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SORGHUM PRODUCTION HANDBOOK FOR UGANDA





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SORGHUM PRODUCTION HANDBOOK FOR UGANDA

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Acronyms

FAO: Food and Agriculture Organisation

ICRISAT: International Crops Research Institute for Semi Arid Tropics

NARO: National Agricultural Research Organisation

NaSARRI: National Semi Arid Resources Research Institute

UBOS: Uganda Bureau of Statistics

SUMMARY

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. The increased area is due to wide scale cultivation of improved sorghum such as Epurpur and now SESO1 which is cultivated for income generation due to its use for making larger beer. The increased production of specialty improved varieties in the last ten years has made sorghum the second most important cereal after maize. However, productivity is generally still low due to a number of factors. Farmers hardly follow the recommended agronomic practices which normally lead to high productivity. Broadcasting is the common practice of sowing sorghum yet row planting at spacing of 60x20cm or 60x30 cm would result in high productivity. Farmers weed only once and do not apply any fertliser or spray to control diseases and insect pests such as shoot flies or stem borers which are problematic especially for late planted sorghum. The most important diseases are ergot, covered kernel smut and anthracnose while insect pests are shoot fly, stem borers and midge. This is cofounded by the low fertility of the sandy-loam soils and high striga infestation which are common in most of sorghum growing regions in addition to poor postharvest handling. After harvesting farmers dry the sorghum on bare ground which leads to contamination with debris. The best practice would be to dry the sorghum on tarpaulin or cemented ground or well swept bare ground for those who cannot afford improved materials. The sorghum should be dried to about 12% moisture content before threshing or storage. Farmers store unthreshed sorghum for use as seed in the following season above the fire place in the kitchen while grain sorghum is stored in granaries either as threshed or unthreshed. The granaries are constructed on raised platforms with rat guards. The stored sorghum should be checked regularly to make sure it is not affected by moulds.

1.0 INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is the world's fifth most important cereal in terms of production and area of coverage (FAO and ICRISAT, 1996) after wheat, rice, maize and barley. The cereal is an important food crop in semiarid areas of sub-Saharan Africa (Wortmann et al., 2009); being the second most important after maize in Africa and the third in Eastern Africa after maize and finger millet. In Uganda, sorghum has become the second most important cereal after maize in terms of production and area of coverage (UBOS, 2010). This is mainly due to the crop being highly commercialised in the brewing value chain and what is grown for this purpose are the improved varieties from the National Semi Arid Resources Research Institute of the National Agricultural Research Organisation (NaSARRI-NARO).

The crop is widely adapted, surviving well under both high input and marginalised low input environments (Rakshit et al., 2014). In Uganda sorghum is mainly produced under drought-prone low input environments with low soil fertility and striga infestation. In such marginalised environments farmers hardly use external inputs such as fertilisers and chemical control of insect pests and diseases despite such constraints being prevalent. The adaptability to marginalised environments makes sorghum a food security and income generating crop for the resource constrained households (Olupot, 2011). Due to the increased importance, mainly for income generation, the rank of the crop has changed to being the second most important cereal (Fig. 1), displacing finger millet. This drastic change is as a result of adoption of improved varieties such as Epuripur, SESO1 and NAROSORG1, which are used in brewing lager beer. However, the on-farm productivity of 700 to 1400kg ha^{-1} is still low despite the increased adoption of improved varieties (Fig. 2) (UBOS, 2010). This is partly attributed to lack of awareness on proper agronomic practices and lack of information materials. This calls for provision of information materials that stakeholders can use in the production of sorghum in order to obtain potential yield.

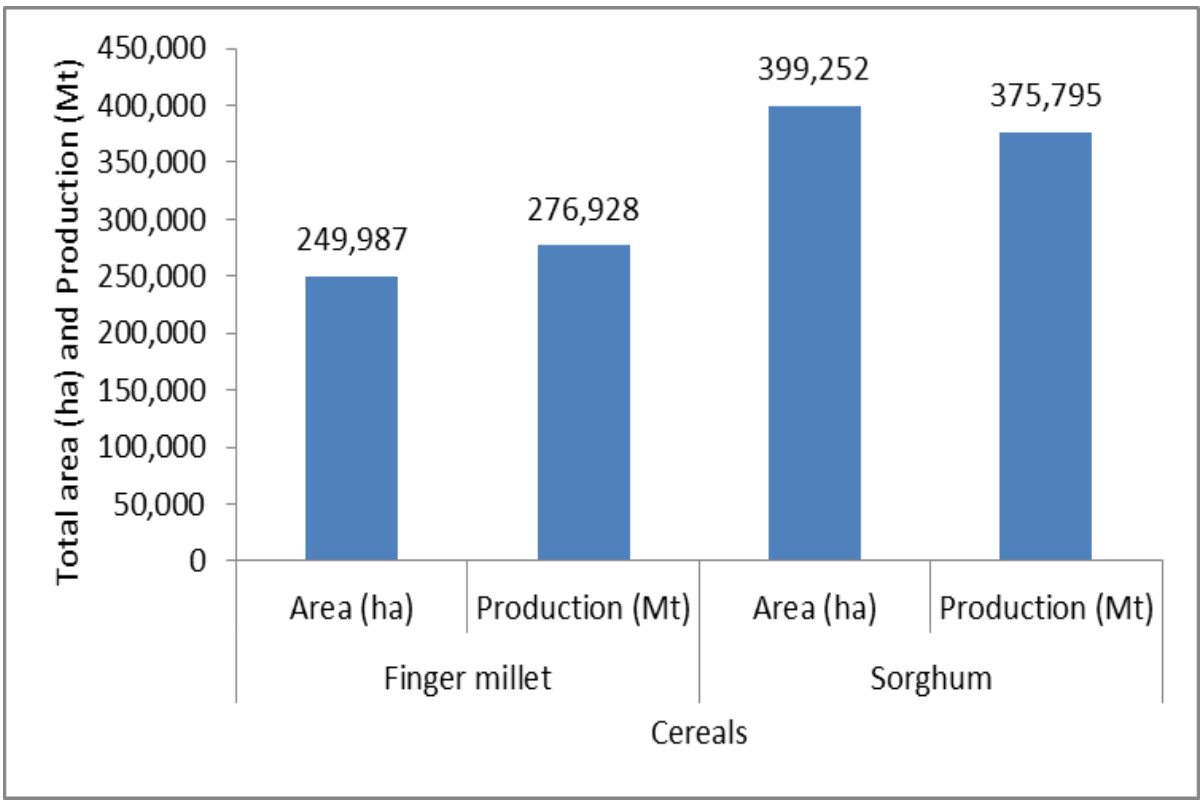


Fig 1: Total area and production of finger millet and sorghum in Uganda

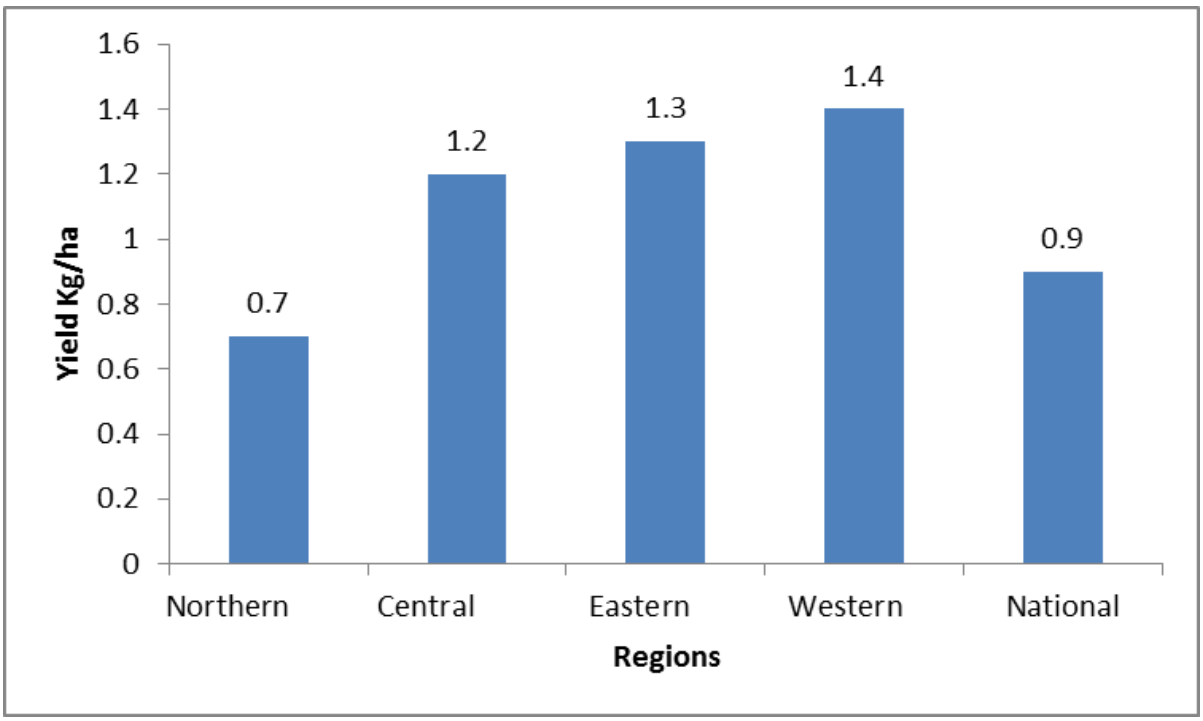


Fig 2: Sorghum productivity by region in Uganda

1.1 Sorghum growing areas in Uganda

In Uganda sorghum is mostly produced in the northern, followed by the eastern and southwestern regions and finally the central region (Fig. 3). In the major producing regions many types of sorghum (Fig. 4) are predominantly grown on sandy-loam soils where planting is done mostly in the second rains (staring August) and ox-ploughing being the common method of land preparation (Olupot, 2011). However, in the east and some parts of the north (Lango) sorghum is planted twice while in some regions such as Karamoja and southwestern the ratoon crop is promoted. Farmers plant farm-saved seed while some buy grain from local markets for planting. Olupot (2011) further noted that all farmers planted sorghum by broadcasting, weeded once using hand hoe and left the field for grazing after harvesting.

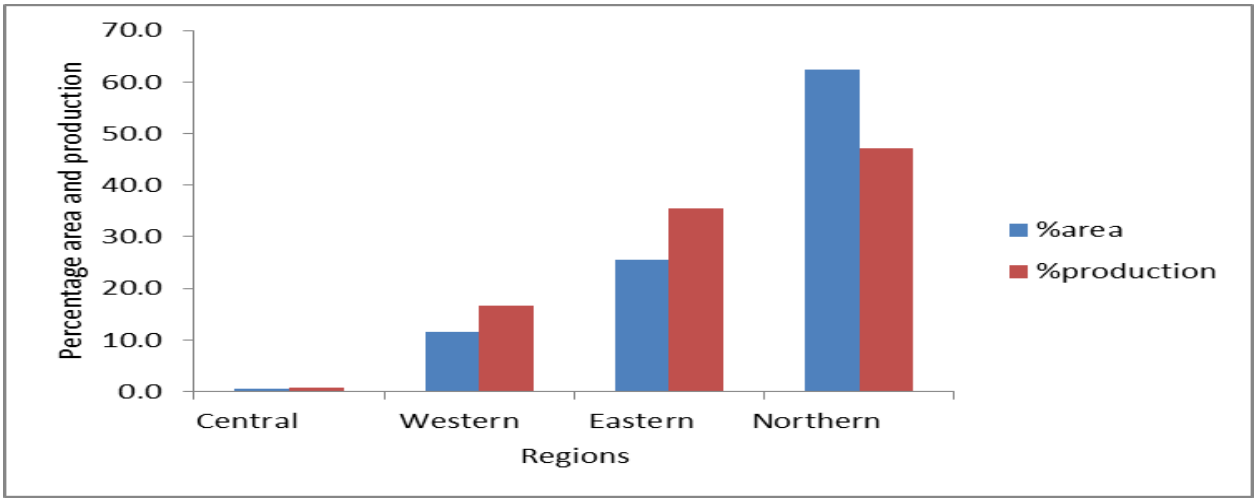


Fig 3: Percentage of sorghum production by region

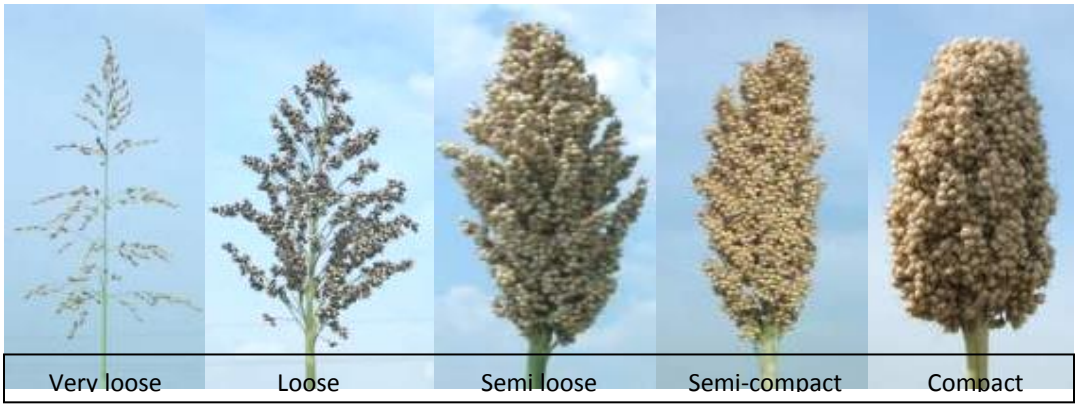


Fig 4: Panicle shapes of sorghum varieties grown in Uganda

1.2 Sorghum uses 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 (Fig. 5). 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 (Fig. 6). The mash is also a good laxative feed for lactating cattle which results in increased milk production.

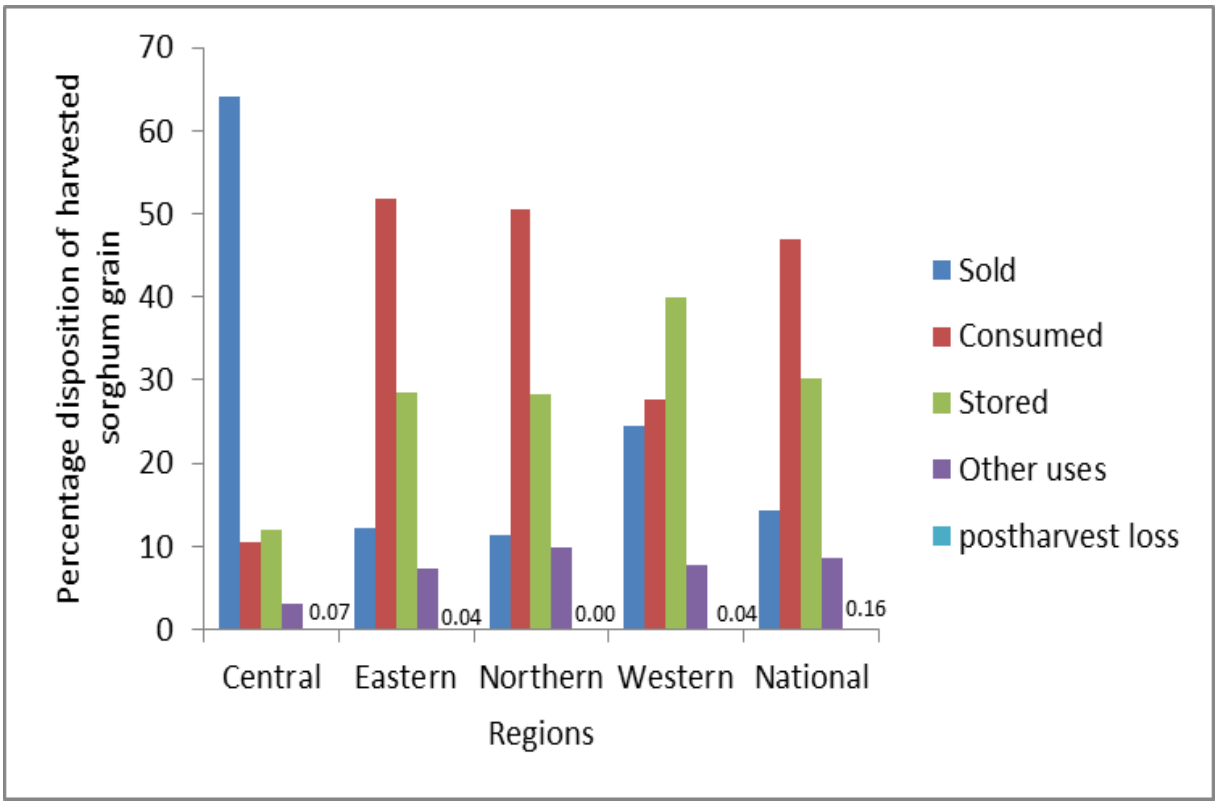


Fig 5: Percentage disposition of harvested sorghum grain



Fig 6: Cattle feeding on sorghum forage mixed with brewer's mash

1.3 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 (Olupot, 2011). Like in most East African countries farmers in Uganda prefer brown to red grain sorghum (Fig. 7) because of the minimal damage from birds. The sorghum with brown and red colour is associated with high tannin levels and less preferred by birds. In addition specialty sorghum such as SESO1 (Fig 8) 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.



Fig 7: Red and brown sorghum mostly desired by farmers for food and income



Fig 8: White sorghum (SESO1 variety) desired for brewing and confectionary

2.0 SORGHUM PRODUCTION ENVIRONMENT

2.1 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 (FAO and ICRISAT, 1996). 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 (Poehlman, 1987). The adaptability enables sorghum to grow from sea level to above 2000m above sea level (Wortmann et al., 2006).

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 (Singh et al., 1997). Unfortunately, the high yield potential is not realised in Uganda because farmers grow low yield potential sorghum under low-input semi-arid conditions (Table 1).

Table 1: Characteristics of the sorghum production zones

Production zones	Altitude (masl)	Latitude (degrees)	Mean temp (^{o}C)	Mean annual rainfall (mm)	Rainfall duration (months)	Planting time (Months)
Northern	1100	2	23	800-1200	4	May-June
North-east (Karamoja)	1250	3	26	<1000	3	May-June
Eastern	1170	1	22	1000-1200	3	April-May August-Sept
Central and West	1160	0	22		4	March-April
South West highlands	1900	-1	18		6	Nov-Dec

2.1.1 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 (Espinoza and Ross, 2005). 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 (Wortmann and Eledu, 1999). Thus there is need to ameliorate the soils with by liming to lower the acidity in order to attain optimum productivity of sorghum.

2.1.2 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 (Wylie, 2010). 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 (Wortmann et al., 2006), indicating that temperature is not a constraint to production.

2.1.3 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 (Ref). 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.

2.1.4 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 (Manschadi et al., 2006). 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 (Fig. 9), 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 (Borrell et al., 2014). 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.

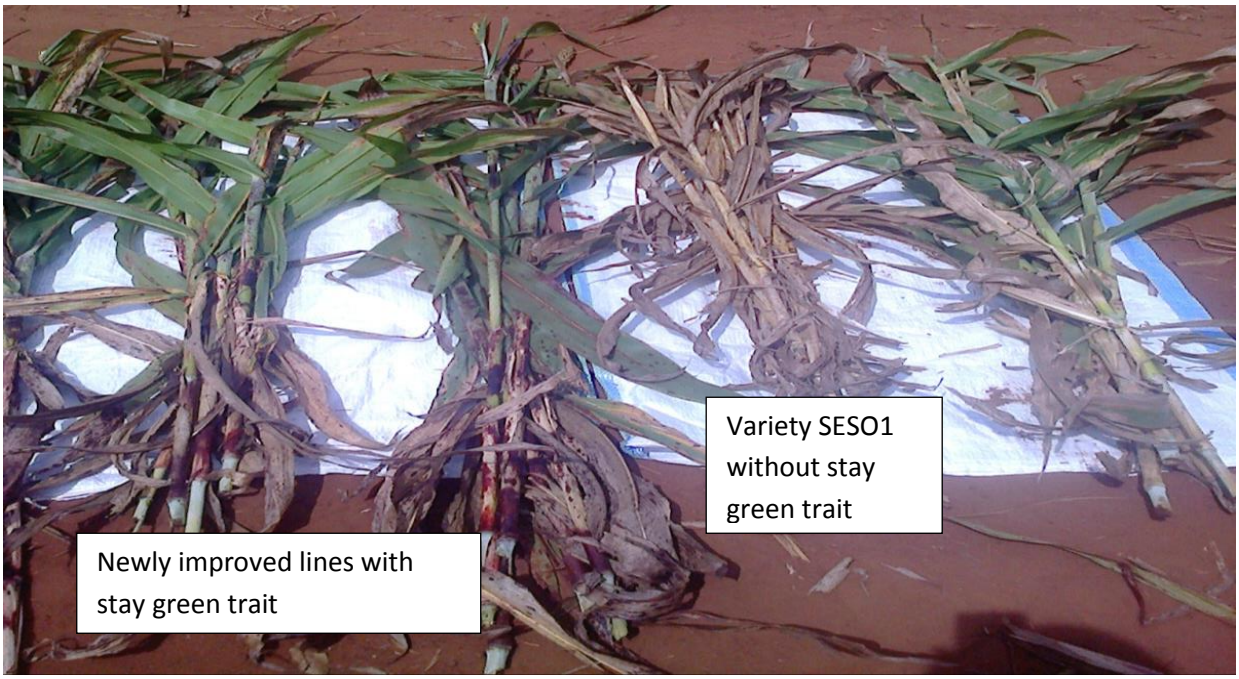


Fig 9: Materials with stay green trait compared with variety without stay green trait

3.0 SORGHUM AGRONOMIC PRACTICES

3.1 Improved sorghum varieties grown in Uganda

During variety selection, certified and quality declared seed of adapted varieties should be purchased from reliable seed sources but for farmer saved seeds, it should be pure, and free from contamination, irrespective of sources of supply. Generally select clean and right variety; tolerant to drought and striga and resistant to common diseases and insect pests. Common varieties currently found on the market are shown in Table 2 though many new varieties are to be released to add on the list.

Table 2: Sorghum varieties grown by farmers 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

3.2 Site selection and land preparation

Select a site with fewer trees to minimise 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 maximise moisture conservation and preventing soil compaction. In high sorghum producing areas the cereal is planted in flat fields (Fig. 10) where land is prepared using ox-ploughs. However, in areas prone to flooding or water logging sorghum should be planted on ridges (Fig. 11).



Fig 10: Sorghum planted in flat field



Fig 11: Sorghum planted on ridges

3.3 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) (UBOS, 2010). 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 south-western 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.

3.4 Planting methods and seed rate

Broadcasting (Fig. 12) is mainly practiced by farmers in Uganda (Olupot, 2011). However, this method leads to wastage of seed and use of more labour 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 (Fig. 13), 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 (UBOS, 2010) while some farmers practice mixed cropping with cereals or legumes (Olupot, 2011). 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 (Manyasa et al., 2016).



Fig 12: Broadcasted Sorghum



Fig 13: Sorghum planted in rows at a spacing of 60cm between and 20cm within rows

3.5 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 (Olupot, 2011) 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 (Fig 14) 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.



Fig 14: Use of animal traction to weed sorghum

3.6 Fertilizer application

In Uganda sorghum is grown in soils with low fertility but farmers do not use fertilisers to enhance productivity (Olupot, 2011). 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 fertiliser 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.

3.7 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.

3.8 Harvesting of 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 (Fig. 15). In Uganda harvesting sorghum is predominantly done by women (Fig. 16) using a sickle or knife. For seed production harvest only disease free heads.



Fig 15: Harvesting of striga tolerant sorghum

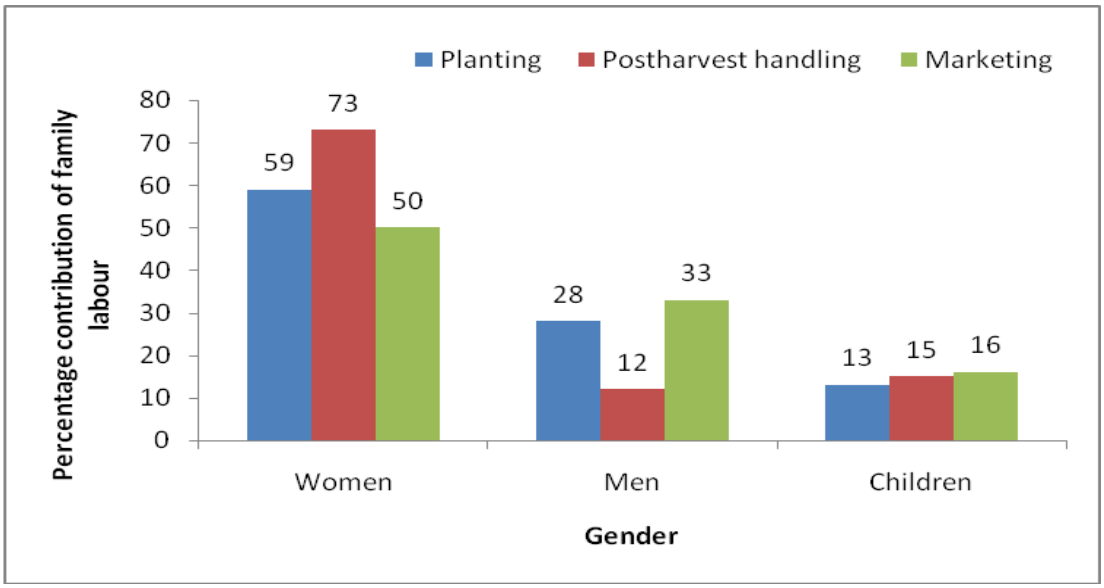


Fig 16: Contribution of family labour in sorghum production

4.0 SORGHUM PRODUCTION CONSTRAINTS AND CONTROL MEASURES

Sorghum is a hardy and versatile crop that survives well in harsh weather conditions, and much of it is produced in more marginal and stress-prone environments in the semi-arid tropics. Despite being hardy, the crop is affected both abiotic and biotic constraints that further reduce productivity. Abiotic constraints include: drought, low soil fertility, water logging and lodging. However, focus will be put on biotic constraints which include; diseases, insect pests, weeds, rodents and birds. Thus, various methods have been recommended for use in the management/control of damage in sorghum production.

4.1 Sorghum diseases

Sorghum is affected by many diseases but those of economic importance in Uganda include: covered kernel smut, grain mold, anthracnose, rust and ergot (Fig. 17). The severity depends on the variety and ambient conditions. Generally smut affects both the red/brown and cream/white seeded sorghum varieties while anthracnose affects mainly the local varieties and the leaf blight and ergot affect mainly the exotic sorghum.

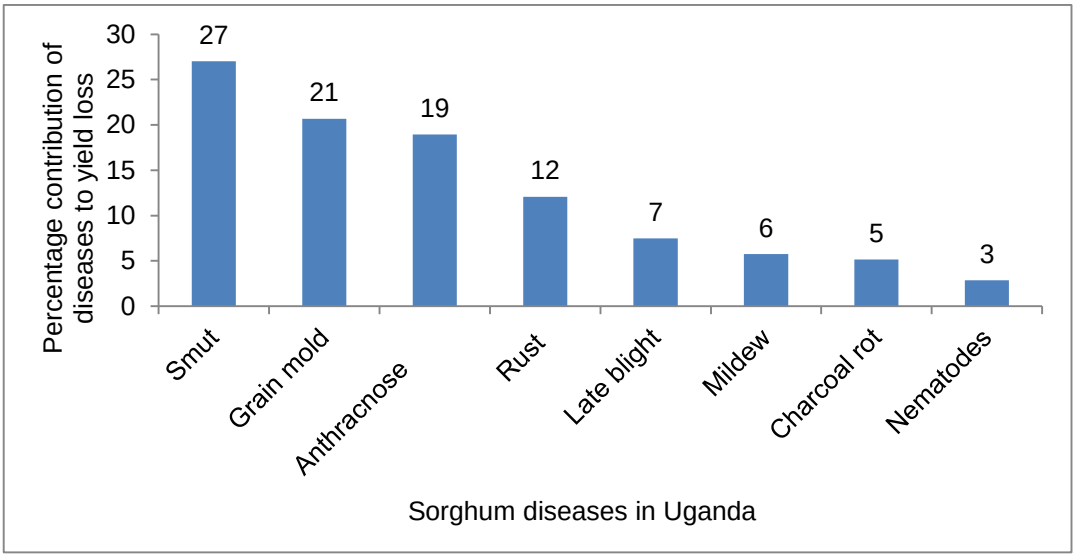


Fig 17: Major sorghum diseases in Uganda

4.1.1 Covered kernel smut

Covered kernel smut disease (*Sporisorium sorghi*) (Fig. 18) 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 of measures; 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.



Fig 18: Sorghum affected by covered kernel smut disease

4.1.2 Ergot

Ergot disease, caused by *Sphacelia sorghi*, (Fig. 19), also known as sugary disease affects the panicle producing mycelium in the affected grain. The affected spikelets 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 of ergot disease involves; 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.



Fig 19: Sorghum affected by ergot disease

4.1.3 Anthracnose

Anthracnose disease caused by *Colletotrichum graminicola*, (Fig. 20) that commonly attacks sorghum leaves, stems and panicle. Symptoms include brick red colouration in a lengthwise split stem. Small circular leaf lesions develop into mature lesions with straw-coloured centres that are reddish and blackish purple, and later coalesce into

larger necrotic tissue. Control measures include; 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.



Fig 20: Sorghum affected by Antracnose disease

4.1.4 Northern leaf blight

Symptoms of Northern corn leaf blight disease include long elliptical shaped lesions with grey centers and tan to red boarders (Fig 21). Control measures include; burning crop residues; deep ploughing at planting and crop rotation.


Fig 21: Sorghum affected by Northern leaf blight

4.1.5 Sorghum rust

Rust disease, caused by *Puccinia purpurea*, manifests as brown blister-like pustules formed on the upper and lower side of the leaf (Fig 22). 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 measures include; 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.



Fig 22: Sorghum affected by rust

4.1.6 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 (Atera and Itoh, 2011). The common striga in Uganda is *Striga hermontheca* (Del.) Benth (Fig 23). 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. 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.



Fig 23: Tolerant sorghum variety under high striga infestation

4.2 Major insect pests that attack sorghum

The most important sorghum insect pests include a complex of stem borers followed by shoot flies and midge. Other insect pests of minor importance are shown in Fig. 24.

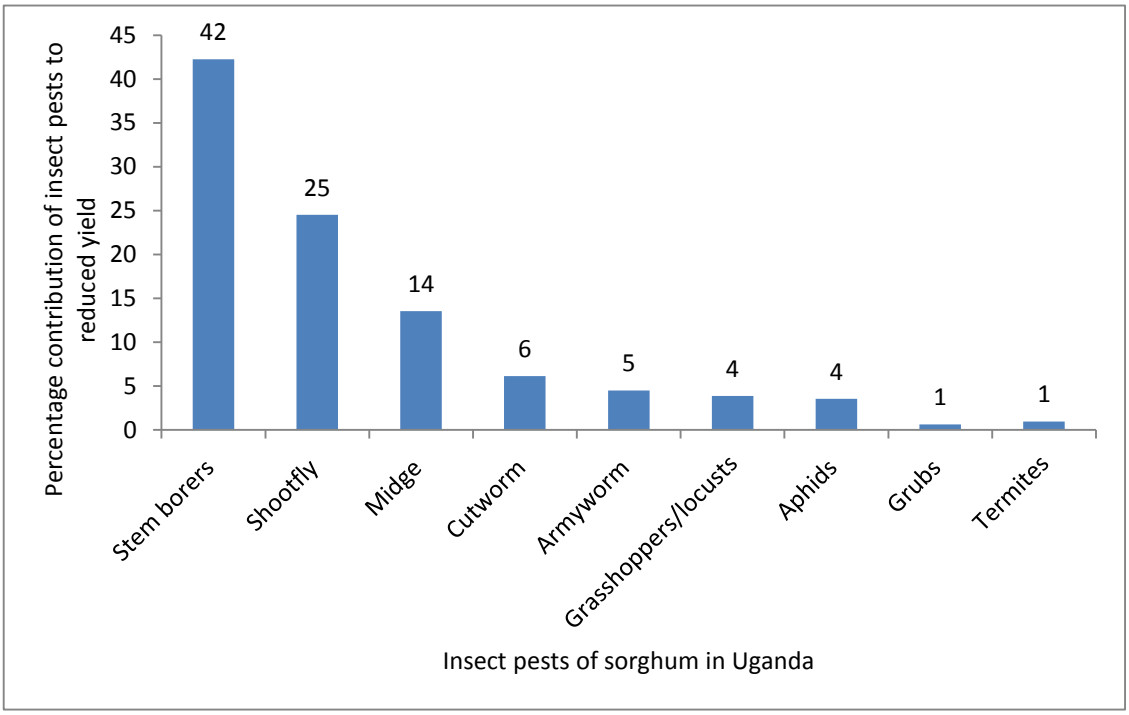


Fig 24: Major insect pests affecting sorghum production in Uganda

4.2.1 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 (Fig. 25), sugarcane borer, maize stalk borer and the pink borer (Matama-Kauma et al., 2008). Control measures include; 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.



Fig 25: Stages of stem borer *Chilo partellus*

4.2.2 Sorghum shoot fly

The shoot fly, *Antherigona soccata* Rondani (Fig. 26), 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 (Sharma and Nwanze, 1997). 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 measures include; 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 or use a botanical insecticide Neem oil 2%. A Combination of the above as integrated pest management is effective in reducing crop damage.



Fig 26: Stages of the shoot fly and dead heart damage

4.2.3 Sorghum midge

Sorghum midge, *Stenodiplosis sorghicola* Coquillet (Fig. 27), 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 (Sharma, 1997). 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 measures include; 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.



Fig 27: Female sorghum midge laying eggs on the sorghum spikelet and sorghum midge damage symptom

Fall army worm

4.2.4 Bird damage in sorghum

Birds are very destructive pests affecting sorghum productivity in Uganda. Several bird species are destructive but the Quelea quelea (Fig 28) 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.



Fig 28: Quelea quelea bird

5.0 POST HARVEST HANDLING AND STORAGE

Post-harvest losses in sorghum occur both in terms of quality and quantity of grain or seed. Loses may be caused by; harvesting sorghum before it is physiologically mature resulting in poor quality, late harvest when most of the grain/seeds have been eaten up by birds or have sprouted, infestation by storage pests, poor store management, poor drying of grains resulting to grain/seeds getting mouldy/rotten, poor threshing method-spillage of grain/seeds or breaking grain/seed, poor storage structures and poor packaging and during transport to market leading to spillage. To minimise the losses subsequent activities after harvesting should be done timely. Such activities include; transporting from the field, drying, threshing/winnowing and storage.

5.1 Drying

Drying is reduction of moisture to about 11-13% moisture content recommended for storage. Sorghum panicles are spread on a clean flat ground (Fig. 29), tarpaulin (Fig. 30), and cemented floor (Fig.31), 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 mouldy, resulting good quality grain and better market.



Fig 29: Drying sorghum on bare ground (common practice)



Fig 30: Drying sorghum tarpaulin (recommended practice)



Fig 31: Drying sorghum tarpaulin (recommended practice)

5.2 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 (Fig. 32) or pound it in a mortar with a pecel 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 minimise contamination reduce grain spillage. Winnowing is then done to remove trash and avoid mechanical seed mixing (Fig. 33). 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 minimise damage by moulds 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.



Fig 32: Threshing sorghum using sticks



Fig 33: Winnowing threshed sorghum

5.3 Storage and packaging

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 (Fig. 34). 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 moulds 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.



Fig 34: Farmer storing sorghum grains in a granary

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