical insecticide Neem oil 2%.
- A Combination of the above as integrated pest management is effective in reducing crop damage.

3. **Sorghum midge**
    - Sorghum midge, *Stenodiplosis sorghicola*, is widely distributed in all sorghum growing areas of Uganda, except in the cold highlands above 1800masl.
    - The female sorghum midge lays 30-120 eggs, which hatch within 2-3 days, in the flower spikelets.
    - The larvae move and feed on developing ovary, preventing normal seed development. Larval period lasts 9-12 days and is the destructive stage of the pest that can cause up to 100% sorghum crop loss.
    - Larvae pupate inside the spikelet and pupal period lasts 3-8 days.
    - Before the adults emerge, the pupae move to the tip of the spikelet, and on emergence, the pupal case remains attached to the chaffy spikelet.

Control

- Early planting at the onset of rains to escape the sorghum midge population build up.
- Planting sorghum varieties with same maturity period at the same time within the communities.
- Sorghum that flowers later than the rest is exposed to higher populations of the sorghum midge for a longer period and suffers severe damage.
- Removing alternative hosts such as Johnson grass and Sudan grass to reduce on the initial early buildup of the pest.
- Field sanitation before the onset of the rains lowers the carry over effect of the diapausing larvae or pupae to subsequent seasons.
- Crop rotation with other none host crops.
- Land fallowing reduces the carry over and buildup of sorghum midge populations and use of resistant or tolerant sorghum varieties.
- Use of inorganic insecticides as the last resort to prevent severe damage can be done and a combination of the above sorghum midge control strategies as integrated pest management is effective in reducing crop damage.

4. **Bird damage in sorghum**
    - Birds are very destructive pests affecting sorghum productivity in Uganda.
    - Several bird species are destructive but the Quelea quelea and the weaver birds are the most important.
    - The Quelea quelea affects mainly the soft dough stage of especially the white/cream seeded varieties while the weaver birds affect the hard dough stage.
    - Depending on the season the red seeded varieties may be less affected.
    - Farmers allege sorghum planted in the second rains is less affected by birds; a reason why many farmers growing lowland sorghum plant in the second rains.

Post-Harvest Handling and Storage

1. **Drying**
    - Drying is reduction of moisture to about 11-13% moisture content recommended for storage.
    - Sorghum panicles are spread on a clean flat ground, tarpaulin, and cemented floor, mats or on rocks under the sun for 3-4 days.
    - Proper drying of sorghum improves the quality of the grain and storability.
    - It can be stored for long without going moldy, resulting good quality grain and better market.
2. **Threshing and winnowing**
    - Threshing is the removal of grain from the panicles.
    - It is usually done by women who manually beat the well dried sorghum panicles with a stick or pound it in a mortar with a pestle to release the grain.
    - It is recommended that threshing should be done on mat, tarpaulin, rock or cemented floor as opposed to bare ground to minimize contamination reduce grain spillage.
    - Winnowing is then done to remove trash and avoid mechanical seed mixing.
    - Keep the harvested grain in hermetic plastic bags properly tied to a void seed mixing.
    - Grain should be stored in clean containers at 12% moisture content to minimize damage by molds and storage insect pests.
    - A high of number of cracked or broken grain will facilitate the activities of storage pests and so sorting of undesired panicles should be done (diseased, poorly filled).
    - Store the produce in cool dry place free from vermin.

3. **Storage and packing**
    - The principal aim for storing sorghum is to maintain the crop in prime condition for as long as possible until the economic market value has risen and also for food security. Sorghum is mainly stored unthreshed in granaries.
    - The granaries should be rat proof to prevent grain damage.
    - If sorghum is stored as grain, it is usually placed in drums or gunny bags and then packed in a store on pallets.
    - It is important that bags are stacked on pallets at about 15 cm above the ground and about 75cm away from walls damage due to molds resulting from high moisture content.
    - Advantages of proper stacking: prevent dampness from floor and wall being absorbed by the stored sorghum grains, ease of cleaning the floor and the walls, ease of counting of the bags in the store and ease of inspection of produce attack by pests.
    - Treat seed with recommended chemical like Actellic, or Malathion dust.
    - Some farmers mix grain with wood ash.
    - Suitable grain packaging materials such as jute bags, cloth bags, carton boxes and tins should be used.
    - The harvested crop can also be stored in cribs or in ware houses.