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Evaluation of Elite Sorghum Accessions for Multiple Disease Resistance

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Introduction

Several plant diseases reduce grain and fodder yields of sorghum *(Sorghum bicolor)* and its stover quality (Bandyopadhyay et al. 2001). Participatory rural appraisal studies in India by Rama Devi et al. (2000) indicated that sale of crop residues to peri-urban milk producers accounted for approximately 50% of the income from sorghum cropping in rural areas of the Deccan Plateau of Andhra Pradesh, Karnataka and Maharashtra, and diseased residues command much lower price in the fodder market. Adverse effects of foliar and panicle diseases on quality and quantity of sorghum grain, fodder and residues have recently been reported (Bandyopadhyay et al. 2000, 2001). Most sorghum diseases can be effectively managed through host-plant resistance. The objective of this study was to identify resistance to multiple diseases in the selected agronomic elite landrace accessions and breeding lines of sorghum. In this article we report both agronomic features and multiple disease resistance of some of the accessions for their possible use in resistance breeding program.

Materials and Methods

Germplasm accessions. During the rainy season 2001, a total of 1671 sorghum accessions, originating from different countries were evaluated for multiple diseases reaction at ICRISAT under natural disease pressure. Of the 1671 accessions, 945 were elite landraces and 726 were breeding lines. Each accession was grown in an un-replicated plot of 2 rows, each of 4 m length, in Vertisol at ICRISAT, Patancheru, India. The space between the rows was 75 cm and between plants in each row was 10 cm. The crop was raised following the standard agronomic practices.

Evaluation for agronomic traits and biotic stresses. Each accession was evaluated for days to 50% flowering, plant height (cm), grain color and overall plant score. Plant scores were recorded on a 1-5 scale, where 1 = excellent, 2 = very good, 3 = good, 4 = poor and 5 = very poor. Diseases were identified using identification keys of Frederiksen and Odvody (2000). Incidence (%) of various diseases was recorded based on number of plants infected of the total plants observed in each plot of 2 rows from flowering (all foliar diseases) to maturity. Disease severity was recorded on 0-100% scale for all diseases except maize stripe virus (MStV). The severity of MStV was recorded considering plant stunting and panicle exertion symptoms at maturity on a 1-5 scale (Navi et al. 2003).

Results and Discussion

Weather during June to September 2001 was congenial for disease development. During June to September there were 54 rainy days with 525 mm rainfall, mean temperature of 21-23°C minimum and 29-33°C maximum, relative humidity 82-93% in the morning and 52-71% in the evening, and wind velocity 5-15 km h^{-1}.

Several diseases were observed on the sorghum plants: anthracnose *(Colletotrichum graminicola),* bacterial leaf streak *(Xanthomonas campestris* pv *holcicola),* ergot *(Claviceps sorghi)* and (C. *africana),* maize mosaic virus (MMV) (a rhabdovirus transmitted by the delphacid plant hopper *(Peregrinus maidis),* maize stripe virus (MStV) (a tenuivirus transmitted by *P. maidis),* leaf blight *(Exserohilum turcicum),* rough leaf spot *(Ascochyta sorghina),* rust *(Puccinia purpurea),* downy mildew *(Peronosclerospora sorghi),* gray leaf spot *(Cercospora sorghi),* oval leaf spot *(Ramulispora*

Table 1. Origin of 945 agronomic elite sorghum landraces evaluated for disease resistance under field conditions during rainy season 2001, ICRISAT, Patancheru, India.

Origin	Number of accessions Evaluated	Number of accessions Disease free	Origin	Number of accessions Evaluated	Number of accessions Disease free
Argentina	4	0	Nepal	1	0
Australia	9	0	Niger	6	0
Botswana	22	1	Nigeria	17	11
Burkina Faso	6	0	Pakistan	5	0
Cameroon	10	2	Philippines	4	0
Chad	4	0	Russia and CIS	71	5
China	14	0	Senegal	2	0
Cuba	1	0	Somalia	9	0
Dominican Republic	1	0	South Africa	136	0
Egypt	2	0	Sri Lanka	1	0
El-Salvador	1	0	Sudan	157	45
Ethiopia	10	3	Swaziland	27	3
Ghana	13	0	Syria	1	0
India	184	4	Tanzania	2	0
Indonesia	1	0	Thailand	2	0
Jamaica	2	0	Togo	1	0
Kenya	7	0	Turkey	5	0
Lesotho	56	1	Uganda	5	0
Malawi	5	2	Unknown	1	0
Mali	11	0	USA	16	0
Mauritania	1	0	Yemen	10	0
Mexico	1	0	Zambia	1	0
Namibia	8	0	Zimbabwe	92	5

Table 2. Agronomic traits of 82 disease-free sorghum landrace accessions evaluated during rainy season 2001, ICRISAT, Patancheru, India[1].

Accession (IS no.)	Origin	Days to 50% flowering	Plant height (cm)	Plant score[2]	Grain color
919	Sudan	78	210	3	Chalky white
1084	India	62	220	3	Straw
2262	Sudan	51	280	3	Chalky white
2263	Sudan	70	320	3	White
2311	Sudan	56	255	3	Chalky white
2319	Sudan	70	230	1	Chalky while
3076	Sudan	75	245	3	Chalky white
3511	Sudan	56	135	3	Chalky white
6910	Sudan	56	300	5	Light brown
6916	Sudan	75	230	5	Light brown
6953	Sudan	57	295	5	Brown
7036	Sudan	61	120	3	Light brown
8328	India	61	245	1	Straw
9283	Sudan	69	200	1	Chalky white
9677	Sudan	61	280	5	Straw
9816	Sudan	62	275	3	Gray
9957	Sudan	75	235	3	Brown
9982	Sudan	61	260	1	White
12467	Sudan	57	150	1	Straw
14429	Lesotho	61	185	3	Light red

continued

Table 2. *continued.*

Accession (IS no.)	Origin	Days to 50% flowering	Plant height (cm)	Plant score[2]	Grain color
15019	Cameroon	64	265	3	Gray
15838	Cameroon	71	385	5	Straw
19036	Sudan	56	200	3	White
19059	Sudan	66	245	1	White
19060	Sudan	60	285	3	Straw
19066	Sudan	64	340	5	White
19077	Sudan	56	220	1	White
19123	Sudan	57	280	5	White
19143	Sudan	64	230	3	Gray
19154	Sudan	58	170	1	Straw
19176	Sudan	73	255	5	Straw
19183	Sudan	75	220	3	White
19204	Sudan	52	235	3	Straw
19305	Sudan	59	150	3	White
19574	Sudan	56	120	1	White
20945	India	75	260	3	Straw
21639	Malawi	68	365	3	Straw
21662	Malawi	79	380	3	Straw
21951	Ethiopia	131	245	5	Straw
22313	Botswana	80	380	3	White
22380	Sudan	77	250	3	Light brown
22495	Sudan	69	235	3	Straw
22517	Sudan	72	360	5	White
22518	Sudan	56	150	1	White
22539	Sudan	72	280	3	Purple
22542	Sudan	70	270	3	Gray
22557	Sudan	64	320	3	Light brown
22563	Sudan	54	125	1	White
22906	Sudan	59	200	3	Reddish brown
23385	Sudan	56	120	1	Straw
24694	Ethiopia	54	150	1	Straw
24695	Ethiopia	75	265	1	Straw
24889	Nigeria	70	255	1	Straw
24978	Sudan	70	215	3	Purple
25009	Sudan	75	355	5	Light brown
25010	Sudan	79	335	5	Reddish brown
25011	Sudan	79	360	5	Reddish brown
25030	Sudan	75	310	5	Gray
26860	Nigeria	61	235	3	Straw
26861	Nigeria	64	185	1	Straw
26862	Nigeria	64	160	1	Straw
26863	Nigeria	70	170	1	Straw
26864	Nigeria	64	220	1	White
26866	Nigeria	70	260	1	Straw
26869	Nigeria	66	245	1	Straw
26871	Nigeria	68	245	1	Straw
26872	Nigeria	68	220	1	Straw
26914	Nigeria	66	230	1	Straw
27046	Zimbabwe	70	250	1	Straw
27063	Zimbabwe	64	340	3	White
27068	Zimbabwe	77	380	5	Brown
29306	Swaziland	64	300	3	Light red
29307	Swaziland	66	300	3	Light red

commuted

Table 2. ***continued.***

Accession (IS no.)	Origin	Days to 50% flowering	Plant height (cm)	Plant score[2]	Grain color
29308	Swaziland	68	325	3	Reddish brown
29673	Zimbabwe	77	400	3	White
30073	Zimbabwe	70	250	1	Straw
32318	India	59	230	1	Straw
35884	Russia and CIS	72	335	3	Straw
40120	Russia and CIS	51	145	1	Straw
40131	Russia and CIS	57	155	1	Straw
40146	Russia and CIS	51	140	1	Straw
40148	Russia and CIS	52	135	1	Straw

1. Accessions were free from anthracnose, bacterial leaf streak, ergot, maize mosaic virus, maize stripe virus, leaf blight, rough leaf spot, rust, downy mildew, gray leaf spot, oval leaf spot, smuts, tar spot and zonate leaf spot.
2. Recorded on 1-5 scale based on panicle exertion, grain color and days to flowering, where 1 = excellent, 2 = very good, 3 = good, 4 = poor and 5 = very poor.

Table 3. Incidence and severity ranges of sorghum diseases in 726 breeding lines during rainy season 2001, ICRISAT, Patancheru, India.

Disease	Incidence[1] (%)	Severity[2] (%)
Anthracnose	13-88	5-100
Bacterial leaf streak	3-10	5-20
Ergot	2-3	2-9
Leaf blight	10-40	4-6
Maize mosaic virus	2-3	Trace-5
Maize stripe virus (MStV)	2-6	4-5
Rust	10-100	2-75
Rough leaf spot	10-20	2-13
Downy mildew	Trace	Trace
Gray leaf spot	Trace	Trace
Oval leaf spot	Trace	Trace
Tar spot	Trace	Trace
Zonate leaf spot	Trace	Trace

1. Recorded from flowering to maturity for all foliar diseases except MStV; incidence of MStV recorded at maturity
2. Recorded on 0-100% scale, except MStV on 1-5 scale.

sorghicola), tar spot *(Phyllachora sorghi),* zonate leaf spot *(Gloeocercospora sorghi),* covered kernel smut *(Sporisorium sorghi),* head smut *(Sporisorium reilianum),* long smut *(Sporisorium ehrenhergii)* and grain mold.

Of the 945 landrace accessions from 46 countries, 82 accessions from India, Lesotho, Botswana, Zimbabwe, Russia and CIS, Swaziland, Cameroon, Sudan, Ethiopia, Malawi and Nigeria were free from all diseases observed (Table 1). A total of 651 accessions from the above 11 countries exhibited field tolerance to multiple diseases, while 294 accessions from 35 countries showed various levels of susceptibility to diseases. Of the 82 accessions that were free from diseases, 31 had excellent plant traits (score 1) with chalky white to straw grain color, 51-75 days to 50% flowering and 120-260 cm plant height (Table 2). The incidence and severity on 726 breeding lines were quite variable and none had multiple disease resistance (Table 3). However, at crop maturity, downy mildew, gray leaf spot, oval leaf spot, tar spot and zonate leaf spot were observed in traces. Of all the diseases observed, MStV is emerging as an important disease of sorghum.

The results provide some useful information on potential risks of bacterial streak and MStV. Sorghum accessions with multiple disease tolerance were identified for their possible use in resistance breeding program.

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The Pattern of Spore Liberation in Major Mold Pathogens of Sorghum

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Introduction

Grain mold of sorghum *(Sorghum bicolor),* caused by a complex of fungi (Navi et al. 1999), poses severe threat to sorghum production and utilization. The principal grain mold fungi in India are *Fusarium moniliforme, Curvularia lunula, Phoma sorghina, Alternaria ahernata, Exserohilum turcicum, Gonatobotrytis* spp and *Aspergillus* spp (Anahosur 1992). The disease occurs when the crop maturity coincides with warm and humid weather. The spread of the disease in the field is so rapid that it becomes increasingly difficult to manage the disease after receiving a rain-shower during physiological or normal maturity. Such a rapid spread of the disease is possible only when the inciting pathogens have the capability of brisk spore production and dissemination mechanisms. However, little information pertaining to pattern (fluctuation in the amount of spore released across hours in a day) and duration of spore liberation in mold pathogens is available. Thus a study was undertaken on the biology of the pathogens to investigate the actual period of spore liberation for different pathogens.

Materials and Methods

To understand the pattern and active period of spore liberation of four mold pathogens, a 7-day Burkard volumetric spore trap was set up in a sorghum field at 0.3 m above crop canopy during *kharif* (rainy) season 2002, where CSH 11 was raised. The weather during the sampling period was moderately favorable for grain mold development. A maximum temperature range of 28.7-31.4°C and minimum temperature range of 20.1-22.2°C, with 95-100% relative humidity prevailed during the period. Total rainfall of 78.4 mm was distributed in 2 rainy days during this period. The air was sampled for spores at the rate of 0.6 m^3 h^{-1} through an orifice 2 mm x 14 mm and directed at the vaseline coated Melinex tape moving at a rate of 2 mm h^{-1}. Spore count was made on hourly basis for four major pathogens *(F. moniliforme, C. lunata, A. alternaia* and *E. turcicum),* by counting the total number of spores available in 2 mm width in Melinex tape, which represented the spores collected in one hour. Spore count was made on hourly basis for 7 days consecutively during maturity stage. The data were presented from 0 h to 24 h with an interval of 2 h, to reveal the active period of spore dispersal by the pathogens in a 24-h day cycle. Again within the active period of spore liberation (which corresponds to the availability of higher spore count in a day), the peak period of spore liberation for major grain mold pathogens was identified.

Results and Discussion

Spores of all the four major mold pathogens were encountered throughout the sampling period of seven days at all hours in a day. Though spores were encountered consistently, higher spore count was observed during **a** particular period in a day. The spore count of *F. moniliforme* increased significantly from Indian Standard Time (IST) 1800 to 0200-0400 of the following day (Table 1). This was linked with the active period of spore liberation. The spore count during the early hours of morning until mid-day was comparatively low (Table 1). During mid-day (at 1000-1600) the spore count was low indicating low levels of spore liberation. The same trend was observed with *C. lunata* and A *ahernata* (Table 1). Observation on hourly spore count of *E. turcicum* did not show any defined pattern, as throughout the sampling period the spore count was consistent. So an active period of spore count was not observed with *E. turcicum.* In the other three pathogens, a peak period of spore liberation was observed. The peak period of spore liberation for *F. moniliforme* was at 2000-2400 while it was at 2200-2400 for *C. lunata* and at 1800-2000 for A. *ahernata.* Thus during this time, the pathogens are rapidly dispersing spores which increases the inoculum load in the air. The importance of ideal environment conditions (temperature of 20-25°C and relative humidity of 90-100%) during the late evening and night hours for mold development was theorized by Bandyopadhyay et al. (2002), when they conducted mist and shelter experiments to investigate the epidemiology of grain molds.