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HANDBOOK ON IMPROVED AGRONOMIC PRACTICES FOR SORGHUM PRODUCTION IN NORTH EAST NIGERIA

Hakeem A. Ajeigbe, Ignatius I. Angarawai, Folorunso Akinseye, Abubakar H. Inuwa, Tukur AbdulAzeez and Michael B. Vabi

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Forward and Acknowledgements

This handbook is intended to guide farmers, extension personnel, students of agriculture and researchers in Nigeria to use improved varieties and associated production practices to increase productivity. The guide draws its lessons from the work and experiences of ICRISAT and its partners in Research for Development on crop-based systems in Nigeria. The publication of this handbook is a demonstration of effective collaboration between ICRISAT, Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU) Zaria, National Agricultural Extension Research and Liaison Services (NAERLS), Federal Ministry of Agriculture and Rural Development (FMARD), numerous farmers' groups and Innovation Platform (IPs). The authors are grateful to the Management of these Institutes and organizations and gratefully acknowledge the work of other researchers that have helped immensely in compiling this manual.

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Prakash Kant Silwal,
Chief of Party,
USAID Feed the Future Nigeria Integrated Agriculture Activity,
International Institute of Tropical Agriculture,
IITA Abuja Station, Kubwa, Abuja FCT, Nigeria.

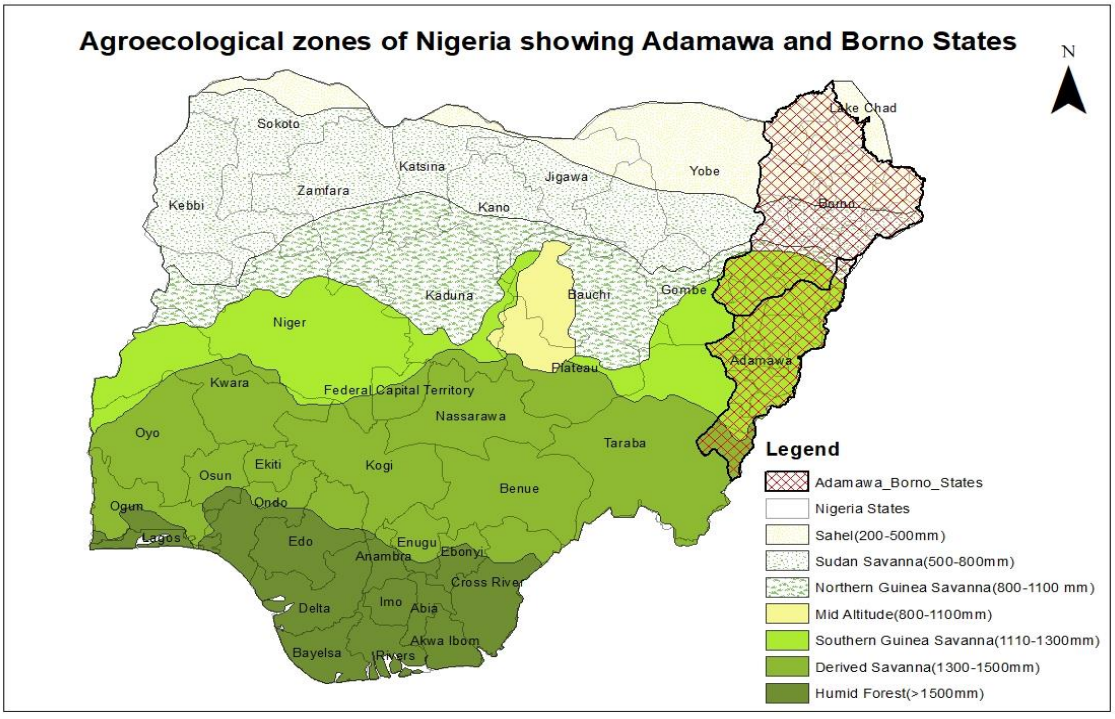
Contents

1. INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench), is an important food crop in Africa and is the fifth most important cereal crop grown in the world as well as the most important cereal food in the Northern states of Nigeria that cover the Sahelien, Sudanian and Guinea Savannah ecological zones. Sorghum is locally called guinea-corn or *dawa*, the most widely cultivated cereal crop and the most important food crop in the Savanna areas of Nigeria. Nigeria is the second largest producer of sorghum, grown on about 5.9 million ha with current annual production estimated to be about 6.7 million tonnes. Sorghum is grown by over 59% and 55% of farmers in Adamawa and Borno States, respectively. It is mostly grown for domestic consumption and the excess sold to generate income. Among the constraints to sorghum production are subsistence farmers who do not invest much in fertilizer and improved varieties, rising labor cost, changing consumer food preferences, bird attacks and parasitic weeds such as *Striga*. Another major problem is the variable rainfall that leads to wild fluctuations in production. Prices fall abruptly in good years, leaving traders reluctant to enter the market. This increases the price risk that sorghum producers face; hence their reluctance to invest in commercial sorghum production.

1.1 Uses of Sorghum

A majority of the domestic produce is used for household consumption by many rural communities. It finds uses in the production of beverage, malt, sorghum meal, and livestock feed, among others. Whole grain is ground into flour used to make traditional foods. Sorghum is mainly used as flour or paste processed into *tuwo* (thick porridge), *kamu* (thin diet porridge), and *pate* (soup like and light porridge mixed with vegetables, sometime containing beans). A gradual increase in demand for pre-processed sorghum convenience foods as well as for industrial sorghum products has been observed. Sorghum is also processed into malt for malted drinks and foods, high quality flours, and as a raw material for the poultry and fish feed industries. Sorghum is also processed into cake, biscuits, sweets and other confectionaries.



2.0 Sorghum Production in Nigeria

Though sorghum is produced in almost all the states of Nigeria, Adamawa, Bauchi, Benue, Borno, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Kogi, Kwara, Nasarawa, Niger, Plateau, Sokoto, Taraba, and Zamfara States are the major producers.

2.1 Cultivation Practices

Sorghum is a warm weather crop that requires high temperature for good germination and growth. The best time to plant is when there is sufficient moisture in the soil. To exploit its inherent yield potential, medium to good and fairly stable rainfall evenly distributed during the growing season are required.

2.2 Soil Requirements

Sorghum can grow on different soils, but optimum grain and stover yields come from when grown on deep fertile, well-drained loamy soil. Clay-loam or loam textured soils with good water retention capacity are best suited for it. Though it can also grow in poor and sandy soils not suitable for maize and rice, it responds better to increased soil fertility. It is more tolerant of alkaline salts than other grain crops and can therefore be successfully cultivated on soils with a pH (KCl) between 5.5 and 8.5, and can also tolerate short periods of waterlogging.

2.3 Climatic requirements

Temperature plays an important role in the growth and development of all crops, sorghum included. The minimum temperature for germination varies from 7ºC to 10ºC. At a temperature of 15ºC, 80% of seed germinates within 7 to 10 days after sowing. The best time to plant is when there is sufficient moisture in the soil and the soil temperature is 15ºC and above. A temperature of 27ºC to 32ºC is required for optimum growth and development. Exceptionally high temperatures cause a decrease in yield due to pollen abortion.

Sorghum is a short-day plant, which means that the plant requires short days (long nights) before proceeding to the reproductive stage. The optimum photoperiod, which will induce flower formation, is between 10 and 11 hours. Photoperiods longer than 11 to 12 hours stimulate vegetative growth. Sorghum plants are most sensitive to photoperiod during flower initiation. The early maturing varieties are photoperiod insensitive.

Sorghum is produced under variable average rainfall conditions between 300 mm and 1,200 mm, for optimum yield. A medium- to late-maturing sorghum cultivar (i.e., maturing within 110 to 145 days) requires approximately 450-800 mm of water during a growing season. Daily requirement varies greatly depending on the growth stage (Fig. 1) and the type of variety grown. Extra-early-maturing varieties have lesser water requirements than medium- and late-maturing genotypes.

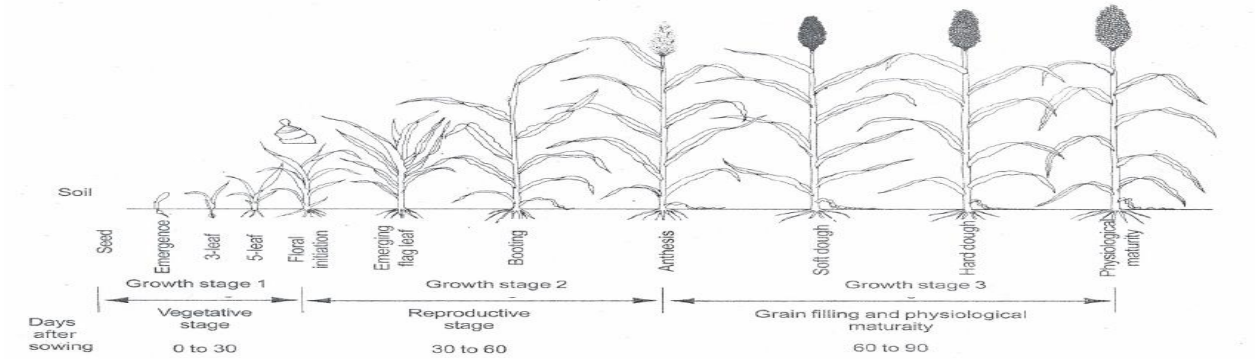


Figure 1. Growth stages of sorghum.

2.4 Land Preparation

Sorghum requires a well-prepared seed bed for good establishment and well-drained fertile land that has been left fallow for two or more years or preferably cropped with legumes in the previous season. It is recommended that farm yard manure (FYM) at the rate of 2-5 t/h be incorporated into the soil at ploughing. However, 1 t/ha annually is good enough to help improve soil structure, moisture retention, and nutrient content. Land preparation depends on the system of sowing. In conventional tillage, plough/harrow and make ridges at 75 cm row spacing. Minimum tillage has been found to be suitable for good yields in drier areas, aiding moisture conservation and reducing production cost.

Plate 1: (L) An animal-drawn ridger runs over the field after FYM application and (R) a well-prepared sorghum field.

2.5 Planting Date

Planting date is determined after the arrival of rainfall. The crop is normally planted from end of May in southern Adamawa State to end of June or early July in northern Borno State, when there is adequate moisture in the soil, depending on the location and variety to be used. The choice of planting date is critical so that the period of critical moisture need does not coincide with a drought period and maturity does not coincide with a drier period.

2.6 Choice of Variety

Variety choice aims to reduce risks by avoiding drought periods during the most critical growing stages of the plant, such as flowering and seed set. Varieties differ in their reaction to the environment and the climate. The yield potential of the farm or field should be known as well as the long-term rainfall pattern to be able to make the best cultivar choice. Long-term rainfall data is usually used as a guide to choose the variety with the appropriate length of growing season suited to the target area. Characteristics such as disease and insect resistance, lodging and head placement are some important factors to be kept in mind when choosing a variety.

Table 1: List of some improved sorghum varieties.

S/No	Variety	Outstanding Characteristics	Agro-ecological adaptation	Maturity
1	SAMSORG 14	- Semi-dwarf - Compact head - White seeded - Resistant to leaf diseases - Height: 140-150 cm	Sudan Savannah	Early maturing (110-120 days)
2	SAMSORG 17 (SK5912)	- Semi-dwarf - Head is semi-compact and ecliptically shaped - Seeds are yellow and of medium size - Tolerant to Striga - Resistant to major leaf diseases	Northern and Southern Guinea Savannah	Late 160-180 days
3	SAMSORG 40 (ICSV 400)	- Dwarf: small seeds - Compact, cream color - Tolerant to Striga - Resistant to major leaf diseases	Sudan and Sahel savannah	Early, 75-85 days
4	Samsorg 41 (ICSV 111)	- Dwarf: small seeds - Compact, cream color - Tolerant to Striga - Resistant to major leaf diseases	Sudan and Sahel Savannah	Early, 80-90 days
5	CSR 01	- Excellent grain quality for industrial use in malting and brewing	Sudan Savannah	110-130 days
6	CSR 02	- Excellent grain quality for industrial use in malting and brewing	Sudan Savannah	110-130 days
7	SAMSORG 44 (SSV20043)	- High yielding - High CHO (flour) - Bold and white seeded -Stay green	Sudan Savannah	120-140 days
8	SAMSORG 45 (Improved Deko)	- Early maturing -High yielding -High micronutrient content	Sudan and Sahel Savannah	85-95 days
9	SAMSORG 46 (Improved Zabuwa)	- Early maturing -High yielding, -Moderate micronutrient content	Sudan and Sahel Savannah	85-95 days
10	SAMSORG 47 (Zauna Inuwa)	- Medium maturing -High yielding -Moderate micronutrient content	Northern Guinea Savannah	110-120 days
11	SAMSORG 48 (Kaura Borno)	- Medium-late maturing - High yielding	Northern Guinea Savannah	115-125 days
12	SAMSORG 49 (CF 35.5)	- Early maturing - High yielding - Medium size grain - Striga tolerant	Sudan and Sahel Savannah	75-85 days
13	CSR-03-H	- Good malting quality	Sudan and Sahel Savannah	90-100 days
14	CSR-04-H	-Good malting quality	Sudan and Sahel Savannah	90-100 days

2.7 Seed Rate and Dressing

To plant a sole crop of sorghum on one hectare of land, 8-10 kg of seeds are needed. Seeds are planted 3 - 5/hole and at 25 - 30 cm distance between stands for good germination. Most soils are contaminated by soilborne disease-causing pathogens. In some cases, soil pests such as root-knot nematode may be found. Before planting, all seed must be dressed. A sachet of Dithiocarbamate (Mancozeb) or other appropriate seed dressing chemical is

enough to dress 4 kg (2 *mudus*) of seeds.

2.8 Planting

Sorghum can be planted manually with a hand pushed planter or an animal-drawn or machine-drawn planter (a tractor-drawn seed drill with 4 coulters that simultaneously cover seeds by a blade attached to the seed drill). Sorghum should be sown at an inter-row (between rows) spacing of 75 cm and intra-row (within rows) spacing of 25 to 30 cm. A planting depth of 5 cm is ideal with sufficient moisture. Under drier conditions, the seed should be planted deeper, but no more than 5 cm.

Plate 2: (L) Manual planting and (R) an animal-drawn planter.

2.9Thinning

Thinning is recommended two weeks after sowing. The seedlings are thinned to two stands per hill. Where gaps exist, there is a need to transplant when the soil is wet and preferably in the evening. The transplants should carry as much root as possible and the foliage should be slightly pruned to reduce evapo-transpiration and transplanting shock. The transplants are to be planted upright. In both the sowing and the transplanting, the soil around the plant should be firmed up.

Plate 3: Germinating sorghum field.

2.10 Fertilization

A blanket application of NPK (15:15:15) fertilizers at the rate of four bags (200 kg) per hectare at planting and urea at the rate of 2 bags (100 kg) per hectare applied prior to flowering is recommended under good soil moisture. It is appropriate to use an animal-drawn ridger or hoe to cover the soil after application. For optimum yield, FYM application of 2 to 5 t/ha and well incorporated during land preparation is recommended. It helps in improving the soil structure, moisture retention capacity in drier areas as well as the nutrient content.

2.11 Fertilizer Micro-dosing

Micro-dosing involves the application of small, affordable quantities of fertilizer with the seed at planting time or as top dressing 4 to 5 weeks after emergence. This enhances fertilizer use efficiency instead of spreading fertilizer over the field, and improves productivity. The practice involves burying 2 cork stoppers full of NPK 15:15:15 in a 5 cm deep hole 5 to 10 days after emergence, followed by a top dressing with 1 cork stopper full of urea 4 to 5 weeks after sowing. Micro-dose can also be done combining organic and inorganic fertilizers or with organic fertilizer alone. One hand full (100-200 g) of organic (cow or sheep and goat dung) per hill is sufficient. Poultry manure could also be used in place of cow/sheep manure at the rate of 50-100 g per hill. Poultry manure has been found to contain more elemental fertilizer nutrients than ruminant manure.

Plate 4: Micro-dose fertilizer application.

2.12 Weeding

Weed control in sorghum is crucial, especially during the first six weeks after sowing, as weeds compete vigorously with sorghum for nutrients and water during this period. Weeding is done about 2 to 3 times at intervals of 3 to 4 weeks depending on weed severity.

- ***Physical methods:*** Weeds can be removed mechanically, using manual labor or simple implements (e.g. hoes, cutlass).
- ***Chemical methods:*** Chemicals formulated as liquids, granules or gasses can be applied to kill germinating or growing weeds or seeds. It is important to cultivate fields before applying herbicides prior to emergence or use selective post-emergence herbicides (see the Integrated Agriculture Activity's Safer Use Action Plan (SUAP) for recommended herbicides).

The root parasite *Striga* is one of the most important challenges in sorghum production that can damage the crop. It mainly occurs under low input farming conditions. The parasitic weeds are single stemmed with bright red flowers. Most of the damage is done before the parasite emerges from the soil. The symptoms include leaf wilting, leaf rolling, and leaf scorching even though the soil may have sufficient water. The tiny seeds are disseminated by wind, water, and animals, and remain viable in the soil for 15-20 years. Rotation with cotton, groundnut, cowpea and pigeon pea will reduce the incidence of S*triga* on sorghum fields. Hand pulling the plants before flowering may help. Some of the improved varieties are tolerant or weakly resistant to Striga. There is no complete resistance to Striga by sorghum. Weakly resistant implies that fewer number of Striga weeds will emerge on the sorghum crop and the damage is less compared to susceptible varieties.

Plate 5: A mature field of (L) SAMSORG 45 and (R) CSR04H

2.13 Harvest

The harvesting time of sorghum varies with location, variety, and planting date. The early-maturing varieties planted in Borno State mature early and are ready for harvest in October, while the medium-maturing varieties are ready in November. In Adamawa State, early- and medium-maturing varieties are harvest by the end of November while late-maturing varieties are harvested in early December. When sorghum is mature and ready for harvest, the leaves will turn yellow to brown, with the lower leaves drying up completely. To ensure that the grain is mature, pluck out a few grains from the panicle and check the point of attachment. If the tip is brownish black, it signifies that the grain is mature and has stopped connection with the plant. If it is greenish, then it is still getting nutrients from the plant. Mature grain will be hard and panicle well filled. As soon as the crop is mature, harvest should commence immediately as some of the varieties tend to shatter, thereby reducing crop yield. For tall and medium-dwarf varieties, the plant is cut down before the panicle(s) (head) is cut off. For dwarf varieties, the panicles are cut off directly from the plant and are packed in a basket or bag. In both cases, the heads are either allowed to further dry in the field or taken home straight for further drying.

2.14 Threshing

This process separates the grains from the panicles of sorghum. It is often done manually by pilling the sorghum heads in a small heap on clean slabs/floor to avoid contamination using sticks. The loose grains are then separated from the chaff by the use of calabashes or a similar container. This rhythmical up-and-down movement of the container with the chaff being blown away by the wind on a breezy day is a very tedious method. Also, threshing can be

done mechanically with motorized threshing machines. Currently, locally fabricated mobile multipurpose threshers are available.

Plate 6: (L) A motorized multi-crop thresher and (R) manual threshing of sorghum.

2.15 Storage

An estimated 35% of produce is lost through insect damage in storage. The major storage pests of sorghum are grain moth (*Sitotroga cerealella*) and grain weevil (*Sitophilus spp.*). Infestation takes place in the field and in old granaries where insects are already present in the stores and also by cross-infestation between granaries during storage.

Sorghum can be stored in airtight containers. PICS bags or modified triple bags which will not allow inflow of air during storage are recommended. PICS bags are available in major markets and towns in Adamawa and Borno States. Also ensure grains are clean with no pathogen and insect before storage. The safe moisture content for storage is less than 12%. A simple method of knowing if your grain is dry, is to break a few grains with your teeth. If they break with a cracking sound, then you can safely assume your grain lot is dry sufficiently for storage. Sorghum cleanliness, however, is another factor that might affect air movement within the grain during storage and reduce the risk of spoilage. The most cost-effective method of limiting the relative humidity in the air space in the grain mass is to control grain moisture (through proper drying) and temperature (by aeration during storage).

3.0 Major Diseases of Sorghum in Nigeria

Sorghum is also attacked by a complex of diseases caused by bacteria, fungi, and viruses. However, improved varieties are largely resistant to the most common diseases. Diseases can be controlled through cultural and mechanical means and through chemical control. The most effective and cheapest way of control is through the use of resistant varieties. Chemical control must always involve strictly following the safety directives of crop protection officers since the chemical must not harm the user, the environment and the off-takers of the crop. The following are some common diseases in Adamawa and Borno State and their control.

3.1 Seedling Blight

Seedling blight is often referred to as "damping off disease." Seedling diseases may be caused by soilborne pathogens, soil, weather and climatic factors, seedling vigor, or any combination of these factors. The primary seedling disease pathogens are Pythium, Fusarium, Aspergillus, and Rhizoctonia which may occur independently or in combinations to cause seedling disease problems.

Control: Using high quality seed, planting when soil temperature is higher, and the use of appropriate seed treatments will minimize seedling disease concerns.

Plate 7: Seedling blight in sorghum.

3.2 Anthracnose

This is the most important foliar disease in both local and improved sorghum varieties caused by *Colletotrichum graminicola* (*C. sublineolum*). It is most prevalent and destructive in the northern and southern Guinea Savannah zones.

Symptoms: Three symptom types (foliar, panicle and stalk) are reported. Recent reports suggest panicle anthracnose is now prevalent in farmers' fields. It is reported that foliar infections can cause up to 47% yield losses in susceptible varieties. Variation in foliar population of *C. graminicola* has been established in Nigeria. There are currently six physiological races in Nigeria.

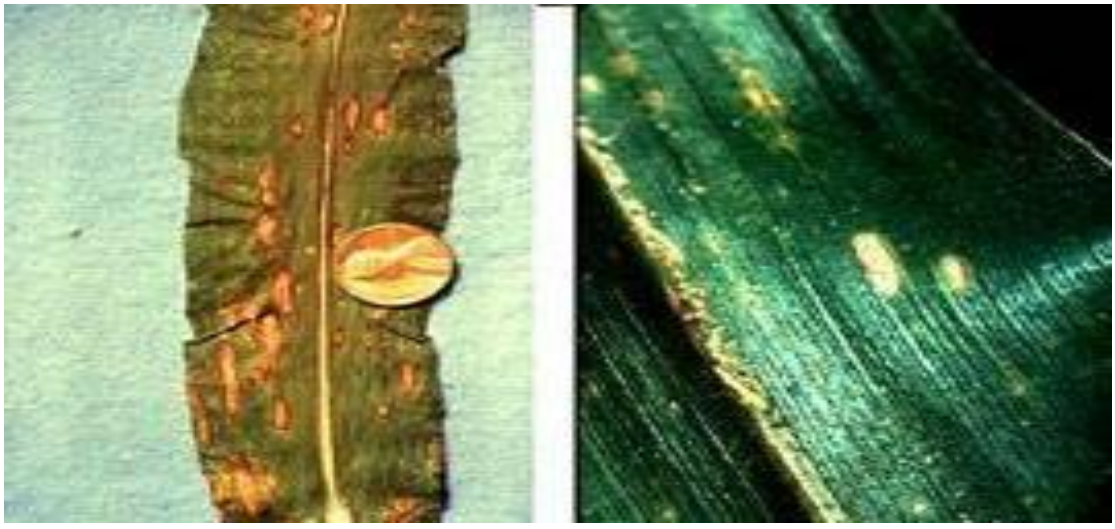


Plate 8: Anthracnose leaf blight.

Control: Management of the disease depends on fungicides and the use of resistant varieties.

3.3 Smut

Smut is the the most widespread group of sorghum diseases in Nigeria, which can cause damage in both traditional and improved cultivars. There are four types of smut in rainfed sorghum: grain or covered smut (*Sporisorium sorghi),* loose smut (*Sporisorium cruentum*), head smut (*Sporisorium reilianum),* and long smut (*Sporisorruim ehrenbergii*). Covered smut is the only post-rainy season smut of sorghum grown in the Lake Chad area. The prevalence of smut varies with location. Covered smut is prevalent in the Sahel, Sudan, Northern Guinea Savanna (NGS) and Southern Guinea Savanna (SGS) zones. Head smut is most prevalent in the SGS zone, with sporadic occurrence in NGS and the Sudano-Sahelian zones. It occurs primarily on late-maturing cultivars and is typically soilborne with infection at seedling stage.

Control: Covered and loose kernel smut are easily and effectively controlled by treating the seed with appropriate fungicide. Seed treatment prevents introducing the head smut fungus into non-infested fields, because there are a number of physiological races of the smut fungi, which can also hybridize with one another. It is extremely difficult to develop highly resistant or immune hybrids, varieties or cultivars. Those varieties, hybrids, and types of sorghum that are resistant to races of covered kernel smut usually are resistant to races of loose kernel smut. Where feasible, promptly remove and burn head smut galls before the spores are scattered. Since the head smut fungus may live in the soil for several years, grow sorghum in the same field only once in 4 years. Such rotation also helps to control other diseases that attack the leaves, heads, stalks, and roots. Long smut can be controlled by planting varieties that will attain flowering at least 15 days to the end of terminal drought.

Plate 9: Different types of sorghum smut.

4.0 Major insect pests

In addition to diseases, sorghum is also attacked by a number of insect pests. Most of these attacks are sporadic, especially with late planting or too early planting and when sorghum is continuously cultivated on the same plot, encouraging the buildup of diseases and pest. They can usually be controlled by cultural practices. Occasionally, the sorghum fields may need chemical protection.

4.1 Spittle bug

The spittle bug (*Poophilus costalis* Walker) is a serious pest of late planted sorghum in the northern Guinea and Sudan Savanna zones. The bug causes considerable damage by feeding on sorghum leaves and within leaf whorls, resulting in chlorotic spots and botches on the leaves. In very severe cases of infestation, the plants become stunted in growth, producing smaller panicles. The pest can attain high densities in late or phased planting. The adult bugs are usually small, brown or grey jumping insects, usually 11 mm long. The nymphs always remain inside a foamy spittle mass resting head downwards on the plant.

Control: Early plantings escape spittle bug infestation as chemical control is not usually necessary. However, in late sown seed production plots, application of cypermethrin controls the insect.

4.2 Sorghum shoot fly

The shoot fly (*Antherigona soccata)* is a widespread and damaging pest in all sorghum growing areas of Nigeria. The damage is the result of larval feeding on the central leaf which wilts and later dries up, giving the characteristic dead heart symptom. The dead heart can be easily pulled out and, at the base, emits a bad smell. The young whitish yellow maggot feeds only on the decaying tissue. Normally, the damage occurs from one week to about one month after emergence. If the attack occurs a little later, plants produce side tillers that may also be attacked. Late sowing during the rainy season increases the likelihood of attack.

Control: The more promising control measures are the adjustment of sowing dates, high seeding rate, use of higher yielding shoot fly-resistant cultivars and the use of cypermethrin.

4.3 Stem Feeders

The stalk borer (*Busseola fusca* (Fuller)) is a very important pest of sorghum in Nigeria, especially in the northern Guinea and southern Sudan Savanna zones. Young larvae feed on leaves, while more mature larvae bore into the stems and produce dead hearts. In severe cases of infestation, plant growth is retarded and flowering and grain production are seriously reduced. Adults normally exhibit a wide variation in color and usually, three generations are produced per year. The third-generation larvae enter into diapauses with the onset of the dry season and complete their development in 5-7 months.

Control: Management or control is achieved by the destruction of dry stalks and stubble by burning, or ploughing reduces borer density. Early sowing reduces infestation. Insecticides such as carbaryl are known to be effective.

4.4 Sorghum midge

Sorghum midge (*Contarinia sorghicola*) is probably the most widely distributed in the Sudan Savanna zone of Nigeria. Damage to sorghum is caused by larvae feeding on the ovary, preventing normal grain development and resulting in a blasted panicle. The pupal stage in a generation lasts only 3 days. Because of this rapid developmental cycle, 9 to 12 generations could occur during one cropping season, thus resulting in the buildup of high populations and infestations when sorghum flowering times are extended by a wide range of planting dates or maturities.

Control: Control is achieved by early and uniform planting of sorghum over large areas and is the most widely accepted method of reducing midge damage. Multiple insecticide applications directed at adults are used primarily to reduce losses in late plantings.

Plate 10: Sorghum midge.

4.5 The Head bugs

The head bug, *Eurystylus oldi* is a serious pest of sorghum in Nigeria. The nymphs and adults, suck the nuts sap from developing grain. The damage starts as soon as the panicle emerges from the boot leaf. Bug damaged dust grain shows distinct red to brown feeding punctures which lead to both quantitative and qualitative losses. Head damage spoils the grain quality, and renders the tan unfit for human consumption. Such grain also shows poor germination. Bug damage also increases the severity of grain molds.

Plate 11: Leaf footed bug on a sorghum panicle.

Control: Host plant resistance remains the major control measure. The use of open panicle sorghum varieties reduces incidence of head bugs.

4.6 African Army Worm

The army worm (*Spodoptera exempta* Walker) is an occasional pest of sorghum in Nigeria. It occurs periodically in major outbreaks, resulting in extensive crop losses. It is a general grass feeder, attacking pasture grasses and other cereal crops. The damage is caused by the larvae. They are gregarious and move through the vegetation at very high infestation rates. Solitary larvae are green, but the gregarious forms have black with green undersides. Pupation occurs in soil and the adults emerge in about a week. Moths migrate long distances, giving rise to outbreaks away from the site of infestation. Outbreaks are usually associated with rain.

Control: Major outbreaks can be controlled only if national or state organizations apply insecticides in outbreak areas. It is very important to detect infestation at an early stage. Small infestations can be controlled by using insecticides (see the Integrated Agriculture Activity's Safer Use Action Plan (SUAP) for a list of recommended insecticides).

4.7 Grasshoppers

Grasshoppers (*Oedalus senegalensis*, Krauss) are a major pest, especially in the Sahel zone of Nigeria. They attack all stages of the plant, but most losses occur when the crop is attacked at the seedling stage or during ripening of the panicles. Both nymphs and adults feed on sorghum as well as other cereals and wild grasses.

Control: It can be controlled by using insecticides.

5.0 Insect pests of stored sorghum

5.1 Maize weevil

The weevil (*Sitophilus zeamnis*) and related species such as rice weevil (*S. oryzzae*) are the most destructive insect pests of stored sorghum grain in Nigeria. They infest a very large variety of stored grains, are cosmopolitan in distribution but are much more damaging in warm humid conditions. Both adults and larvae feed on grain, which may often be damaged beyond use.

Control: Storing grains under dry and clean condition, in insect proof containers are some control measures. If the grain moisture content is less than 9%, the insect is unable to feed. If keeping the grain dry is not practical, fumigation may be the only feasible protection.

5.2 Flour beetles

The confused flour beetle (*Tribolium confusum*) and the flour beetle (*T. castenum*) are generally widely distributed. They are found infesting stored sorghum and other grains in granaries and warehouses. Larvae of *T. confusum* feed on flour or other materials such as grain dust and broken surfaces of grain kernels. They are primarily secondary feeders. Adult beetles of *T. castenum* can readily be observed by the tunnels they construct when they move through flour or other granular products. When the attack is severe, contaminated grain or flour turn grayish yellow and become mouldy, with a pungent smell.

Control: Storing products in sealed containers provides effective control. Fumigants are also effective.

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ICRISAT HIGHLIGHT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in the drylands of Asia and sub-Saharan Africa. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid or dryland tropics has over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT and its partners help empower these poor people to overcome poverty, hunger and a degraded environment through better agriculture. ICRISAT is headquartered in Hyderabad, Telangana State, in India, with two regional hubs (Nairobi, Kenya and Bamako, Mali) and country offices in Niger, Nigeria, Zimbabwe, Malawi, Ethiopia and Mozambique. ICRISAT conducts research on six highly nutritious drought-tolerant crops: chickpea, pigeon pea, pearl millet, finger millet, sorghum and groundnut. ICRISAT envisions prosperous, food-secure and resilient dryland tropics. To achieve this, its mission is to reduce poverty, hunger, malnutrition and environmental degradation in the dryland tropics. It approaches this through partnership-based international agricultural research for development that embodies *Science with a Human Face*. ICRISAT's strategy is anchored on socio-economic process called inclusive market-oriented development (IMOD). ICRISAT has defined six developmental outcomes that it believes will help the poor to move along the IMOD path: food sufficiency, intensification, diversification, resilience and health & nutrition, and women empowerment. Significant reductions in poverty and increases in food security in the dryland tropics are possible through this route. ICRISAT believes this is the way to meet its inspirational targets of halving the incidence of poverty in smallholder farming households, halving the incidence of hunger, halving childhood malnutrition and significantly increasing the resilience of tropical dryland smallholder farming.