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Management of Sorghum Smuts and Anthracnose Using Cultivar Selection and Seed Dressing Fungicides in Maiduguri, Nigeria

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ABSTRACT

Smuts and anthracnose are important floral and foliage diseases of sorghum, respectively. A study was carried out for the control of these diseases using an integrated control approach. In this regard combinations of early and late maturing varieties with seed dressing chemicals were investigated for their potentials. Incidence and severity of smuts vary significantly between sorghum cultivars as well as between seed dressing chemicals. Metalaxyl (Apron star) treated sorghum plants recorded the lowest mean smut incidence of 4.8% with severity of 0.9%, while un-treated plants recorded the highest mean smut incidence of 11.25% with mean severity of 5.2% representing disease reduction of 57% and 83%, respectively. Significant differences were found between cultivars with regards to anthracnose infection at both booting and at crop maturity stage but there was no significant difference between chemicals. A combination of metalaxyl with ICSVIII (early maturing cultivar), which produced a higher grain yield is here recommended for the drier ecological region, while metalaxyl with Guzama red (late maturing cultivar), which had the mean smut incidence of 3.0 and severity of 0.6 is recommended for the Sudan Savanna areas, which has higher rainfall than the Sahel region. Apron star is the latest formulation of metalaxyl is better seed fungicide for the control of anthracnose and smuts in cereals crops.

Key Words: Seed dressing fungicides; Sorghum; Smuts; Anthracnose; Disease incidence; Disease severity

INTRODUCTION

Smuts and anthracnose are the most wide spread group of diseases in all sorghum growing areas of Nigeria. They are damaging to local and improved cultivars especially, where un-treated seeds are sown. Smut damage is confined almost entirely to the head or panicle, reducing both the grain yield and forage value. Four distinct smut diseases of sorghum are recognized, they are Covered kernel smut induced by the fungus *Sporisorium sorghi* (Synonym *Sphacelotheca sorghi*), loose kernel smut induced by the fungus *Sporisorium cruentum* (Synonym *Sphacelotheca cruenta*), head smut induced by *Sporisorium holci-sorghi* (Synonym *Sphacelotheca reiliana*) and long smut attributed to the fungus described as *Sorosporium ehrenbergii* Kuhn though its generally accepted name since 1903 has been *Tolyposporium ehrenbergii* (Frowd, 1980; Pande *et al*., 1993; Marley, 2003).

Crop losses in Nigeria from all the four smuts, was estimated at > 7% of the crop annually (Doggett, 1988; Dahlberg & Hash, 1998). In Sudano-Sahelian Savanna of Nigeria farmers recognize covered and long smut as major production constrains. Anthracnose is reported to cause considerable losses of up to 47% in Nigeria (Tyagi, 1980; Marley, 1997; Gwary *et al*., 2003; Gwary & Asala, 2006a) and up to 67% in other parts of West Africa (Thomas *et al*., 1996). The fungus infects leaves, stalk, peduncle, panicle and the grain either separately or together (Pastor Carrales & Frederickson, 1980).

Several control measures have been recommended, all aimed at reducing disease damage to the crop. Seed dressing with fungicide is one of the cheapest and the most effective means of controlling seed and soil borne sorghum diseases of smut and anthracnose. They are convenient for farmer's use, improve stands and seedlings raised from treated seeds are healthier than those from un-treated seeds (ICRISAT, 1982). Other measures employed for the control of these diseases include the use resistant cultivars. However, progress in this direction has been very slow in the developing agriculture in countries like Nigeria. It has also been difficult to find cultivars with multiple resistances against all the major diseases. For this reason, this simple trial investigated the combined use of seed treatment fungicides and a selection of cultivars for the effective management of both smut and anthracnose diseases of sorghum in the Sudan Savanna of Nigeria. This was done in consideration of the erratic nature of the rainfall of the region and cultivar acceptability to the area.

MATERIALS AND METHODS

The study was conducted on the Research farm of the Department of Crop Protection, University of Maiduguri (Lat 11º 15′ N 13º 05′ E), which is located in the Sudan Savanna of Nigeria and has an annual rainfall of 450 – 600 mm per annum. The land was prepared at the beginning of the rainy season and the trial was laid out in a randomized split plot design, where the sorghum cultivars were assigned to the main plot and the seed treatment fungicides to the subplot. The treatments were replicated four times. The sorghum cultivars were obtained from the seed multiplication farm of the Department of Crop Protection. Warwarabashi and ICSVII are early maturing cultivars, while Guzama white and Guzama red are late season cultivars. The fungicides were purchased from the Agrochemical stores in Maiduguri. The properties of the fungicides used and their rates are given in Table I. The seeds were coated with the fungicidal treatments at the recommended rates and sown on July 7, 2004. Four to five treated seeds were sown per hole and germinated seedlings were thinned to two plants per stand and thinning was done during the first weeding at weeks after germination. Fertilizer and other agronomic practices were applied as recommended by BOSADP 1993 for sorghum production in the region.

Observations and data recording. The incidence of the two diseases, smut and anthracnose were recorded by establishing the proportion of plants showing the symptoms and expressing the result in percentage. Ten plants were tagged in each plot on which disease severity and yield related data were recorded.

Anthracnose severity. At grain formation stage, leaf anthracnose was assessed using the scale adopted by Gwary *et al*. (2003) as described below:

1 = No symptoms or presence of chlorotic flecks
2 = 1 - 5% leave area covered with lesion
3 = 6 - 10 leave area covered with lesion
4 = 11 - 20% infected florets
5 = 21 - 30% leave area covered with lesion
6 = > 31 - 40% leave area covered with lesion.

The mean % severity was computed using the formula:

$$\frac{\sum n \times 100}{N \times 6}$$

Where,

∑n = summation of individual ratings
N = Total number of plants assessed times the highest score
6 = The highest score on the rating scale.

Smut severity. At physiologic maturity, the severity was scored on the tagged plants using the severity rating scale used by Gwary *et al*. (2001) as follows:

1 = No infected florets to 15% infected florets
2 = 16 - 20% infected florets
3 = 21 - 29% infected florets
4 = 30 - 45% infected florets
5 = 46 - 75 infected florets
6 = 75% infected florets
7 = 41 - 50% leave area covered with lesion
8 = 5 - 75% leave area covered with lesion
9 = > 75% leave area covered with lesion.

The mean % severity was computed using the formula:

$$\frac{\sum n \times 100}{N \times 9}$$

Where,

∑n = summation of individual ratings
N = Total number of plants assessed times the highest score
9 = The highest score on the rating scale.

Yield Parameters

Days to 50% booting. Days to 50% flowering was determined by monitoring the number of days when 50% of the plants in each plot came into booting stage. This is calculated from the days after sowing.

Days to 50% panicle formation. Days to 50% maturity was determined by monitoring the number of days when 50% of the sorghum heads in each plot produced grains. This is calculated from the days after sowing.

Grain yield. When matured, the sorghum heads from the two inner rows in each plot were cut, sun dried, threshed and winnowed. The grains were weighed. The figures were later converted to kilograms per hectare.

Data analysis. All data collected were statistically analyzed according to the split plot design. Yield data was square root transformed before analysis to take care of complete yield loss for the late maturing cultivar. Means are compared using LSD values.

RESULTS

Table II shows the duration for booting and panicle formation in the four sorghum varieties. Warwarabashi had the lowest number of days to attain booting and panicle formation followed by ICSV111 suggesting that they are early maturing cultivars. Guzama white and Guzama red had the highest number of days to attain booting and panicle formation and known as late maturing cultivars.

The incidence of smut diseases is presented in Table III, Warwarabashi and ICSV111 are early maturing cultivars, while the other two cultivars, Guzama white and Guzama red are late maturing. The seed treatment chemicals used had significantly suppressed the smut incidence to a lowest mean level of 4.8% to 7.23% compared to the un-treated plots, which had the highest mean smut incidence of 11.25%. Even among the treatments, significant difference exist, Apron star had the lowest mean smut incidence of 5.78% followed by Dress force with 5.78% and Forte plus with 7.23% mean smut incidence. The late maturing

Table I. Fungicide seed treatments used in the field trial and their rates for the control of Sorghum smuts and anthracnose in Maiduguri, Nigeria during 2004

Fungicide	Active ingredients (w/w)	Formulation	Application rate of product
Apron star	20% Metalaxyl –m, 20% Thiamethoxam 2% Difenoconazole	Dust	10g/4kg of seeds
Dress Force	20% Metalaxyl –m, 20% Imibaclopriv 20% Cevaconazole	Dust	10g/3kg of seeds
Forte Plus	32.5% Mancozeb 27.5% Thiophanate methyl 15% Diazinon	Dust	10g/4kg of seeds
Control	None	None	None

Table II. Number of days* to booting and panicle formation in the four sorghum cultivars evaluated in the Sudan Savanna of Maiduguri, Nigeria

Cultivars	Number of days to 50% booting	Number of days to 50% panicle formation
Warwarabashi	60	67
ICSVIII	72	77
Guzama white	93	98
Guzama red	90	95

*Mean of four replications

Table III. Incidence of smut disease on four sorghum cultivars under three seed treatment fungicides during 2004 rainy season at Maiduguri, Nigeria

Seed dressing chemicals	Sorghum cultivar				
	Warwarabashi	ICSVIII	Guzama white	Guzama red	Mean
Apron star	7.2	6.0	3.0	3.0	4.80
Forte Plus	11.9	8.2	5.8	3.0	7.23
Dress force	14.1	3.0	3.0	3.0	5.78
Control	13.4	18.0	10.6	3.0	11.25
Mean	11.65	8.80	5.58	3.0	

SED = 0.4, LSD = 0.82, Cultivar: SED = 0.4; LSD = 0.82; Seed dressing Chemicals; 1. 05, LSD = 2.14 (Interaction)

cultivars had the lowest mean smut incidence of 3.0% to 5.55% the early maturing cultivars had the highest mean smut incidence of 8.80 - 11.65%, respectively. Significant difference also exists with interactions between varieties and seed dressing chemicals. Severity of smut diseases similarly varied significantly between treatment chemicals as well as between sorghum varieties (Table IV). Apron Star had the lowest mean severity of 0.9% followed by Dress force recording 1.2% mean smut severity and Forte plus, which recorded 2.4% mean severity. The un-treated plot on the other the hand had the highest meant smut severity of 5.2%. Significant difference was also observed with interactions between cultivars and seed treatment chemicals.

Table V shows reactions of the four sorghum varieties to anthracnose. Individual sorghum cultivars reacted differently to the disease. While ICSV111 showed resistant reaction types as characterized by absence of midrib lesion, leaf sheath lesion and necrotic spots which are symptoms of resistance, Guzama red, Warwarabashi and Guzama white showed distinguished symptoms such as chlorotic flecks, midrib lesion at early stage, leaf sheath lesion, necrotic spots on leaf lamina with panicle infection in Warwarabashi. There was no significant difference between treatment chemicals and un-treated plots. Guzama red and Warwarabashi had the highest severity of anthracnose and there was equally no significant difference with interactions between sorghum varieties and treatments.

The development of anthracnose on susceptible varieties increased slightly with increasing severity among the three sorghum cultivars, Guzama white, Guzama red and Warwarabashi (Table VI). No significant variations were observed between seed dressing chemicals as well as with interactions between seed dressing chemicals and sorghum cultivars. Table VII shows grain yield for the treatments. There was significant difference in yield between cultivars with ICSV111, which recorded the highest mean square root transformed grain yield of 90.26 kg/ha followed by Warwarabashi with 87.24 kg/ha. Guzama red and Guzama white recorded the lowest mean grain yield of 3.0 kg/ha. Significant difference also exist in terms of grain yield between seed dressing chemicals with Apron star recording the highest mean grain yield of 50.33 kg/ha followed by Dress force recording 47.10 kg/ha and forte plus, which recorded 42.37 kg/ha, there was no significant interaction between seed treatment chemicals on the yield.

Table IV. Severity of smut disease recorded on four sorghum cultivars treated with three seed treatment fungicides during 2004 rainy season at Maiduguri, Nigeria during 2004 rainy season at Maiduguri, Nigeria

Seed dressing chemicals	Sorghum cultivar				
	Warwarabashi	ICSVIII	Guzama white	Guzama red	Mean
Apron star	1.3	1.4	0.6	0.6	0.9
Forte Plus	2.4	4.2	2.2	0.6	2.4
Dress force	3.0	0.6	0.6	0.6	1.2
Control	3.0	11.2	5.9	0.6	5.2
Mean	2.4	4.4	2.3	0.6	

SED = 0.4, LSD = 0.8, Cultivar: SED = 0.4; LSD = 0.8; Seed dressing Chemicals; 0. 55, LSD = 1.12 (Interaction)

Table V. Severity of anthracnose recorded on four sorghum cultivars treated with three seed treatment fungicides during 2004 rainy season at Maiduguri, Nigeria at Maiduguri at 63 days after sowing during the 2004 rainy season

Seed dressing chemicals	Sorghum cultivar				
	Warwarabashi	ICSVIII	Guzama white	Guzama red	Mean
Apron star	12.7	3.0	12.5	13.0	10.3
Forte Plus	13.0	3.0	12.6	13.1	10.4
Dress force	12.8	3.0	12.7	12.8	10.3
Control	12.9	3.0	12.7	12.9	10.4
Mean	12.9	3.0	12.6	13.0	

SED = 0.5, LSD = 0.10, Cultivar: SED = 0.5; LSD = 0.10; Seed dressing Chemicals; SED = 0. 14, LSD = 0.29 (Interaction)

DISCUSSION

The result of the study revealed that the four sorghum varieties vary significantly in their reaction to smut incidence and severity. Significantly high mean smut incidence and severity was observed on the early maturing cultivars, while lower incidence and severity was observed on the late maturing cultivars. These variations between cultivars to some extent might be attributed to the individual inherent reactions of the individual varieties to the fungal pathogen. Smut incidence and severity was reduced significantly with the seed treatment chemicals. Even among seed dressing chemicals, significant difference also exist with Apron Star, which recorded the lowest smut incidence and severity, un-treated plots however, show the highest smut disease incidence and smut severity.

Smut disease that were prevalent, were the covered smut and long smut, respectively. This was observed by Komolafe and Joy (1983). According to them, covered smut and long smut are common in West Africa, while loose smut is common in other parts of Africa and Asia occurs occasionally in West Africa. The prevalent occurrence of covered smut and long smut might be attributed to their biology. The fungal pathogen *Sporisorium sorghi,* which transmits covered smut, over winter primarily as teliospores germinating with the seeds, which is systemic (Doggett, 1988). Long smut *Sorosporium ehrenbergii* on the other hand, is derived from air borne sporidia, which make its occurrence very common. The occurrence of the different symptom of anthracnose suggests the different phases of the disease according to chlorotic flecks on leaves, necrotic spots on leaf sheath lesions and infections as observed by (Gwary *et al*., 2003). The presence of chlorotic flecks was common with Warwarabashi, Guzama white and Guzama red but were absent in ICSV111. The infected cultivars show symptoms like circular to epical spots form on the leaves ranging from 1.5 to 6 mm in diameter. Their color were reddish orange or reddish purple, black purple. As the spots aged the centre became grayish to dark straw-colored and numerous pustules with prominent black to dark brown setae appear. The spots emerged to form large reddish patches on the leaf. Setae are interspersed among conidiophore in the pustules (acervuli) as observed by (Dogget, 1988). The panicle phase of the anthracnose appeared only on Warwarabashi variety and were absent on ICSV111, Guzama white and Guzama red. (Gwary *et al*., 2003) have earlier shown the early maturing characteristics of Warwarabashi cultivar but also showed it high susceptibility to both leaf and panicle anthracnose.

Seed dressing fungicides are used for controlling pathogens carried by the seeds, for protecting the seeds from soil borne pathogens and protecting the seedlings from both soil and air borne pathogens. The three fungicides tested in this trial were found to be effective in reducing the plant infection with anthracnose and smuts. According to Akpa and Manzo (1991) systemic fungicide, Apron plus 50% dust can reduce the risk of loose smut disease. Similarly Marley (1995) and Mtisi (1996) also reported that metalaxyl and thiram based formulations gave better control of covered kernel smut.

Gwary and Asala (2006b & c) reported that for effective control of *C. sublineolum* in the fields, seed dressing with Apron plus or Thiram supplemented with foliar sprays (Benomyl, Carbendazim & Dithane M-45) has been found effective in reducing the subsequent symptoms (midrib spots, necrotic spots & leaf sheath lesion) with little noticeable acervuli. However, the use of fungicide sprays is recommended for use only in seed production plots as it is not economical to use in farmers field (Marley, 2004).

Table VI. Severity of anthracnose recorded on four sorghum cultivars treated with three seed treatment fungicides during 2004 rainy season at Maiduguri, Nigeria at Maiduguri at 77 days after sowing during the 2004 rainy season

Seed dressing chemicals	Sorghum cultivar Warwarabashi	ICSVIII	Guzama white	Guzama red	Mean
Apron star	12.9	3.0	13.2	13.3	10.6
Forte Plus	13.0	3.0	13.2	13.5	10.7
Dress force	13.0	3.0	12.9	13.3	10.6
Control	13.1	3.0	13.2	13.2	10.6
Mean	13.0	3.0	13.1	13.3	

SED = 0.05, LSD = 0.10, Cultivar: SED = 0.05; LSD = 0.10; Seed dressing Chemicals; SED = 0. 14, LSD = 0.29 (Interaction)

Table VII. Grain yield* (kg/ha) of four sorghum cultivars evaluated with three seed treatment fungicides in Maiduguri during 2004 rainy season

Seed dressing chemicals	Sorghum cultivar Warwarabashi	ICSVIII	Guzama white	Guzama red	Mean
Apron star	19.87	103.45	3.0	3.0	50.33
Forte Plus	81.58	81.89	3.0	3.0	42.37
Dress force	88.99	93.39	3.0	3.0	47.10
Control	86.51	82.30	3.0	3.0	43.70
Mean	87.24	90.26	3.0	3.0	

*Yield data were square root transformed; SED = 0.71, LSD = 1.45, Cultivar: SED = 0.71; LSD = 1.45; Seed dressing Chemicals; SED =2. 05, LSD = 4.19 (Interaction).

CONCLUSIONS AND RECOMMENDATIONS

The result of the study has in a way provided better information on the four sorghum varieties in terms of their relative individual resistance to both smut disease incidence and severity. These varieties therefore can serve as test materials on which further work can be done to improve them. Although the late maturing cultivars recorded lowest yield, this was due to low rainfall distribution, hence these varieties could potentially perform, where rainfall is higher than this part of the ecological zone of the country. A combination between metalaxyl seed treatment with ICSVIII (early maturing cultivar), which produced a higher grain yield is here recommended for the drier ecological region, while metalaxyl with Guzama red (late maturing cultivar), which had the mean smut incidence of 3.0 and severity of 0.6 is recommended for the Sudan Savanna areas, which has higher rainfall than the Sahel region. The need to constantly recommend the appropriate fungicides and crop cultivars for the region is important step towards assisting the farmers.

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