Status of Sorghum Covered Kernel Smut and Reaction of Some Sorghum Cultivars in Northeast Ethiopia

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Abstract

Covered kernel smut caused by the fungus *Sporisorium sorghi* is the major disease threatening sorghum [*Sorghum bicolour* (L.) Moench.] production in northeast Ethiopia. The present study was made to assess the distribution, incidence and severity of the disease in the area and to evaluate the reaction of some sorghum cultivars to the disease. A field survey was made in six predominantly sorghum growing woredas/districts from three zones of northeast Ethiopia in 2001 main crop season. Disease assessment was made in a total of 102 farmers' fields, drawn by random selection of a total of 17 peasant associations (PAs) and then 6 fields from each PA. According to the findings of the study, the disease was widely distributed in sorghum fields in northeast Ethiopia with different incidence and severity levels. The zonal mean incidence for North Wollo was 12%, South Wollo 5%, and Oromiya 6%. The highest zonal mean severity was in North Wollo (13%). The disease occurred on all the cultivars grown by farmers in the three zones with varying incidence and severity levels. The improved variety $76T_1$#23 (27%) and the local cultivar Humera (21%) were severely affected. Whereas, the local cultivar Degalit had the lowest incidence (5%) and severity (4%). The improved cultivars were more susceptible. In the cultivar reaction study, 38 sorghum genotypes were evaluated for resistance to the disease under artificial inoculation condition in the field. According to the findings, 4 of the genotypes were highly resistant and 3 resistant, while the other accessions were moderately resistant to susceptible. In conclusion, covered kernel smut was highly distributed and severe in northeast Ethiopia. On the other hand, there were some highly resistant local cultivars that were highly resistant, resistant or moderately resistant, indicating the good opportunity in local cultivars as sources of resistance that could be used in developing improved sorghum varieties.

Key words: covered kernel smut, *Sporisorium sorghi,* sorghum, genotypes, Ethiopia

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench.] is one of the most important cereal crops both in area and production in the lowlands and intermediate elevations of northeast Ethiopia (Berhane and Yilma 1979). The current average sorghum yield in Ethiopia is very low, i.e., about 1200 kg/ha (CSA, 2002) as compared to the world average of 3100 kg/ha. Diseases are among the major factors that contribute to sorghum yield reduction in subsistence farming. Among the many fungal, bacterial and viral diseases, smuts are the major and economically important ones in Ethiopia and elsewhere in the world wherever sorghum is grown (Sundaram 1980 Frowd, 1980, Mengistu 1982, Temam 1990).

There are four types of smut that attack sorghum. These include: head smut (*Sporisorium reilianum* (Kühn) Langdon & Fullerton), loose kernel smut, (*Sporisorium cruentum* (Kühn) K. Vanky), covered kernel smuts (*Sporisorium sorghi* (Link) in Willd.), and long smut (*Sporisorium ehrenbergii* Vanky). Among these, covered kernel smut is not only widespread and the most destructive but also seed-borne (Tarr 1962, Frederiksen and Odvody 2000).

Covered kernel smut of sorghum has been reported from most sorghum growing countries of Africa, Asia, Europe, Australia, and North, Central and South America (Tarr 1962, Frowd 1980). Currently, it has become important in developing countries of Africa, because farmers continuously use their own seed reserved from the preceding season without seed dressing chemicals (Frowd 1980).

Despite the fact that the disease causes significant losses in sorghum yield, its distribution, incidence and severity has not been adequately quantified in northeastern parts of Ethiopia (Merkuz 2001). Ethiopia is a center of diversity for sorghum, and thus the genetic variability in the country is tremendous (Berhane and Yilma 1979). Therefore, there is a possibility of finding sources of resistance for covered kernel smut in Ethiopian sorghums.

In a recent study (Merkuz 2001), two resistant local sorghum genotypes (Tetron and Zengada) from collections of northwest Ethiopia were reported. However, the reactions of Ethiopian sorghum collections of the Institute of Biodiversity Conservation (IBC) and cultivars commonly grown by farmers in northeast Ethiopia were not investigated against the disease very well. The present study was, therefore, undertaken to investigate the distribution, incidence and severity of covered kernel smut and to evaluate the reactions of some local cultivars retained by IBC and those commonly grown by farmers in northeast Ethiopia.

Materials and Methods

The survey of sorghum covered kernel smut was conducted during the 2001/2002 main cropping season in major sorghum growing areas of North Wollo, South Wollo and Oromiya administrative zones in northeast Ethiopia. The survey areas lie in 400 to 1880 m altitude, $10^0$45'00"N latitude and $39^0$26'38"E longitude (SARC 1999).

Based on the area under sorghum crop, six representative woredas (districts) in the survey area were selected in cooperation with extension staff of the zonal bureaus of agriculture. The altitudes of surveyed areas were also recorded. The survey was conducted using standard techniques (Cochran 1977) when most of the sorghum was at milk and dough development stages. A total of 17 representative peasant associations (PAs) were selected from the woredas at random, and disease was assessed in six randomly selected fields from each PA. Observations on sorghum covered kernel smut incidence and severity (James 1974) were made in a total of 102 farmers' fields.

Sample plants were systematically selected by moving diagonally in an 'X' pattern from one end of each field to the other at the milk and dough development stages. Fifty plants were selected randomly from five spots in each of the two diagonals of the field, and the panicles were recorded as either diseased or healthy. Disease severity was determined based on 15 randomly selected plants in each field as percentage of the panicle infected. Finally, to determine the variation among the surveyed districts, data on disease incidence and severity were statistically analyzed (t-test) with SPSS computer package.

Thirty-eight sorghum genotypes including two susceptible checks were obtained from the Institute of Biodiversity Conservation (IBC), Addis Ababa. Seeds of the test materials were artificially inoculated in the laboratory by applying teliospores of the fungus at the rate of 2.0 g/kg of seed. Inoculated seeds were planted at the trial site of Sirinka Agricultural Research Center (SARC) during the 2001 crop season. Each entry was planted in 2 rows of 5 m length each in randomized complete block design with 3 replications. Fertilizer and other agronomic practices were applied as per the standard recommendations. To classify

reactions of the test genotypes, the mean disease incidence was used, where <1%, incidence was highly resistant, 1–2% resistant, 2–5% moderately resistant, 5-10% moderately susceptible, and >10% susceptible (Abbas 1991).

Results

In the surveyed areas, both local cultivars and improved varieties of sorghum were found to be widely cultivated by the farmers. Covered kernel smut was observed to occur in sorghum fields in almost all the surveyed areas. However, the distribution and severity of the disease varied from place to place (Table 1).

In two districts of North Wollo Administrative Zone (i.e. Kobo and Habru), disease was assessed in a total of 36 farmers' fields in 6 PAs. Among the PAs in Kobo Woreda, the highest disease incidence (17.7%) was recorded at Abuare and the lowest (13.7%) at Ayou. In Habru Woreda,

Table1. Incidence of sorghum covered kernel smut in farmers' fields in northeast Ethiopia

Administrative Zone	District	Peasant Association	Percentage incidence by no. of fields						
			1*	2	3	4	5	6	Mean
North Wollo	Kobo	Mendefera	16	22	2	12	6	34	15.3
		Ayou	14	8	20	26	12	2	13.7
		Abuarae	10	26	28	22	12	8	17.7
	Habru	Mehalamba	22	18	0	6	24	18	14.7
		Mersa	14	8	22	16	0	0	10.0
		Gerado	0	0	0	0	0	0	00.0
South Wollo	Ambassel	Chefae	0	2	6	6	8	10	5.3
		Robbit	16	0	22	0	0	0	6.3
		Tisabalima	0	4	0	4	0	10	3.3
Oromiya	Artumajille	Derensa	4	4	6	0	4	12	5.0
		Chefarobbit	0	0	10	14	12	5	6.8
		Chireti	2	2	14	0	28	0	7.7
	Chefadawa	Kelo	2	2	0	4	0	30	6.3
		Shekla	4	2	10	6	12	4	6.3
		Woledi	10	12	14	8	6	12	10.3
	Bati	Kemi	0	0	2	2	0	4	1.3
		Enesa	2	0	0	22	4	16	7.3

Table 2. Severity of sorghum covered kernel smut in farmers' fields in northeast Ethiopia

Administrative Zone	District	Peasant Assocation	Percentage severity by no. of fields						
			1*	2	3	4	5	6	Mean
North Wollo	Kobo	Mendefera	25	26	0.4	9	7	26	15.6
		Ayou	30	0.6	22	21	11	0.7	14.2
		Abuarae	25	20	25	22	13	7	18.7
	Habru	Mehalamba	24	25	0	2	25	22	16.3
		Mersa	24	12	12	28	0.4	0	12.7
		Gerado	0	0	0	0	0	0	0.0
South Wollo	Ambassel	Chefae	0	0.9	2	4	6	1	2.3
		Robbit	0	22	31	0	0	0	8.8
		Tisabalima	0	2	0	0.5	0	33	5.9
Oromiya	Artumajille	Derensa	3	0.8	6	0	0.23	13	3.8
		Chefarobbit	0	0	7	24	7	8	7.7
		Chireti	0.3	2	18	0	27	0	7.9
	Chefadawa	Kelo	0.7	0.6	0	2	0	34	6.2
		Shekla	0.9	3	16	16	26	3	10.8
		Woledi	11	7	7	0.5	0.9	7	8.0
	Bati	Kemi	0	0	0.1	0.1	0	0.8	0.2
		Enesa	0.7	0	0	35	0.7	23	9.9

disease incidence ranged from 0% at Gerado to 14.7% at Mehalamba (Table 1). Among the PAs in Kobo, the maximum (18.7%) disease severity was recorded in Abuare and minimum (14.2%) was from Ayou. In Habru ,the highest (16.3%) disease severity was recorded at Mehalamba and the lowest (0%) at Gerado. All the observed fields at Gerado were free from the disease (tables 1 and 2). The result of a t-test showed that there was highly significant difference ($p < 0.05$) in disease incidence and severity between Kobo and other woredas (tables 3 and 4).

In South Wollo Administrative Zone, 18 sorghum fields from 3 PAs were surveyed, and covered kernel smut was found in most of the fields. Among the PAs, the highest disease incidence (6%) was observed at Robbit and the lowest (3%) at Tisabalima (Table 1). At Chefae, 5% disease incidence was recorded. The mean maximum (9%) and mean minimum (2%) disease severity were recorded from Robbit and Chefae, respectively (Table 2).

In Oromiya Administrative Zone, disease incidence and severity were assessed in a total of 48 fields in 8 PAs from three woredas: Artumajille, Chefadawa, and Bati. The disease was found to occur in the visited farms with varying degrees of incidence and severity levels between locations and cultivars (tables 1 and 2). Among the PAs,

Table 3. T-value of mean disease incidence difference test between districts during the 2001 main crop season

District	Mean incidence	Kobo	Habru	Ambassel	Artumjille	Chefadawa	Bati
Kobo	15.55	-					
Habru	8.22	2.247**	-				
Ambasel	4.99	4.031***	1.241	-			
Artumajille	6.50	3.246***	0.608	0.704	-		
Chefadaw	7.65	2.861***	0.025	1.235	0.483	-	
Bati	4.33	3.546***	1.209	0.988	0.800	0.871	
Mean incidence		15.55	8.22	4.99	6.50	7.65	4.33

*** Significant at 0.01% level ** Significant at 0.5% level

Table 4. T-value of mean disease severity difference test between districts during the 2001 main crop season

District	Mean severity	Kobo	Habru	Ambassel	Artumjille	Chefadawa	Bati
Kobo	16.15	-					
Habru	9.69	1.791	-				
Ambasel	5.69	2.998**	1.069	-			
Artumajille	6.47	3.110***	0.950	0.0.236	-		
Chefadaw	8.34	2.371**	0.379	0.770	0.613	-	
Bati	5.03	2.807**	1.083	0.158	0389	0.488	
Mean severity		16.15	9.69	5.69	6.47	8.34	5.03

*** Significant at 0.01% level ** Significant at 0.5% level

Table 5. Mean incidence and severity of covered kernel smut on selected sorghum cultivars in different farmer's fields in northeast Ethiopia

Cultivar	District	Incidence (%)	Severity %
Cherekit	Artumajille	6.8	6.8
	Chefa-dawa	5.8	5.2
Degalit	Ambassel	3.7	2.2
	Bati	2.7	2.3
	Chefa-dawa	8.8	9.0
	Habru	0.0	0.0
	Kobo	8.0	7.0
Humera	Habru	16.0	21.1
Jigurti	Ambassel	5.67	7.6
	Habru	3.5	3.5
	Kobo	10.0	9.3
Gambella-1107	Artumajille	2.00	0.3
	Chefa-dawa	10.0	11.0
	Habru	22.0	12.0
$76T_1$#23	Bati	22.0	35.0
	Chefa-dawa	12.0	26.0
	Kobo	20.2	20.7

the highest mean disease incidence (10%) was encounterd at Woledi in Chefadawa Woreda and the lowest (1%) at Kemi in Bati Woreda (Table 1). The highest mean disease severity (11%) was recorded at Shekla in Chefa-dawa Woreda, while the lowest (0.2%) was observed at Kemi in Bati (Table 2).

There was statistically significant difference ($p < 0.5\%$) between woredas in disease incidence and severity (Table 3). The highest disease incidence (16%) and severity (16%) were found at Kobo, while the lowest incidence (4%) and severity (5%) were encountered at Bati (tables 3 and 4). Among the three administrative zones, the mean maximum of 12% covered kernel smut incidence and 13% severity were found in North Wollo Zone, while incidence and severity were very low in South Wollo and Oromiya zones (tables 1 and 2). The variation might be because farmers mostly grew genetically diverse local sorghum cultivars.

In all the surveyed areas, farmers grew both local and improved sorghum cultivars. The commonly grown local cultivars were Jigurty, Humera, Degalit and Cherekit, while $76T_1$#23 and Gambella-1107 were the commonly grown improved varieties. According to the results on the field reaction of these cultivars to covered kernel smut, almost all local and improved cultivars were affected, though disease incidence and severity varied with cultivars and over locations (Table 4). It was also noted that most of the local cultivars showed relatively lower covered kernel smut infection than the improved ones. For example, the late maturing local sorghum cultivar Degalit scored the lowest disease incidence (5%) and severity (4%) levels. In all the surveyed areas, $76T_1$#23 and Humera were severely affected by covered kernel smut with mean disease severity of 27% and 21%, respectively.

Table 6. Response of different genotypes of sorghum to covered kernel smut under artificial inoculation conditions in the field during 2001

Genotype	Disease incidence (%)*
Acc.# 69057	2.2(1.5)e-g**
Acc# 69324	10.9(2.2)a-g
Acc# 69422	8.2(2.9)a-g
Acc# 69431	6.2(2.2)b-g
Acc# 69446	7.3(2.8)a-g
Acc# 70112	8.2(2.5)a-g
Acc# 70230	3.6(1.8)d-g
Acc# 70373	11.4(3.3)a-g
Acc# 70464	1.5(1.2)fg
Acc# 70636	13.5(3.5)a-f
Acc# 70667	1.2(1.2) fg
Acc# 70696	6.5(2.3)a-g
Acc# 70804	1.2(1.1) fg
Acc# 70828	5.6(2.2)b-g
Acc# 70872	0.0(0.7)g
Acc# 70990	4.8(2.2)c-g
Acc# 72838	0.0(0.7)g
Acc# 73536	4.3(1.9)c-g
Acc# 73645	5.4(2.2)b-g
Acc# 74097	8.7(2.6)a-g
Acc# 74098	0.0(0.7)g
Acc# 75452	15.0 (3.9)a-e
Acc# 210947	7.1(2.7)a-g
Acc# 210949	9.6(3.1)a-g
Acc# 210952	7.8(2.6)a-g
Acc# 210971	4.9(2.1)c-g
Acc# 210973	9.3(2.7)a-g
Acc# 212641	18.2(4.8)ab
Acc# 212642	7.5(2.4)a-g
Acc# 212643	2.1(1.5)efg
Acc# 212644	3.5(1.9)c-g
Acc# 214839	16.6(4.0)abc
Acc# 214842	11.4(3.0)a-g
Acc# 214845	0.0(0.7)g
Acc# 69233-3	4.4(2.1)c-g
Acc# 210949-4	9.5(3.1)a-g
Acc# 69472(Check)	16.2(4.1)a-d
Acc# 69473(Check)	19.1(4.3)a
LSD at 0.05	1.875
CV%	48.11

*Mean of three replications.

**Values with the same letter in a column are not significantly different using DMRT at 5% level. Data in parenthesis are square root transformed value.

In Kobo Woreda, due to rainfall shortage, farmers dominantly cultivated the early maturing improved variety $76T_1$#23 that was found to be highly susceptible to covered kernel smut with disease incidence of 20% and severity of 21% (Table 5). The study findings indicated that the disease was more prevalent at Kobo.

The study findings on cultivar resistance to sorghum covered kernel showed that the mean disease incidence varied greatly among the 38 sorghum genotypes evaluated including 2 susceptible checks (Table 6). In addition, the results revealed that 4 genotypes were highly resistant (<1% incidence), 3 resistant (1–2%), 8 moderately resistant (2–5%), 14 moderately susceptible (5–10%) and the remaining 9 genotypes susceptible (>10%). The disease incidence ranged from 0 to 19.11% (Table 6). The susceptible check Acc# 69473 scored the highest disease incidence of 19%, while Acc# 212641 and 214839 scored disease incidence of 18 and 17%, respectively, and were rated as highly susceptible. On the other hand, Acc# 70872, 72838, 74098 and 214845 were free from smut infection and were rated as highly resistant. Three genotypes, viz., Acc# 70464, 70667 and 70804, scored disease incidence of approximately 1% and were thus rated as resistant.

Discussion

Covered kernel smut was found to be a wide spread disease in all the major sorghum growing areas of northeast Ethiopia. But the distribution and severity varied across woredas. Although the disease was widely distributed in the study area, it was found to be highly predominant in North Wollo Administrative Zone where the average covered kernel smut incidence and severity were 12% and 13%, respectively. In South Wollo and Oromiya zones, however, relatively lower mean disease incidence (5–6%) and severity (6-7%) were encountered. At subsistence farmers level, even that much disease intensity would have a significant negative impact on the production of sorghum. Some researchers reported different results; for instance, in some parts of Africa, up to 50% yield loss was recorded (Frowd 1980). In east Ethiopia, combined losses due to smuts were estimated up to 28% in which losses caused by covered kernel smut alone accounted for about 17% (Ashagari 1973). In northwest Ethiopia sorghum covered kernel smut alone was reported to cause about 48% average yield loss in farmers' fields in hot spot areas (Merkuz 2001).

The finding on disease intensity obtained in the current study was consistent with earlier reports. According to Sundaram (1980), sorghum covered kernel smut is the most serious disease in most African countries where prophylactic control measure particularly seed dressing, is not used. A field survey on the disease conducted in Nigeria and neighboring countries revealed up to 30% infection in hot-spot areas and an average yield loss of 5 to 10% (Frowd 1980, Sundaram 1980). According to the present study in northeast Ethiopia subsistence farmers did not use seed dressing fungicides in sorghum. Moreover, in most of the sorghum growing areas of the region farmers cultivated both local cultivars and improved sorghum varieties. The disease was found to be prevalent in all the cultivars grown, but improved sorghum varieties were found to be more susceptible and severely attacked as compared to local sorghum cultivars. Even late maturing local sorghum cultivars showed relatively lower covered kernel smut incidence than early maturing local sorghum cultivars. In general, the reaction of the six commonly grown sorghum cultivars to the disease was found to vary in the surveyed areas. This might be attributed to differences in climatic factors or there was variability in the pathogen population in the area (Frowd 1980).

With regards to variations in reactions of sorghum genotypes to covered kernel smut,

some observations have been reported by some researchers. Abbas (1991) evaluated 29 sorghum genotypes in the field for resistance to covered kernel smut and found 2 to be immune, 7 highly resistant to resistant (1–2% disease incidence), the remaining 20 genotypes to be moderately susceptible (2–5% disease incidence) and highly susceptible (>10% disease incidence). In Pakistan, twenty-five sorghum genotypes from various sources were screened against the disease and were found to vary greatly in their response to smut. Though no variety was immune, five were resistant, seven intermediate and the rest were susceptible (Mizra 1982).

Thus, results of the present investigation revealed that sorghum covered kernel smut is widely distributed and had the potential to negatively influence sorghum production in northeast Ethiopia. The reactions of cultivars commonly grown by farmers in the region were found to vary greatly from susceptible to resistant that might also be true for similar environments in other sorghum growing areas of Ethiopia. Therefore, the disease has to be given priority in efforts to develop appropriate sorghum protection strategies. Moreover, improving the resistance level of the adapted local cultivars seemed to be promising for future development of resistant sorghum varieties that might be used in integrated management of the disease in combination with other control methods.

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References

Abbas A. 1991. Screening for resistance to smuts of some new sorghum varieties and efficacy of seed dressing fungicides against covered kernel smut (Sphacelotheca sorghi). M.Sc. thesis in Plant Protection, Damascus University, Damascus, Syria.

Ashagari D. 1973. The importance of sorghum smuts and their control in the Alemaya area. East African Agricultural and Forestry Journal 39:28.

Brehane Gebrekidan, Yilma Kebede. 1979. The traditional culture and yield potential of the Ethiopian high lysine sorghum. Ethiopian Journal of Agricltural Sciences 1: 108-115.

Cochran W.G. 1977. Sampling techniques. John Wiley and Sons, New York. 428 pp.

CSA (Central Statistical Authority). 2002. Area and production for major crops. Statistical Bulletin No. 227. CSA, Addis Ababa, Ethiopia.

Frederiksen RA., Odvody GN. 2000. Compendium of Sorghum Diseases (2nd edn). The American Phytopathological Society. (APS) Press. 78 pp.

Frowd JA. 1980. A World Review of Sorghum Smuts. In: Sorghum Diseases: A World Review. Eds. Williams RJ., Frederiksen RA., Mughogho LK., pp. 331--348. Proceedings of the International Workshop on Sorghum Diseases, 11-15 December, 1978, ICRISAT, Hyderabad, India.

James, W.C. 1974. Assessment of plant diseases and losses. Annual Review of Phytophathology 12: 27-48.

Mengistuu Hulluka. 1982. Disease of sorghum at some locations in Ethiopia. Ethiopian Journal of Agricultural Sciences 4:45-54.

Merkuz Abera. 2001. Distribution and severity of sorghum covered kernel smut, varietal differences and its impact on yield in Northwest Ethiopia. M.Sc. thesis, Alemaya University.

SARC (Sirinka Agricultural Research Centre). 1999. Annual Research Progress Report. Sirinka, Woldia. 45 pp.

Sundaram NV. 1980. Importance of sorghum smut in African countries. In: Sorghum Diseases: a World Review. Eds. Williams RJ., Frederiksen RA., Mughogho LK., pp. 349-

350. Proceedings of the International Workshop on Sorghum Diseases, 11-15 December, 1978, ICRISAT, Hyderabad, India.

Tarr SAJ. 1962. Disease of sorghum, Sudan grass and broom corn. The Common Wealth Mycological Institute, CAB International, UK. 380 pp.

Temam Hussien. 1990. A review of sorghum disease research in Ethiopia. In: Cereals of the Semi-Arid Tropics. Ed. Wolf J. N., pp. 253-257. Proceedings of a Regional Seminar on Cereals of the Semi-Arid Tropics, September 12-16, 1989, International Foundation for Science (IFS), Garoua, Cameroon. 318pp.