CHAPTER 3

SORGHUM.

D. A. Aba, N.UA. Idem, P. S. Marley, and* D. N. *Maigida

Institute for Agricultural Research, Ahmadu Bello University, Zaria

Introduction

Sorghum (*Sorghum bicolar* (L.) Moench) is one of the commercial cereal crops in the world with more than 40 million hectares dedicated to it's cultivation (FAO, 1993) with Asia (9.6 million hectares) as a leading continent, followed by Africa (5.7 million hectares) North and central America (2.7 million hectares) Australia (0.73 million hectares) and USSR (0.18 million hectares) (Dogett, 1988). It ranks fifth in importance among cereal grain crops in the world behind wheat, rice, maize and barley (Smith and Bhaskaran, 1986); sixth among important dietary sources of energy for the world's population (Cock, 1985). Although tropical in origin, it is cultivated geographically between latitudes 45°N and 35°S and thrives in areas with 3000-14mm rainfall and at altitude as high as 7100m above the sea level.

Sorghum is a major stable food in many parts of the world. It has very extensive use as a food crop in Africa, Asia, and as a major food grain in North America and more recently in South Africa (Picket and Oswalt, 1979). Sorghum locally called guinea-corn, is the most widely cultivated cereal crop and the most important food crop in the savanna areas of Nigeria. Sorghum production in Nigeria spans from the derived savanna in the southwest and southeast into the southern Guinea savanna, into the northern Guinea and the Sudan ecologies. It is cultivated between latitude 6° 30'N and 14°N all in the savannas of the country. Sorghum accounts for 50% of the total cereal production (including rice, maize, millet and wheat) and occupies about 46% of the total land area devoted to cereal production. In terms of hectarage, about 6 million hectares of land is put under sorghum production with average yields of 1.7t ha^{-1} and a total production of 6 million tonnes annually (NAERLS, 1996). This is a very versatile and hardy crop, being adapted to highly varying environment. In the savanna and semi-arid Sahel regions, millions of people consume sorghum in their daily diets as staple food. Sorghum is mainly used in the form of flour or paste processed into two main dishes. "Tuwo" a thick porridge and *OGI* or *KAMU* a thin diet or porridge (Obilana *et al.*, 1984). Other dishes that are sometimes made from sorghum include a number of deep fried snacks, steamed dumplings and other boiled or roasted snack foods (Obilana *et al.*, 1984.)

Breeding Programme

The most common landraces of sorghum in Nigeria are Kaura, Farafara and Guinea. The Tchad, Sokoto Unibellati and Truncate races are less common (Curtis, 1967). There are three common races of sorghum grown as rainfed crops in virtually all the ecological zones of the country. The Tchad race (earliest maturing) are restricted to Lake Chad Basin and

comprise both the rainfed types and a specialized type called the *'MASAKWA'* or *'MOSKWARI'* (Ogunlela and Obilana. 1983) which is grown during the dry hamattan season on dry soils where the fields are flooded during the rains and the residual moisture is sufficient to carry the crop to maturity without supplementary irrigation. They are photoperiod sensitive types and have a thick pericarp.

Generally, members of kaura race are high yielding with characteristically long and compact, semi-compact heads, very large grains with a yellow endosperm and pericap, and the panicle shape varies widely in shape, glummer colour and glummer covering. A panicle length of 55cm. has been recorded in this group of sorghum (Prasada Rao, *et al.*, 1981). The Kaura are mostly adapted to and cultivated in the Sudan savanna but some are also grown in the northern Guinea savanna zone.

This race has excellent combining ability which results in the production of excellent crosses. (Obilana, *et al.*, 1984).

The Farafaras are mostly guinea-candatums with conspicuous dark and light glummes. This group has a thick white pericap and a white endosperm. Some have a coloured testa (surcoat). Farafara race are early maturing and high yielding with the added advantage of having white grain which is mostly preferred by the farmers. These sorghum are adapted mainly to the northern parts of the Sudan nd Sahel savanna zones of Nigeria. The semi-dwarf to semi-tall "wash" types sorghum mostly dura and a few caudatum (Obilana *et al.*, 1984) which are extensively cultivated on the sand dune of Jigawa and Borno states, are within this race.

These wash types have been observed to be tolerant and possibly resistant to drought.

The Guinea sorghum are most widely cultivated and adaptable race. They are most common in the southern and northern Guinea savannas and are also found in the southern parts of Sudan Savanna where it is wetter (Plate 3.1).

Plate 3.1: Field of Sorghum, IAR., Samaru

The members of this race are typically tall highly photoperiod-sensitive and medium maturing with loose, very long and broom-like panicles. The grains are characteristically flattened, fluffy, translucent and easily threshable, and have good quality for local food dishes. The mesocarp is in and the colour of the pericarp vary from red, yellow or white. Colored testes are absent while corneous endesperm is common. Guinea sorghum of West Africa including Nigerian are

known to be resistant to weathering (Harlan and Dewet, 1972) and suffer little or no damage from insect infestation and have high recovery abilities. Leaf diseases even though common and symptoms may be visually and copiously present in the plant, do not cause any appreciable losses. Majority of the guinea sorghum grown in Nigeria belong to the subrace *Guineance* which are adapted mostly to the southern and northern Guinea savannas. While a few belong to the subrace *Conspicum* which are adapted to the high land areas of both southern and northern Guinea savanna zones (Table 3.1).

TABLE 3.1. Nigerian land races of sorghum.

Landrace (Common name)	Taxonomic Race	Species	Natural adaptation Zone
Kaura	Kaura	Durra-Caudatum	Sudan savanna, northern Guinea savanna, southern Guinea savanna.
Farafara savanna	Farafara	Guinea-caudatum	Sahel and Sudan
Farafara	Guinea	Guineense	Sahel and Sudan savanna
Muri		Conspicum	
Onakkalori			
Firbuji			
Sana-dawa	Chad	Durra-Caudatum	Sahel and Sudan savanna
Sanbul			
Arkunja			

'Kauras', 'Farafaras' and 'Guineas' sorghum are variously tolerant to *Striga* in all the savanna zones and are agronomically alike with desirable characters such as drought tolerance and high yields.

Within the inter-zones, among the four ecological zones, several intermediates between and among these major races abound. Thus there are the Durra-guinea, Guinea bicolar and Guinea-dura (Prasad Rao *et al.*, 1981). These local sorghum range in grain yield from 14.0 g/plant to 175g/plant with an average of 98 g/plant.

Sorghum improvement.

Sorghum improvement by breeding started in 1956, (Obilana 1983) years of selection in the Institute for Agricultural Research (IAR) Samaru with the genetic mandate for sorghum improvement have resulted in the development and release of sorghum varieties which are suited to the specific ecological zones in Nigeria. The criteria used in their development have included a combination of desirable factors of adaptability, acceptable plant height, seed colour and quality, resistance/tolerance to *striga* and high yield.

Plate 3.2: SAMSORG 17(SK 5912), IAR., Samaru

Varieties have also been developed with suitable

qualities for industrial use such as brewing (SK 5912, ICSV 400). Many of the varieties developed by IAR, Samaru have short stalks, which make them amenable to mechanical harvesting.

Short-season sorghum have been developed and released for production in the semi-arid areas and southern part of the Sudan, where the rainfall is less than 600mm. The best performing and highest yielding among these are listed in Table 3.2.

TABLE 3.2. Improved early maturing sorghum varieties released by IAR, Samaru for the Sudan savanna ecology.

Release Name	New Name	Characteristics
KSV4(BES)	SAMSORG-3	Short season type, maturity period 25-105 days semi-dwarf. Resistant/ tolerant to striga. Seed colour cream. Potential yield 1.5-2.5 t ha^{-1} yield.
KSV 11	SAMSORG-5	Short season, maturity period 95-105 days. Tolerant to striga. Dwarf type. Seed colour white. Potential yield,1.5-2.5 t ha^{-1}
KSV 12	SAMSORG-6	Short season, maturity period 95-105 days. Tolerant to striga. Semi-dwarf. Potential yield 1.5-2.5 t ha^{-1}. Seed colour cream.
ICSV 4000	SAMSORG-40	Short season. Maturity period 95-100 days Semi-dwarf. Tolerant to striga. Potential yield 2.5-3.5t ha^{-1} Seed colour cream. Use for malt production and brewing.
ICSV 111	SAMSORG-41	Short season. Maturity period 95-100 days. Semi-dwarf. Tolerant to striga. Potential yield 25-3.5 t ha^{-1}.
NR 71176	SAMSORG-38	Short season. Maturity period 95-105 days. Semi-dwarf. Potential yield 1.5-2.5 t ha^{-1} Seed colour cream.
NR 71182	SAMSORG-39	Short season. Maturity period 95-105 days. Semi-dwarf. Potential yield 1.5-2.5 t ha^{-1}.

In the Northern guinea savanna, medium maturing sorghum varieties have also been developed and released. Here the rainfall requirement ranges between 600-1800mm, with about seven months of rain. The best performing types are listed in Table 3.3.

TABLE 3.3. Improved medium maturing sorghum varieties released by IAR Samaru for the Northern Guinea Savanna ecology.

Release Name	New Name	Characteristics
KSV 7	SAMSORG-13	Medium season. Maturity period 130-145 days. Semi-dwarf, slightly susceptible to striga. Potential yield 1.5-2.5 t ha^{-1}. Seed colour cream.
KSV 8	SAMSORG-14	Medium season. Maturity period 130-140 days. Potential yield 2.5-3.0 tha^{-1}. Seed colour white.
SSV7(L.1499)	SAMSORG-21	Medium season.Maturity period 150-160 days. Semi-dwarf. Tolerant to striga Potential yield 30-35 t ha^{-1}. Seed colour white.
SSV9(L. 243)	SAMSORG-23	Medium season. Maturity period 150-160 days. Tolerant to striga. Potential yield 2.5-3.5 t ha^{-1}. Seed colour cream.
SSV 10 (L. 533)	SAMSORG-24	Medium season. Maturity period 150-160 days. Potential 2.5-3.5 t ha^{-1}. Tolerant to striga. Seed colour cream.

In the southern Guinea savanna where there is more rainfall, late-maturing sorghum varieties that are photoperiod-sensitive have also been developed and released. In the southern Guinea savanna, the growing period is very long (over 180 days) with very late-maturing sorghum adapted to the zone taking more than 6 months to mature. The best performing

varieties for this zone are in Table 3.4.

TABLE 3.4. Improved late maturing sorghum varieties released by IAR Samaru for the Southern Guinea ecology.

Release Name	New Name	Characteristics
KSV 3 (SK 5912)	SAMSORG-17	Long season. Semi-tall. Tolerant to striga. Maturity period 165-175 days. Potential yield 2.5-3.5 t ha^{-1}. Seed colour yellow. For Industrial use especially for brewing, livestock, confectionery.
SSV 2(FBL)	SAMSORG-16	Long season. Tall. fara fara, Maturity period 165-175 days. Potential yield 2.5-3.5 t ha^{-1}. Seed colour white. Use by Industries especially for brewing

Seed Sources for Released Varieties.

The Institute for Agricultural Research has the mandate for the genetic improvement of sorghum for the whole of Nigeria, covering the four main savanna ecological zones.

It is therefore mandatory for the Institute for Agricultural Research (IAR) to continuously maintain it's breeder seed, and in some cases foundation Seed stock. The Institute can grow enough foundation seed of any of the varieties listed in Tables (3.2 - 3.4) on request.

Cultural Practices

Site Selection.

Sorghum is a cereal crop that can grow in a wide variety of soils ranging from heavy clay in the southern Guinea savanna to sandy loam in the Sudan/Sahel savanna ecologies. It does best in soils with high moisture retention capacity that are well drained and fertile clay loam in nature. It is fairly tolerant to alkalinity and salinity. It can tolerate some drought situations that is why it is described as a hardy crop.

Land clearing

Land clearing is usually done just before the on-set of the rains. Crop residue of the previous crop grown on the area including shrubs are cut and burnt, while bushy trees are pruned to reduce their shading effect on the crop.

Field Preparation

Sorghum is most important in the northern Guinea and the Sudan savanna ecologies where the soils are light and sandy, this is also similar in the Sahel savanna where minimum land preparation through tilling is required. The seeds are planted in old furrows by farmers in such areas. In heavier soils such as in the southern Guinea savanna ecology proper land preparation is necessary. Where a tractor is available the land should be ploughed and left for two weeks. It is them harrowed and ridged 75 to 90cm apart.

With the ox-drawn mould board bulls are trained to break or split old ridges to form new ones in the old furrows. After the land preparation the seed bed should be weed-free and the soil well pulverized.

Choice of varieties: There are three main ecologies with seasonal variations, these include the southern Guinea savanna (SGS) with a long growing period of about seven to eight (7-8) months of rainfall. the varieties to grow here should be long duration or late maturing (Table 3.4).

In the Northern Guinea Savanna (NGS) the growing season is shorter than in the SGS but longer than in Sudan/Sahel savanna. Varieties of sorghum to be grown here are medium maturing. The rainfall here last between six and seven months (6-7 months). In the Sudan/Sahel savanna, the growing period is short with the rainfall lasting between four and five months (4-5 months) Varieties of sorghum grown here are short duration or early maturing in order to escape the drought that is frequently experienced at the end of the growing season. The varieties adopted to this area are a listed in Tables 3.2-3.3.

Seed rate.

To plant a sole crop of sorghum in one hectare of land, you need 10-15kg of seeds. Seeds are planted 3-5 seeds/hole and at 25-30cm between/stands for good germination to occur.

Seed dressing

Most soils are contaminated with soil borne diseases like bacteria and fungi. In some cases insect pests and soil pests such as root-knot nematode may be found. Before planting your seed, dress all seeds with seed dressing chemicals. Use one sachet of Fernasand -D to dress 3 kg (3 *mudus*) of seeds or one sachet of Aprons plus 50DS to dress 1.0kg (1 *mudu*) of seeds.

Planting

Timing- plant your sorghum seed as soon as the rains are established on well prepared seed bed to enhance good germination plant after a good rain. Poor seed germination, will eventually affect the yield.

Thinning

Thinning is done 2-3 weeks after planting. The seedlings are thinned to 2 plants per stand, where gaps exist you 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 the everpotranpiration and shock. The transplants are planted upright. In both the planting and the transplants the soil around crop should be firmed.

Fertilizer application

Nigerian soils are deficient **in the major nutrient** elements -nitrogen, phosphorus **and potassium and** some essential micro-nutrient.

Rate:

For good sorghum growth and yield 64kg Nha^{-1}, 30 kg $P_2O_5ha^{-1}$ and 30kg K_2Oha^{-1} are required. While the phosphorus and potassium are applied during land preparations nitrogen is applied in split application. Half the nitrogen rate is either applied at planting or three weeks after sowing and the balance banded or spot applied 25cm from the plant at six weeks after sowing.

Fertilizer rates can be satisfied by using the following fertilizers;

a) 4 bags of 15:15:15 NPK compound fertilizer during land preparation or at planting or at 3 weeks after sowing. This should be followed by 2.5 bags of CAN or 1.5 bags Urea 6 weeks after sowing.

b) 1.5 bags of DAP (18-46-0) Plus one bag of potash and 1 bag of urea at planting followed by 1.2 bags of urea at 6 weeks after sowing.

c) 1.5 bags of urea plus 3.3 bags of SSP (18% P_2O_5) at planting followed by 1.3 bags of urea or 2.3 bags of CAN 6 weeks after sowing.

Where the land is prepared with tractor the first dose of the fertilizer or combination of fertilizers should be applied after harrowing and before ridging. It is more economical to spot apply the first dose of fertilizer about 3 weeks after sowing. This increases the crop rigor and controls weeds. There is need for molding up the ridges after the application of the second dose of nitrogen, this helps in covering the fertilizer up and weed control.

Weed Control.

Weed infestation can reduce crop yields by as much as 30-50% (Shebayan, 1992) if not controlled. *Striga*, a parasitic weed had been found to cause total crop failure where susceptible sorghum varieties have been planted in highly infested fields.

To control the non-parasitic weeds, two weedings at 3 weeks and 6 weeks after sowing is required. Where parasitic weeds are a problem, apart from choosing a striga tolerant or resistant sorghum variety, all emerged striga plants should be hand pulled and burnt.

Increasing the nitrogen fertilizer rate from 64 kgN to 90kg N ha^{-1} will help the crop growth vigor to withstand the attack by *striga*.

There are recommended herbicides for the control of parasitic and non-parasitic weeds. Listed below (Table 3.5) are the various herbicide treatments, their rates (using an empty milk tin measure) and time of application.

Table 3.5. Recommended herbicides for weed control in Sorghum

Product Name and formulation	Rate or $kgha^{-1}$	Time of application	Medium size (170ml capacity) peak milk tin measure (MTM) in		Remarks
			Knapsack sprayer filled 10L mark (Red/Blue nozzle)	CD filled to ½ mark (Red/Blue nozzle)	
Guinea savanna(GS) Gardoprin A 500 FW	3-4.3-4	Pre-emergence	3/4 - 1	3 - 5	Not effective on grass
Gadoprim 500S Ramred 480 Sc	3.0±5.0	"	½ + ¼	2 + 5	-ditto-

Source: Crop and livestock production: Training Manual for **Women** in Agriculture, NAERLS - ABU, Zaria.

Harvesting.

Time of harvest varies with the duration of the crop variety. Early maturing varieties mature early and are ready for harvest in October/November. Sorghum that

is mature and ready for harvest will be well filled and the grain will be hard. The leaves will turn yellow to brown with the lower leaves drying up completely. As soon as the crop is mature, harvest should commence immediately as some of the varieties tend to shatter and you will loose much seed (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.

Post-harvest processing and storage

Where the sorghum is to be stored in heads, the heads should be well dried for good keeping. If the grains are to be stored the heads are dried thoroughly before they are threshed. The panicles are pounded in a mortar or beaten with sticks on a smooth floor preferably cement floor to avoid sand particles.

Whether the heads or grains are to be stored, the store should be cleaned fumigated with phostoxin or actellic dust so that it will be insect-free. If the crop is to be stored in bags, the bags should be air tight and fumigated with photoxin at the rate of two tablets per bags of 100 kg seed.

Crop Protection

In Nigeria, Sorghum (*Sorghum bicolor*) is subject to attack by numerous diseases and the witchweed, *Striga hermonthica*. The most damaging diseases are anthracnose (*Colletotrichum graminicola*), grey leaf spot (*Cercospora sorghi*), smuts (*Sporisorium sorghi*, *S. erhenbergii*, *S. cruentum* and *S. reilianum*) and grain mould caused by a complex of fungi (*Fusarium moniliforme*, *F. pallidoroseum*, *Phoma sorghina*, *Curvularia lunata*, *C. graminicola*). *Striga hermonthica* continues to be a major constraint to sorghum production. A grain mould/head bug relationship, ladder leaf spot and nematodes and viruses attacking sorghum in farmers fields are reported. Important insect pests include the stem borer *Busseola fusca*, midge *Contarina sorghicola*, spittle bug *Poophilus costalis* and the head bug *Eurystylus oldi*. Management practices used in the control of these pests are highlighted.

Sorghum production is limited by many constraints including biotic factors (diseases and insect pests) in Nigeria. Over 32 diseases caused by fungi, bacteria, viruses and nematodes have been reported. A few of these diseases are currently of major importance, some have potential as emerging, while many are limited in occurrence. A large number of insect species have been reported on sorghum in Nigeria. However, only a few are of economic importance.

Major Diseases

Foliar diseases

Anthracnose

Anthracnose caused by *Colletotrichum graminicola* (syn. *C. sublineolum*), is the most important foliar disease on both local and improved sorghum varieties. It is most prevalent and destructive in the northern Guinea and Sudan zones. Although three symptom types (panicle, foliar and stalk) are reported, recent reports suggest that panicle anthracnose is now prevalent in farmers

fields. It is reported to cause yield loss from foliar infection of up to 47 percent on susceptible varieties. Variation among foliar population of *C. graminicola* has been established in Nigeria. Current status establishes the existence of six physiological races in Nigeria.

Management of the disease has depended on fungicides and the sowing of resistant varieties. Many resistant lines have been identified in Nigeria and include:IS 5359, IS 5360, IS 20302, IS 24733, IS 24721, ICSV 901 NG, CSM 417, Malisor 84-5, Nagawhite, Yar'ruruka, Gaya Early. Lines with resistance to foliar, panicle and grain anthracnose have also been identified.

Grey Leaf Spot

This disease caused by *Cercospora sorghi* is most prevalent on local varieties in the Guinea savanna zone. It is reported to cause yield losses attaining 36% in highly susceptible genotypes e.g. SAMSORG 17 (SK 5912). Mixed infections of this disease and zonate leaf spot (caused by *Gloeocercospora sorghi*) have been observed. Disease management is based on host plant resistance (where available). Genotypes such as Nagawhite, ICSV 901 NG, Yar'ruruka, ICSV 902 NG, Sariasso 3, Sariasso 10 and Gaya Early have been identified to have resistance to grey leaf spot.

Panicle diseases
Grain mould

Grain mould (GM) is one of the most important diseases limiting sorghum production within Nigeria, although earlier surveys in the sixties and seventies had indicated that it was rare in farmer's fields. It is

prevalent on early maturing local and improved varieties grown in the Sudano-Sahelian zones and also on medium maturing local and improved varieties introduced into the southern fringes of northern Guinea savanna and in the southern Guinea savanna. It is caused by a complex of fungi including : *Fusarium moniliforme; F. pallidoroseum; Curvularia lunata; Phoma sorghina; Aspergillus flavus*; species of *Acremonium, Bipolaris, Cercospora, Exserohilum, Nigrospora, Gleocercospora, Phomopsis*, and *Verticillium*. Grain moulds degrade crop yield and quality by discolouration, smaller seed size and reduced feed processing quality. Further, mouldy grain has been reported to contain aflatoxins, zearalenone and patulin.

Predisposition to mouldiness of grains through head bug activity has been established in Nigeria. Head bugs, especially *Eurystylus oldi*, puncture grain during feeding and oviposition, thus predisposing it to infection and mould development. Two cultivars (IS 14384 and CCGM 39/17-2-2) have been identified to have high levels of resistance to both grain moulds and head bugs. Further, dominant grain mould fungi were identified as *Phoma* spp. (predominantly *P. sorghina*) and *Fusarium* spp. (predominantly *F. moniliforme*). Most importantly, this study suggests hypotheses to explain relationships between grain mould, weather and head bugs. High relative humidity possibly affects grain mould in two ways: first by providing suitable conditions for infection, and also by enhancing fungal sporulation.

Management of grain mould in Nigeria has been through the use of several approaches that target both grain moulds and head bugs. These include the use of

host plant resistance, cultural practices e.g. date of planting and integrated management options where high yielding local resistant varieties are planted at appropriate periods.

Smuts

Smuts are the most widespread group of diseases in sorghum growing areas of Nigeria where they cause damage on both traditional and improved cultivars. There are four smuts on rainfed sorghum: grain or covered smut (*Sporisorium sorghi*), loose smut (*Sporisorium cruentum*), head smut (*Sporisorium reilianum*) and long smut (*Sporisorium ehrenbergii*). Covered smut is the only post-rainy season smut of sorghum grown in the Lake Chad area. The prevalence of smuts among the agro-ecological zones of Nigeria varies from one area to another. Covered smut is prevalent in the Sahel, Sudan, northern Guinea savanna (NGS) and southern Guinea savanna (SGS) zones. Although covered smut was once endemic, it was successfully controlled by use of seed dressing chemicals. Recent evidence, however, suggests that the incidence has increased dramatically. Similarly, loose smut, which was once reported as light and sporadic in occurrence is now widespread with increasing incidence around the Sudano-Sahelian zones.

The increased incidence of covered and loose smuts are attributable to many factors such as increased cost and erratic supply of agricultural inputs, lack of suitable seed treatment chemicals and the existence of an alternate host *Cynodon dactylon* for the covered smut pathogen in the region.

Covered smut management continues to be based on

seed dressing fungicides, host plant resistance. Resistant varieties identified include: ICSV 2; ICSV 1049; ICSV 1002 and NSV 74.

Long smut is predominantly a disease of the dry Sudano - Sahelian zones. Management of the disease is by use of resistant varieties where available and by late planting. Resistant varieties identified include ICSV 400, Nagawhite, Yar'ruruka (Jollof), 90 SN 7 and ICSV 901 NG.

Head smut is most prevalent in the SGS zone of West and Central Africa (WCA) with sporadic occurrence in the NGS and the Sudano-Sahelian zones. It occurs primarily on late maturing cultivars and management is through sowing of resistant varieties.

Parasitic Weeds

Striga hermonthica is a major biotic constraint to sorghum production in Nigeria where many local and improved varieties are susceptible to the parasite. Yield losses, particularly under drought conditions, may be very high (90-100%).

Host plant resistance can be a major component of integrated Striga management when it occurs in adapted, productive cultivars. The variety SAMSORG 41 (ICSV 111) has been identified while SAMSORG 17 (KSV 8) has also been identified to be tolerant to *S. hermonthica* in Nigeria. Other management approaches include cultural and mechanical activities such as hand pulling, crop rotation, trap cropping, catch cropping, mixed cropping; chemical and integrated control approaches. Biological control of *Striga* spp. is a research area which has shown recent promise.

Minor Disease

Sooty stripe, caused by *Ramulispora sorghi*, ergot caused by *Claviceps africana* has been observed on seed production plots. Head blight, caused by *F. moniliforme*, is prevalent in the Northern Guinea and Sudan zones where it occasionally causes significant yield loss.

High incidence of oval leaf spot (*Ramulispora sorghicola*), zonate leaf spot and leaf blight (*Exserohilum turcicum*) occur, but at low levels, in many farmers fields in the northern Guinea and Sudan zones while rough leaf spot (*Ascochyta sorghina*) is predominant in the southern Guinea savanna. A high incidence of ladder leaf spot (*Cercospora fuscimaculans*) occurs in the southern Guinea savanna.

A relationship between sorghum yellow leaf blotch caused by *Xanthomonas* sp. and spittle bugs (*Locris rubens; Poophilus costalis*) has been reported in Nigeria where the feeding bugs transmit the bacterium *Xanthomonas* sp. Maize Streak virus (MSV) and Maize mosaic virus (MMV) are reported on Sorghum in Nigeria.

Eighteen genera of plant parasitic nematodes have been reported to be associated with sorghum and other cereals in the Nigerian savanna. Species belonging to five genera: *Pratylenchus; Aphelenchoides; Helicotylenchus: Tylenchus*; and *Ditylenchus* occurred in more than 50% of the surveyed fields. *Pratylenchus and Helicotylenchus* species had the highest incidence occurring in 90% of sorghum fields surveyed. This study established a correlation between incidence of Pokkah boeng (induced by *F. moniliforme*) and the

incidence of nematode symptoms across all fields surveyed.

Storage fungi especially *Aspergillus flavus, A. niger, A. ochraceus. Penicillium notatum. Penicillium* spp. Have been reported to be associated with stored sorghum grain in Nigeria. Sorghum grain stored with moisture content higher than 12% are highly predisposed to infection.

Insect Pests of Major Importance

Nearly 15 insect species have been reported as pests of sorghum in Nigeria. However the major pests include:

Foliage feeders

Spittle bug

The spittle bug, *Poophilus costalis* Walker is a serious pest of late planted sorghum crop 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 blotches 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 plantings. The adult bugs are usually small brown or grey jumping insects usually 11mm long. The nymphs always remain inside a foamy spittle mass resting head downward on the plant.

Early plantings escape spittle bug infestation as chemical control is not usually necessary. However in seed production plots sown late, application of Furadan 3G into the whorls control the insect.

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 loss of crops. 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 are black with green undersides. Pupation occurs in soil and the adults emerge in about 1 week. Moths migrate long distances, giving rise to outbreaks away from the site of infestation. Outbreaks are usually associated with rains.

Control of major outbreaks can be satisfactorily effected only if national or state organisations apply insecticides in outbreak areas. It is very important to detect infestation at an early stage. Small infestations can be controlled by using insecticides such as malathion, endosulfan and trichlorphon.

Grasshoppers

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

Control can be achieved by using insecticides. Malathion and diazinon are particularly effective.

Sorghum shoot fly

The shoot fly *Antherigona soccata* (Rondani) is a widespread and damaging pest in all sorghum growing areas of Nigeria. The damage is as a 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 1 week to about 1 month after emergence. If the attack occurs a little later, plants may produce side tillers that may also be attacked. Late sowing during the rainy season increases the likelihood of attack.

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 systemic insecticides (e.g. carbofuran).

Stem Feeders

Maize Stalk borer

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 colour. Usually, three generations are produced per year. The third generation larvae enter into diapause with the onset of the dry season and complete their development in 6 - 7 months.

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 carbofuran and carbaryl are known to be effective.

Head Feeders

Sorghum midge

The sorghum midge (*Contarina 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 for only 3 days and a generation is completed in 14 to 16 days. Because of this rapid developmental cycle, 9 to 12 generations could occur during one cropping season, thus resulting in the build up of high populations and infestations when sorghum flowering times are extended by a wide range of planting dates or maturities.

Control is achieved by early and uniform planting of sorghum over large areas 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. The resistant variety ICSV 197 has been identified.

Head bugs

The head bug, *Eurystylus oldi* is a serious pest of sorghum in Nigeria. The nymphs and adults suck the sap from developing grain. Damage starts as soon as the panicle emerges from the boot leaf. Bug damaged grain shows distinct red to brown feeding punctures

which create quantitative and qualitative losses. Head bug damage spoils the grain quality, and renders the grain unfit for human consumption. Such grain also has poor germination. Bug damage also increases the severity of grain moulds.

Host plant resistance remains the major control measure. The use of open panicle sorghums reduces the incidence of head bugs.

Insect pests of stored sorghum

Maize weevil

The weevil (*Sitophilus zeamais*) and related species, rice weevil (*S. oryzae*) are the most destructive insect pests of stored sorghum grain in Nigeria. They infest a very large variety of stored grains and 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 can be achieved by storing grain in a dry, clean condition, in insect proof containers. If the grain moisture content is less than 9%, the insect is unable to breed. If keeping the grain dry is not practicable, fumigation may be the only feasible protection.

Flour beetles

The confused flour beetle (*Tribolium confusum*) and the red flour beetle (*T. castenum*) are generally widely distributed. They are found infesting stored sorghum grain and other grains, seeds, flour, dried fruits and nuts, granaries, mills and warehouses. The 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 the construct when they move through flour or other granular products. When attack is severe, contaminated grain or flour turn greyish yellow and become mouldy, with a pungent smell.

Exclusion of insects by storing products in sealed containers provides effective control. Fumigants are also effective.

Angoumois grain moth

The grain moth *Sitotroga cerealella* (Olivier), is a cosmopolitan storage pest of sorghum in Nigeria. It is also known to attack maize, rice and wheat. Infestation can begin in the field. In storage, the infestation is confined to the upper layer of grain. The larvae bore into the grain and remain there until they emerge as adults from round emergence holes. The infested grain is completely hollowed out and filled with larval excreta or webbing.

Control is easily achieved by keeping grain moisture content below 12%. Fumigation is also very effective.

Insect Pests of Minor Importance

Other insect pests of sorghum reported in Nigeria include the shoot fly (*Antherigona soccata*), bollworm (*Heliothis armigera*) and the blister beetle *Mylabris pustulata*). Storage pests of minor importance include lesser grain borer (*Rhyzopertha dominica*) and the flat grain beetle (*Crptolestes pusillus*).

Harvesting
Processing and Utilization

Sorghum is a popular grain of the Guinea, Sudan and Sahel savanna zones. It is used in a variety of dishes and in some places, sorghum forms the major grain cereal in the diet of the people. It is utilised in the preparation of main dishes, snacks and can be combined with some protein based crops to prepare weaning foods for children. In Nigeria, particularly is most Northern States, sorghum grain in utilised mainly in the preparation of "*tuwo*"-a thick-dough product prepared with sorghum flour and boiling, water and consumed with a sauce, popularly called "*miya*". However, before sorghum grain is ready for food preparation it has to undergo some processing.

When sorghum is harvested, there is need to thresh it in order to obtain clean grains for immediate or future used.

Nutritive value of sorghum

Sorghum constitutes substantial amounts of energy and protein in the diet of the majority of people in the sub-Saharan regions. It's contribution in terms of digestible protein and energy available to the body are of higher quality than those obtained from root and tuber crops (Table 3.6). Table 3.6 shows that sorghum is a good source of other nutrients such as calcium, iron, thiamine, riboflavin and macin. These nutrients, though needed in small quantities are very important for growth and development, especially for children, pregnant and lactating mothers. It therefore means that with proper meal planning, sorghum can be utilized to the advantage of the majority of those who

consume the crop in their daily meals.

Table 3.6: Composition of Common Food Crops grain in Nigeria (per 10%)

Crops	Protein /	Energy Kcal (mg)	Calcium (mg)	Iron (mg)	Vit A (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vit C (mg)
Sorghum flour	9.5	353*	28	10.0	20	28	0 9	3 4	0
Cassava (fresh)	1.2	138	68	1.0	45	0.04	0.05	0.6	31
Yam (fresh)	1.9	111	52	0.8	25	0.11	0.02	0.3	6
Plantain (raw)	1.2	128	8	1.3	170	0.08	0 04	0 6	20

Sources: Okoruwa and Kling (1996) Nutrition and quality of maize
(*) Dovlo *et al.* (1976). Cowpea Home Preparation and Use in West Africa.

Furthermore, recent research activities on the improvement of sorghum cultivars have produced some varieties that have high protein content which can further enhance the diet. Some sorghum varieties produced by the Institute for Agricultural Research, Ahmadu Bello University, Zaria and tested in the laboratory have shame same of these results. (Table 3.7). Thus training farmers and consumers in general, to utilise what they produce efficiently becomes an important tool for the development of a nation.

Table 3.7: Nutrient Contains of New Sorghum Varieties

Crop	Protein (%)	Oil (%)	Iron	Zinc
SAMSORG 17 (SK 5912)	13.88	4.08	0.019	0.012
L 187	11.41	3.57	0.019	0.012
Franada Red	11.44	2.52	0.019	0.008
ICSV 1007	11.91	4.31	0.016	0.013
SAMSORG 14 (KSV-8)	9.94	3.55	0.016	0.014
S 35	10.19	4.34	0.013	0.08

Sources: Food Science & Technology Programme Report of Cropping Scheme, 2001

Processing of sorghum.

Sorghum can be processed in the traditional or industrial way to produce different products suitable for the preparation of traditional and modern products as well as for use in the industry.

A vast majority of the producers and consumers of sorghum grain are faced with the daily task of manually dehulling and pulverizing the sorghum grain before preparing their daily meal. Women and children labour hard and spend long hours of their time dehulling the grains to remove the outer layers. This is usually necessary

because some sorghum varieties, if the outer layers are not removed may adversely affect the cooking and the taste of the final products. However, it is important to note that not all sorghum varieties are suitable for dehulling. For instance, varieties with soft endosperm can pulverise on the slightest impact with the pestle, and therefore are not suitable for dehulling.

Traditional way of processing sorghum

There are several ways that sorghum can be processed for food. Two of these ways are the focus of this paper. The first method is the popular method, the sorghum is processed by just cleaning it to remove dirt, stones and other debris. It is then ground and sieved to produce grits and fine flour which can be used for various food preparations. A variation in this method is, after cleaning the grain, it is washed, dried ground and sieved to produce grits and fine flour which are also used for different food preparations.

In the second processing method, the sorghum kernel is dehulled lightly with mortar and pestle to remove the bran. The dehulled sorghum is washed and sun dried then ground and sieved to produce grits and fine flour. These can be used separately for different food preparations or can be used jointly to prepare "*Tuwo*".

Another variation in this line of production is after dehulling, the sorghum is washed and soaked for 2 to 3 hours before it is ground wet. The ground mixture at this stage can be used to cook gruels and other weaning porridge. Or water is added and then sieved using fine cloth. The mixture is allowed to settle, the water is drained and a thick product is left which is used to prepare "*kunu*", "*akamu*" and other foods. In some cases, the dehulled sorghum does not undergo any sieving after it has been ground; the product can be used to prepare "kunu". This is a popular type of "*kunu*" among the people of Southern Kaduna State of Nigeria. In this case, the "*kunu*" has other items added. For instance, pearl millet is dehulled, cooked soft and added to the sorghum mixture to produce the "*kunu*". Sweet potato flour may be added as sweetener.

Industrial processing

In the industrial processing system, sorghum can be processed to produce different products suitable for different food preparation as well as for use by the industries.

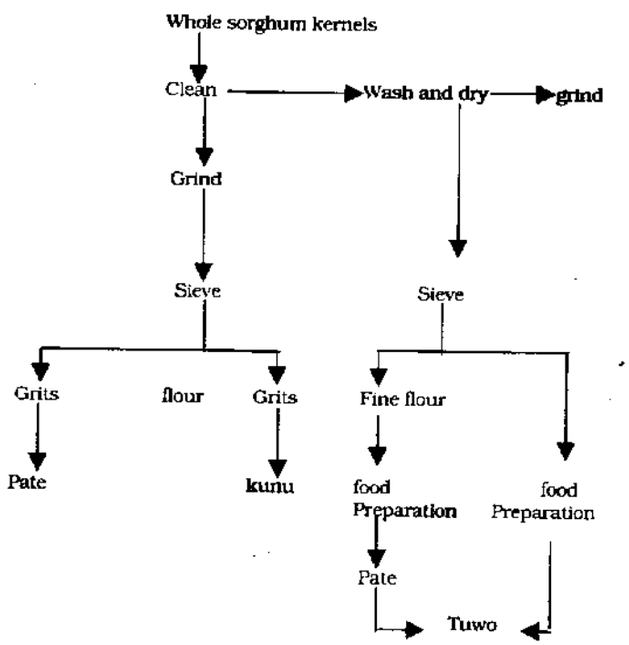

Fig. 3.1: ***Traditional dry method of processing sorghum***

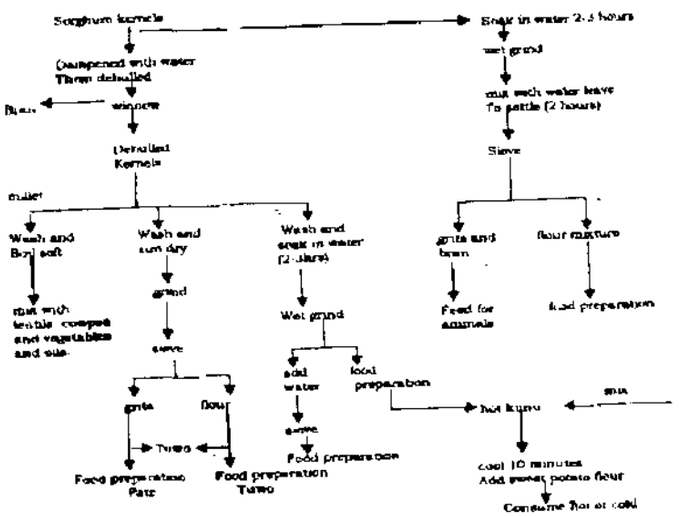

Fig. 3.2 Tradition method of processing sorghum for food preparation

In the dry processing system, the grain goes through the dehulling process where the germs are removed. The dehulled sorghum is ground and used for extrusion cooking to produce weaning food, or can be sold as a product similar to polished rice.

The first milling stage produces a coarse grinding, which, when sieved would produce a product with high amount of grits with relatively low content of damaged starch. The grit produced is used as brewer grits or may be utilised for the preparation of thick sorghum porridges commonly found in East Africa.

The second milling stage produces a fine product with high starch damage and is suitable for preparing foods such as "*Kisra*" (Sudan) and "*Roti*" (India).

After sieving from the first milling stage, a fine product is produced which can be used to produce composite flour for bread, starch and other foods such as "*tortilla*" (Mexican), and Injera.

Other products that can be obtained in the industrial processing are oil and sorghum flaking.

Wet Milling

Wet milling of sorghum is very similar to that of maize, except for the following differences which are of significant importance.

The wet milling of sorghum in the industrial systems shows lower starch recovery than that of maize;

there is greater difficulty in separating the starch from the protein and germ of sorghum than in maize;

the systems produce a lower oil yields from sorghum than in maize;

the gluten produced from sorghum does not have the carotenoid desired by the broiler industry;

the starch so obtained from sorghum is frequently stained by anthocyanin which must be bleached;

and the bleached starch has altered cooking properties and appearance.

Like in maize, the objective of wet milling of sorghum is to separate the starch and the protein from the endosperm. Generally sorghum requires a longer

steeping time than maize in order to modify the peripheral endosperm for wet millings. Thus steeping of sorghum in warm water must be given the required time. When this is achieved, the sorghum grain must go through the dehulling process, where the brain and the germ are removed. In the processing chain, the grain is soaked in diluted sulfurous acid at 45°C-52°C for 30-40hours, after which the kernels are degerminated to separate the germ for oil extraction. The residue of the degerminated product is finely ground to release the starch by use of hydroclones. The starch is washed and dried and converted into wide range of uses.

Uses of sorghum

Recent studies in the utilization of sorghum is geared towards complete utilization of the whole biomass of the sorghum plant. The main strategy is how to maximize the utilization of the crop through. Optimal application of each botanical fraction. It is therefore suggested that the whole sorghum plant can be transferred into intermediates for uses in various industries.

However, sorghum like other cereals such as maize and millet has way uses in Nigeria and in most parts of the world. In Nigeria it is an important staple food crop for majority of the people that produce it; and it is an important feed source for livestock as well as for many industries.

Under the traditional system, sorghum is used for the preparation of dishes such as Tuwo, a thick dough eaten with *miya* (a name for local soup), varieties of gruels and porridges. Other use for sorghum is when

the whole grain are dehulled, boiled soft and eaten with vegetables and oil. Or it is mixed with tentils, vegetables and oil. The grits obtained from the coarse grinding are used for dishes such as *pate* (*Pate* can be thin-watery with vegetables or thick dough with lentils and oil), and *cous-cous*. Sorghum is a major ingredient for the production of *mos*-a local bear consumed in most rural areas in the Northern States of Nigeria. Sorghum is also used as a base for the production of weaning foods.

Industrial uses of sorghum includes malt/cocoa drink called Bournvita, malted sorghum for use by the brewers, glucose and syrup production.

In other countries such as India, Sudan, Ethiopia and East African countries, sorghum grains with hard endosperm are utilised for the preparation of foods such as "Ugali". When the grains go through the second step of milling, the products obtained are used for preparing "Kisra" and "Roti". Sorghum with soft endosperm is used for preparation of "tortilla" and "Injera". Other products that are obtained are starch (including sweeter syrups, crystallise super and adhesive) and oil. Composite flour for bread making and other confectioneries are other possibilities that sorghum can be utilised.

References

Ajayi, O. 1990. Possibilities for integrated control of the millet stem borer *Acigona ignefusalis* Hampson (Lepidoptera: Pyralidae) in Nigeria. *Insect Science and its Application* 11:109 - 117.

Ajayi, O. 1994. Insect pests. *In "ICRISAT and Collaborative programs western and Central Africa Region, Annual Report 1994".* ICRISAT Sahelian Center, B.P. 12404 Niamey, Niger. Pp 139 - 143.

Ajayi, O. 1995. Sorghum head bugs and Stem borers. In *"ICRISAT and Collaborative programs western and Central Africa Region, Annual Report 1995".* ICRISAT Sahelian Center. B.P. 12404 Niamey. Niger. Pp 107 - 109.

Amatobi, C.I., Apeji,S.A. and Oyidi, O. 1983. Field observations on food plants and grasshoppers in Gumel area of Kano State. *Nigerian Field* 53: 99 - 106.

Anaso.E. and Buahin, G.K.A. 1994. Feeding preferences of the Sahelian grasshopper *(Oedalus senegalensis). Nigeria Journal of Plant Protection* 15: 52 - 63.

Chindo, P.S., Weber, G.K., and Elemo, K.A. 1997. Sustainability of intensified cereal based systems in the savannas: nematodes as a constraint. In *"Contributing to food self-sufficiency: Maize research and development in West and Central Africa".* (B. Badu Apraku, M.O. Akoroda, M. Oudraogo and F.M. Quinn, eds.) Proceedings of a regional maize workshop, 29 May B 2 June, IITA, Cotonou, Benin Republic. Pp 343 - 353.

Curtis, D.L. 1967. Classification of Nigerian Sorghum. *Experimental Agriculture* 3: 275.

Debrah, S.K. 1993. Sorghum in Western Africa. In *"Sorghum and Millets commodity and research enviroment".* (Byth, D.E. ed.) Patacheru, A.P. 502 324, India. ICRISAT. Pp 17 - 37.

Dogett. H. 1988. Sorghum. 2nd Ed. Longman, London Publishing in the United States with Wiley, New York.

Harlan, J.R. and J.M.J. De Wet. 1972. A Simplified Classification of Cultivated Sorghums. *Crop Science* 12:172-176.

Harris K.M. 1976. The sorghum midge. *Annals of Applied Biology* 64: 114 - 118.

Harris, K.M. and Nwanze K.F. 1992. *Busseola fusca (Fuller), the African maize stalk borer: a handbook of information.* Information Bulletin No. 33. Patancheru 502 324, A.P. India. ICRISAT: Wallingford, U.K.: CAB International. 92pp.

ICRISAT/FAO. 1996. *The World sorghum and millet economies, facts, trends and outlook.* International Crops Research Institute for Semi-Arid Tropics (ICRISAT) and Food and Agriculture Organisation of the United Nations (FAO). 68pp.

International Crops Research Institute for Semi-Arid Tropics (ICRISAT) (1992). Utilization of sorghum and millets. Edited by M. I. Gomez, L. R. House, L. W. Rooney and D.A. V. Dendy. Patachera, Andhra Pradesh, India.

International Crops Research Institute for Semi-Arid Tropics (ICRISAT) and Institute For Agricultural Research (IAR) (1990) Industrial utilization of sorghum. Summary Proceedings of a Symposium on the correct status and potential of Industrial uses of sorghum in Nigeria, held 4th - 6th December, 1998. Kano, Nigeria.

Kent, N. L. (1975). Technology of cereals with special reference to wheat. Second Edition. Pergamon Press Oxford. New York. Toronto. Sydney. Paris. Braunschweiy.

Marley P.S., Thakur, R.P. and Ajayi O. 2001a. Variation among foliar isolates of Colletotrichum sublineolum of sorghum in Nigeria. *Field Crops Research* 69:133 - 142.

Marley, P.S. 1995. *Cynodon dactylon*: alternative host to *Sporisorium sorghi* Link causal organism of sorghum covered smut. *Crop Protection* 14: 491- 493.

Marley, P.S., and Aba, D.A. 1999. Current status of sorghum smuts in Nigeria. *Journal of Sustainable Agriculture* 15: 199 - 132.

Marley, P.S., and Ajayi, O. 1999. Sorghum grain mould and the influence of head bug Eurystulus oldi in West and Central Africa. *Journal of Sustainable Agriculture* 13:35 - 44.

Marley, P.S., and Malgwi, A.M. 1999. Influence of head bugs (Eurystylus sp.) on sorghum grain mould in the Nigerian savanna. *Journal of Agricultural Science, Cambridge* 132: 71 - 75.

Marley, P.S., Bandyopadhyay, R., Tabo, R., and Ajayi, O. 2001b. Availability of sorghum germplasm with multiple resistance to two major diseases in the Nigerian savanna. *Tropical Science* 41: 44 - 49.

Marley, P.S., Elemo, K.A., Aba, D.A., Onu, I., and Akintayo, I. 2001c. Reactions of sorghum genotypes to anthracnose and grey leaf spot diseases under sudan

and sahel savanna field conditions of Nigeria. *Journal of sustainable Agriculture USA* 18(2/3): 105 - 116.

Marley, P.S., Manzo, S.K., and Ebenebe, A.C. 1997. *Comparative storability of three sorghum cultivars in Nigeria.* Tropical Science 37: 65-70.

NAERLS. 1996. Prospects and Problems of the 1996 Cropping Season. A report of a study conducted by the National Agricultural Extension Research and Liaison Services (NAERLS) and Agricultural Planning Monitoring and Evaluation Unit (APMEU). 2-4 Oct. 1996. NAERLS, Ahmadu Bello University, Zaria 62p.

Nwanze, K.F. 1985. Sorghum insect pests in West Africa. In *"Proceedings of International Sorghum Entomology workshop"*. 15 - 21 July 1984, Texas A & M University, College Station, Texas, USA. Patancheru 502 324, A.P. India: ICRISAT.

Obilana, A. Tunde. 1983. Status of sorghum research towards better and increased productivity. Paper presented at the joint National Workshop on NAFPP 10-15 January, Moor Plantation, Ibadan.

Obilana, A. Tunde. 1984. Sorghum crop improvement In Cropping Scheme Meeting – Notes on Cereals Research Programme IAR., - ABU., Samaru – Zaria, Nigeria.

Obilana, A.T., O. Ajayi and S.K. Manzo. 1984. Sorghum improvement in Nigeria. Paper presented at the Workshop on "Sorghum Improvement in West Africa" held at Ouagadougou, Burkina Faso, No. 27-30, 17pp.

Ogunlela, V.B. and A. Tunde Obilana. 1983. Masakwa. The "Harmattan Sorghum" in Nigeria. NOMA 4:4-6.