ISSN: 2347-4688, Vol. 11, No.(3) 2023, pg. 795-802

Current Agriculture Research Journal

www.agriculturejournal.org

Assessment of Varietal Resistance and Fungicides on Management of Smut Disease of Sorghum in Central Tanzania

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Abstract

Sorghum smut disease caused by the fungus *Sporisorium spp* is one of the serious constrain on the productivity and quality of the sorghum grain yield especially in areas where farmers do not treat seeds before planting where grain yield loss of up to 80% is reported in different parts of the world. A Randomized Complete Block Design experiment was laid down to determine the relatively higher resistant sorghum variety and proper fungicide for management of smut disease in central Tanzania. The materials used in this experiment included some selected genotypes of sorghum (Wahi, Hakika, Macia, Langalanga Gombela and one commercial variety) with different selected fungicides (Seed Watch 20WS, Apron Star WS 42% and Snow Angel W30% DS). Results revealed that, there was high significant difference among sorghum varieties tested ($P < 0.05$) on disease incidence and severity whereby the lowest incidence and severity of 4.57% and 11.41% respectively were recorded on Commercial variety while highest incidence 22.18% and Severity 19.07% were in Langalanga landrace. Among fungicides the lowest disease incidence and severity (3.72 and 11.15 respectively) were observed on Apron stars fungicide (20% Metalaxyl-m, 20% Thiamethoxa and 2% Difenoconazole) while the highest incidence (36.93%) and severity (26.68%) were recorded on control. From the present study, smut management using combination of improved sorghum varieties with the application of seed dressing fungicides especially with Metalaxyl-m, Thiamethoxam and Difenoconazole is recommended for use in central part of Tanzania.

Article History
Received: 19 March 2023
Accepted: 22 December 2023

Keywords
Fungicides;
Smut-Disease;
Sorghum Varieties;
Tanzania;
Varietal Resistance.

Introduction

Sorghum (*Sorghum bicolor* (L) Moench) is ranked fifth in the world in terms of importance among many staple food crops like maize, rice, wheat and cassava while in Tanzania it ranked fourth after maize, rice and wheat. In Tanzania sorghum is mainly grown

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Doi: https://dx.doi.org/10.12944/CARJ.11.3.10

in the semi-arid areas which include central part of the country (Dodoma and Singida) as well as part of Lake Zone such as Tabora, Shinyanga, Mwanza, and Mara regions. These regions together produce 50% of the country's sorghum output of average 0.667 tonnes from 0.675 hectares per year. For about thirty years the average grain yield of sorghum has remained 1 t/ha in Tanzania and East Africa compared to the potential yield of 2.5 to 3.5 t/ha reported in America and other parts of the world.[1,2,3,4]

Sorghum production has been facing several constrains which includes both biotic and abiotic factors.[20] Among biotic constrains, smut is one of the most important fungal diseases of sorghum in Africa.[5] It is caused by *Sporisorium* spp and it is commonly found in areas where no seed dressing treatment before planting is done.[6] Grain yield loss due to this disease reported to range from 6 – 80% in farmers' fields planted with susceptible varieties.[7]

Studies have shown that, use of sorghum varieties with relative higher resistance to smut diseases together with fungicides seed dressing, reduce smut disease incidence and severity.[8,9,10] According to,[11] in Tanzania covered kernel smut and head smut are among the diseases of sorghum that had adverse impacts to sorghum production especially in the central parts, however there is limited information on cultivated genotypes that are resistant to smut disease of sorghum as well as on the application of fungicides for the disease management. This study is designed to assess and recommend on the available sorghum varieties with relative higher resistance to the disease, and proper fungicides for smut management.

Materials and Methods

Study Area

The experiment was conducted during the 2018/19 season at Hombolo Agricultural Research Centre (TARI-Hombolo) in Dodoma Region at latitude 5° 45′S and longitude 35°57′ E, and 1020 MSL. with mean annual temperature of 22.7°C. The site also is characterized by unimodal rainfall that extends from November/December to April/May, followed by a long dry season from May to October.

Experimental Materials

Six sorghum varieties (Wahi, Hakika, Macia, Langalanga, Gombela and a Commercial variety) commonly grown by famers in the central Tanzania were used in this experiment. Wahi, Hakika, Macia and Commercial variety are improved sorghum varieties while Langalanga and Gombela are local landraces used as local checks. All genotypes were collected from (TARI-Hombolo). Fungicides used were, Seed Watch 20WS, Apron Star and Snow Angel 30% DS (Table 1).

Table 1: Fungicide seed treatments used in the field trial and their rates for the control of Sorghum smuts at Hombolo, Dodoma Tanzania

Fungicides used	Active ingredients	Recommended rate (applied)
Seed Watch 20WS	10% Imidacropid 5% Metalaxyl 5% Cabendazzim	10g / 4kg of sorghum
Apron Star WS 42%	20% Metalaxyl-m 20% Thiamethoxa 2% Difenoconazole	10g / 4kg of sorghum
Snow Angel W30% DS	10% Imidaclopid 10% Metalaxyl 10% Thiram	10g / 4kg of sorghum
Control	None	None

Experimental Design and Treatment Allocation

Field experiment was laid in Randomized complete Block design (RCBD). Treatments allocated as 6 x 4 (Sorghum varieties x fungicides) factorial combinations with four replications; plots size was 3m x 3m at spacing of 0.30m x 0.75m. The seeds were coated with the fungicides at the recommended rates and for each variety one plot in each replication kept as control with no fungicide dressing. The trial was established in January 2019 under open field growing conditions with no inoculation where natural infection was expected to occur as the site is hot spot for smut disease.

Data Collection

Data collected included plant population at different growth stages, days to 50% flowering plant height (cm), panicle length, Smut disease incidence and severity. Smut disease incidences scoring started two weeks after flowering by the proportion of plants showing the symptoms and expressing the result in percentage. Then the varieties were classified into Immune, Very resistant, Moderate susceptible, Susceptible and Very susceptible level of resistance according to Kutama *et al*., 2011.Smut disease severity was scored at physiological maturity using a scale (1 - 9 rating scale) as suggested by[9] (Table 2)

Table 2: Smut disease Severity scale as discussed by[9]

Scale	Details	Scale	Details
1	0 - 15% infected florets	6	≥ 75 % infected florets
2	16 -20% infected florets	7	41 – 50 leaves area covered with lesions
3	21- 29% infected florets	8	51 – 75 leaves area covered with lesions
4	30 – 45% infected florets	9	≥ 75 % leaves area covered with lesions
5	46 – 75% infected florets		

Then, the percentage disease severity was calculated using the following formula

Disease Severity Index (%) = (∑nx 100)/(Nx 9) %

Where,
∑n is sum of all scores, N in the total number of plants in plot and 9 is the highest score on the rating scale.[9]

Data Analysis

Data subjected to the analysis of variance (ANOVA) using Genstat Software 15th Edition. For the homogeneity of variance, percentage disease incidence and severity were Arcsine transformed, after analysis the means returned to the original form as before transformation. Simple correlation coefficient (r) and coefficient of determinant were carried out.

Table 3: Effect of Sorghum Varieties on percentage disease incidence and severity, Panicle length (PL), days to 50% flowering and Plant Height

Variety	DFL(Days)	PH(cm)
Wahi	62.62^{b}	121.80^{a}
Hakika	63.50^{b}	126.20^{a}
Macia	59.50^{a}	126.10^{a}
Commercial variety	69.75^{c}	160.40^{b}
Gombela	72.12^{d}	170.50^{b}
Langalanga	84.81^{e}	230.30^{c}
GM	68.72	155.89
CV(%)	2.8	13
SD	8.62	42.7
p-Value	<.001	<.001

All means in the same column followed by the same letters are not significantly different at p≤0.05 according to Duncan New Multiple Range Test.
GM=grand mean, CV=Coefficient of variance, SD=Standard deviation SDI=Smut disease Incidence (%), SDS=Smut Disease Severity (%), DFL=Days to 50% Flowering, PH=Plant Height (cm)

Table 4: Interaction of Sorghum Varieties and applied Seed dressing fungicides on percentage Disease incidences

Fungicides used	Sorghum varieties						
	Wahi	Hakika	Macia	C variety	GOMBELA	Langalanga	Mean
Seed Watch	8.05^{abcd}	9.24^{abc}	8.48^{abcd}	4.46^{abc}	11.16^{bcde}	12.08^{de}	8.91^{b}
Apron Star	3.75^{ab}	3.71^{ab}	4.04^{abc}	2.79^{a}	3.98^{abc}	4.02^{abc}	3.72^{a}
Snow Angel	11.37^{cde}	8.93^{abcde}	7.47^{abcd}	4.66^{abc}	12.63^{de}	16.07^{e}	10.19^{b}
Control	33.97^{f}	36.16^{f}	39.51^{f}	6.35^{abcd}	49.04^{g}	56.56^{h}	36.93^{c}
Mean	14.29	14.51	14.88	4.57	19.2	22.18	

All means in the same column followed by the same letters are not significantly different at p≤0.05 according to Duncan New Multiple Range Test.
P value= 0.001, Coefficient of variance= 17.3 Standard deviation=16.01 C Variety= Commercial variety

Table 5: Interaction of Sorghum Varieties and applied Seed dressing fungicides on percentage disease Severity

Fungicides used	Sorghum varieties						
	Wahi	Hakika	Macia	C variety	Gombela	Langalanga	Mean
Seed Watch	15.64^{cde}	16.29^{de}	14.32^{bcd}	10.91^{ab}	14.38^{bcd}	13.70^{abc}	14.21^{b}
Apron Star	9.93^{a}	11.23^{ab}	12.01^{abc}	11.02^{ab}	11.44^{abc}	11.24^{ab}	11.15^{a}
Snow Angel	17.23^{e}	13.99^{abc}	13.63^{abc}	11.51^{abc}	13.93^{abc}	13.89^{abc}	14.03^{b}
Control	23.06^{f}	26.59^{fg}	29.82^{gh}	12.22^{abc}	30.95^{h}	37.43^{i}	26.68^{c}
	16.47b	17.03^{bc}	17.44^{bc}	11.41^{a}	17.68^{bc}	19.07^{c}	

All means in the same column followed by the same letters are not significantly different at p≤0.05 according to Duncan New Multiple Range Test.
P value= 0.001, Coefficient of variance= 7.70 and Standard deviation=7.66.01.

Results

Discussion

A significant difference (p = 0.001) was observed among varieties on the growth parameters days to 50% flowering and plant height (Table 3). The variation on these parameters among sorghum varieties was expected due to the differences on genetic make-up among the varieties which may be inherited from the parents used on variety development.[12] Also,[13] reported differences among the tested sorghum varieties that could be attributed by the genetic variability of the tested sorghum genotypes, in which the gene they possessed characterizes their performance.

In this study, two types of smut disease, covered kernel smut and long smut disease were observed but the first was dominant. No head smut or loose kernel smut was observed, this may be contributed by high soil temperature during crop emergency. According to[9] high soil temperatures during crop emergency may favours crop germination and inhibit the pathogen germination that may results into low sorghum smut disease incidences.

Fig. 1: (A) Long smut on sorghum varieties (B) Covered smut of sorghum at TARI Hombolo Centre on established of trial

A very highly significant differences (p = 0.001) was observed in disease incidence and severity of smut diseases among sorghum varieties (Table.5). Langalanga and Gombela were observed with both, the highest mean smut disease incidence 22.18% and 19.20% and severity 19.07 and 17.68% respectively. The lowest smut incidence and severity, 4.57 and 11.41% respectively, was observed on Commercial variety.

According to the smut resistance scale described by,[14] considering responses of sorghum varieties on disease incidence when not applied with fungicides (Table 4), all sorghum varieties tested in this study had levels of resistance to smut disease between very resistant and very susceptible. Langalanga was very susceptible genotype with disease incidence of more than 50% while Commercial variety was observed to be very resistant with incidence of 6.35%, other varieties such as Wahi, Hakika and Gombela were susceptible with smut disease incidence ranging between 33.97 and 49.04%.

The variations obtained on disease incidence and severity within different sorghum varieties tested may be due to the differences in the individual inherent reaction to smut pathogen. These results agree with an earlier report by[9,14,6] that resistance to smut disease is controlled by single gene and, being resistant or susceptible variety depends on the parent used to develop the variety.

In this study, the commercial variety showed promising results for overcoming the effect of smut diseases. More studies especially on artificial inoculation of the smut disease mainly covered kernel and long smut (observed to be dominant) together with molecular characterization to reveal the gene that responsible for disease resistance need to be done, and if confirmed this variety can be used as source of resistance to smut disease in the future breeding programs. Other improved sorghum varieties which are commonly grown in central zone (Wahi, Hakikam and Macia) were observed to be susceptible to smut disease but shown high grain yield when treated with fungicides (Table 6). Local varieties Langalanga and Gombela were the most susceptible among the varieties tested.) Improved varieties are less infected by sorghum diseases in Tanzania while local varieties like Langalanga are highly affected by different non-fungal and fungal diseases such as smut disease).[11]

Again, a very high significant difference (p = 0.001) was observed among the fungicides seed dressing treatments on the smut disease incidence and severity. The highest smut disease incidence (36.93%) and severity (2.8%) respectively, were observed in plots where no fungicide was applied and the lowest smut disease incidence (3.72%) and severity (11.15%) respectively, were recorded on Apron Star (Table 4 and 5). All the three fungicides used in this experiment were observed to be effective for sorghum smut diseases management as significantly reduced the smut diseases incidence and severity when compared to the untreated sorghum plants.

A very high significant difference ($p < 0.001$) was observed on the interaction between the fungicides used and sorghum varieties. The best combinations observed were Apron Star and Commercial variety with smut disease incidence and severity of 2.79% and 11.02% respectively.

The results obtained agree with the previous studies by[9,15,16] that fungicides with Metalaxyl component can be used for effective management of smut pathogen. For maximum management of sorghum smut disease, a combination of more than one method is required such as seed dressing fungicide, use of resistant variety and supplement of fungicide spray before the booting stage especially for seed production plots as suggested by.[18] This will overcome the challenge of air borne pathogens (*Sporisorium ehrenbergii*) in which its infection occurs within the season before the booting stage through the flag leaf.[19] Study by[16] indicated that metalaxyl when used as seed dressing is effective on controlling loose and covered smut disease of sorghum in Nigeria, while long smut disease as an air-borne disease was not significantly be lowered by seed treatment, which resulted into high long smut disease incidence at 95 days after sowing

There was no significant difference among fungicides applied and the interaction between sorghum varieties and fungicides applied ($p < 0.05$) on the days to 50% flowering, plant height. The low effect of smut diseases on the growth parameters may be due to the low incidence and severity of smut disease recorded in fungicide treated plots. According to,[17] the effect of smut disease on the growth parameters depends on the level of the incidence and severity of disease. Similar findings have been reported by,[6] when assessing the resistance of sorghum lines and hybrids to sorghum grain mold and long smut in Senegal.

Conclusion and Recommendations

The present study indicated that, if sorghum seeds are sown without seed treatment it leads to higher smut disease incidence and severity which may results into reduction in grain yield and hence low profit in sorghum production All seed dressing fungicides used in this study showed effectiveness on sorghum smut disease management where smut disease incidence was reduced from 36% from undressed seeds to 3.7 and 10 percent when seeds are treated with fungicides and yield increased by about 29 percent.

For this study Apron star, Seed Watch and Snow Angel 30% DS observed to perform well in smut management and can be labeled for smut management in Central part of Tanzania as well as in other semi-arid areas. Most varieties used in this study were susceptible to smut disease although the resistance of Commercial variety to smut disease should be confirmed by more trials.

Trials with artificial inoculations of specific smut disease should be conducted to determine specific effect and varieties that are resistant to the specific smut disease especially covered kernel smut which appeared to be dominant in the study area.

Acknowledgement

Special thanks to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) under Hope II project for funding this study, and thanks to all co-authors for their valuable edition and correction based on their specialized subject.

Funding

The author(s) received no financial support for authorship, and/or publication of this article.

Conflicts of interest

The authors declare no conflict of interest.

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