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SCREENING AND BREEDING SORGHUM FOR MIDGE RESISTANCE

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ABSTRACT

Sorghum midge, Contarinia sorghicola Coq. is the most important pest of grain sorghum. Sixteen germplasm and 14 breeding lines showing stable resistance to midge have been identified. Progress has been made in developing improved midge resistant breeding lines with acceptable yield and grain quality. Sorghum variety, ICSV 197 (PM 11344) has shown high levels of midge resistance over seasons and locations. Its yield potential is comparable to some of the commercial cultivars. PM 6751, PM 7061 and PM 8787-2 have been identified as non-restorers. Midge resistance is a quantatively inherited trait governed by both additive and nonadditive, but predominantly nonadditive genes. Dominant genes contributed most towards midge resistance followed by additive x additive, additive x dominance, and additive gene effects.

INTRODUCTION

Sorghum midge, Contarinia sorghicola Coq. is the most destructive pest of grain sorghum in Asia, Africa, Australia, Europe and the Americas. Plant resistance is one of the most effective and economic means of keeping the midge population below the economic threshold levels. At ICRISAT, major emphasis has been placed on developing cultivars resistant to different insect pests through an interdisciplinary approach. Major emphasis has been placed on: developing effective screening techniques; screening germplasm/breeding stocks to identify sources of resistance; converting resistant sources for use in a breeding program; transfering midge resistance from unadapted germplasm sources into improved and adapted cultivars; strengthening the sources of resistance by accumulating diverse genes from different sources; and generating basic genetic information for formulating an effective breeding program.

MATERIALS AND METHODS

Screening/Testing Procedures

The germplasm and breeding lines were screened under natural and no-choice conditions (Sharma, 1984). Dharwad (Karnataka, India)

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has been used as a 'hot spot' location and is used for initial large scale screening. To improve the efficiency of selection for midge resistance, planting dates were adjusted and two to three sowings were undertaken at fortnightly intervals to synchronize flowering with the peak activity period of the sorghum midge. Natural midge infestation was increased by planting infester rows of a susceptible cultivar (CSH-1) 20 days earlier than the test material. At the flag leaf stage, chaffy sorghum heads (kept moist for 10 days) carrying diapausing midge larvae were spread between the infester rows. This helped increase the migde population by 2 to 3 times.

Selected, less susceptible cultivars (both germplasm accessions and breeding lines) were also tested at Bhavanisagar, Hisar and Pantnagar in India. Cultivars showing less susceptibility across locations were tested under no-choice conditions using the headcage technique (Sharma, 1984). Nearly 20 primary branches at half-anthesis were retained on each panicle for resistance screening.

The cultivars were rated visually for midge damage on a 1 to 5 scale (see Table 1). In advance tests, florets with midge larvae and chaffy florets were also recorded on a sample of 500 florets drawn from five earheads.

Breeding Procedures

Both pedigree and population breeding methods wre used. A broad-based population for resistance to panicle feeding pests (midge and earhead bugs) was developed by using ms_3 and ms_7 male-sterility genes, and is being improved further using low to moderate insect pressure. The procedures involved in making crosses, screening and selecting for resistance, agronomic traits, and grain quality are outlined in Figure 1. Unit 1 involved the identification, conversion, and strengthening of the source material. Unit 2 involved the development of agronomically elite cultivars and hybrid parents, and in unit 3, resistance was transferred from unit 1 material to unit 2 material. Segregating material in unit-3 was advanced as outlined in Figure 1. Less susceptible lines identified in unit 3 were tested in the International Sorghum Midge Nursery (ISMN) to identify widely adapted and stable resistant lines for farmers' use.

Genetics of Resistance

The genetics of resistance to sorghum midge was studied in a set of seven sorghum cultivars under natural conditions during 1983 rainy season at Dharwad using diallel as well as generation mean analyses. TAM 2566, S-GIRL-MR 1, AF 28 and DJ 6514 were used as midge resistant parents and SPV 422, SPV 351 and SC 108-3 as susceptible parents in these studies. Data for midge resistance were recorded in terms of % seed set, and the results were analysed for combining ability and gene effects according to method 2 and model 2 of Griffing (1956) and Hayman (1958) respectively.

RESULTS AND DISCUSSION

Screening and Breeding for Midge Resistance

Sixteen germplasm lines (IS 2479C, IS 3461, IS 7005, IS-8571, IS 8721, IS 9807, IS 10712, IS 12666C, IS 15107, IS 18733, IS 18836, IS 19474, IS 19512, DJ 6514, TAM 2566, and AF 28) have been identified showing consistently high levels of midge resistance under headcage and multilocation testing. Eighteen cultivars (both germplasm accessions and breeding lines) have shown stable resistance across locations (Tables 1 and 2). A number of promising midge resistant breeding lines (PM 6751, PM 7061, PM 7495, PM 7317-5, PM 7318-2, PM-7322, PM 7363, PM 7390-1, PM 7397, PM 8787-2, PM 7032, PM 7493, PM 7526 and ICSV 197) have been developed. PM 7032 and PM 7526 have yielded eight times more than the standard cultivar CSH 6 under natural midge infestation.

ICSV 197 (PM 11344) has been identified as the most promising midge resistant cultivar. It has been evaluated for midge resistance over a range of environments (Table 3), and has shown stable resistance across locations and seasons. It is a tall dual type (2.5 m) cultivar. It has tan plant color, flowers in about 75 days, and is less susceptible to anthracnose (20%, compared with 75% damage on susceptible check IS 18442), and downy mildew (15%, compared with 90% damage on susceptible check DMS 652). It has a cream colored, hard, corneous, medium sized grain, and is 25% higher than DJ 6514 (1.6 g/100 grains). The panicles are compact at the base, semi-compact in the middle, and loose at the top. Its threshability is good and grain weathering is low. Its yield potential is comparable to the commercial cultivars (Table 4). It yields nearly 50% higher than its resistant parent DJ 6514. It is being extensively tested by the All India Coordinated Sorghum Improvement project (AICSIP) and is also being utilized by other national programs and ICRISAT regional programs in various countries. PM 7348, PM 7168, and PM 7357 have been found to be less susceptible than the local checks to sorghum midge in El Salvador, Brazil, and Argentina, and are already being used as midge resistant parents in various national programs.

Lines PM 6751, PM 7061, and PM 8787-2 have been identified as non-restorers and are being converted into male-steriles for the production of midge resistant hybrids. PM 6751, PM 7061, PM 7348, PM 7495, and ICSV 197 are also being used as resistant donor parents for generating breeding stocks. Their crossed derivatives appear to be agrnomically better than the first cycle material generated by using the original sources.

Genetics of Midge Resistance

Resistance to sorghum midge is a quantatively inherited trait. It is controlled by both additive and nonadditive, but predominantly by nonadditive gene effects. DJ 6514 and TAM 2566 were the best general combiners. In general, parents having a high level of midge resistance showed better combining ability and have been found to be useful in breeding for midge resistance. Differences were also noticed for resistance genes in different source parents. AF 28 does not seem to be a good source since it has not produced any useful segregants in any cross combination. Dominance and additive x additive gene effects were found important in a majorit,; of crosses. However, additive x dominance gene effects also showed good contribution in some crosses, alone as well as in combination. The dominant genes contributed most towards midge resistance followed by additive x additive, additive x dominance, and additive gene effects.

CONCLUSIONS

Sources of resistance to sorghum midge have been identified and utilized for developing improved midge resistant cultivar with a yield potential comparable to the commercial cultivars. Midge resistance is a quantatively inherited trait and is predominantly controlled by nonadditive gene effects. Dominant genes contribute most towards midge resistance. Efforts need to be made in developing midge resistant male-sterile lines for the production of potential midge resistant hybrids.

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TABLE 1

Midge damage in 25 cultivars across 10 testing environments (1984 International Sorghum Midge Nursery)

Cultivar	Damage rating[a/] Dharwad	Gujarat	Parbhani	Patancheru I	Patancheru II	Kovilpatti	Tolichowki Hyderabad	Ghana	Sotuba Mali	El Salvador
IS 61	5.0	2.0	2.0	2.0	3.0	5.0	-	5.0	3.0	5.0
IS 2549C	2.5	2.0	2.0	3.0	3.0	1.0	3.5	4.0	1.0	1.0
IS 3461	1.0	1.0	2.0	2.0	3.0	1.0	1.0	3.0	1.0	1.0
IS 7005	1.0	1.5	2.0	2.5	3.0	1.0	1.0	3.0	1.0	1.0
IS 8571	1.5	1.5	1.0	3.3	3.3	1.0	1.0	2.0	1.0	1.0
IS 10712	2.0	2.5	1.0	3.0	4.0	1.0	3.0	3.5	1.5	1.0
IS 15107	1.0	1.5	2.0	3.0	2.0	2.0	2.0	2.0	2.0	1.0
IS 18733	1.0	1.0	1.0	3.0	3.0	4.0	2.5	2.5	1.0	1.5
IS 19512	1.0	2.0	2.0	2.5	2.0	1.0	1.5	3.0	1.0	1.0
IS 21873	2.0	3.0	2.0	2.5	2.5	4.0	2.0	4.0	1.0	1.0
PM 6751	3.0	1.5	2.0	3.0	3.0	1.0	1.5	3.0	1.0	1.0
PM 7032	2.0	2.0	2.0	2.5	2.5	1.0	1.5	3.0	1.0	1.0
PM 7061	1.5	1.5	2.0	3.0	2.5	1.0	1.0	4.0	1.0	1.0
PM 7164-1	2.0	2.0	1.0	3.0	3.5	4.0	1.5	4.0	1.0	1.0
PM 7318-2	2.0	1.5	3.0	2.0	3.0	1.0	2.0	3.0	1.5	1.0
PM 7322	1.0	1.0	2.0	3.0	3.0	2.0	2.0	3.5	2.0	1.0
PM 7526	1.0	3.0	1.0	3.0	2.5	1.0	1.5	3.0	1.0	1.0
PM 8787-2	2.0	1.0	1.0	3.0	3.0	1.0	1.5	3.0	1.0	1.0
ICSV 197	1.0	2.5	2.0	2.5	3.0	1.0	1.0	3.5	1.0	1.0
AF 28 (R)	1.0	2.0	1.0	2.0	3.0	1.0	1.5	2.0	1.0	1.0
TAM 2566 (R)	1.0	1.0	2.0	3.0	2.5	1.0	2.0	3.0	1.0	2.0
DJ 6514 (R)	1.0	2.5	2.0	2.0	2.0	2.0	1.5	3.0	2.0	1.0
Local Cultivar (S)	4.0	3.0	2.0	5.0	4.0	4.0	5.0	4.0	3.5	4.0
CSH 1 (S)	4.0	2.5	2.5	5.0	4.0	5.0	5.0	4.5	3.5	5.0
SE	±0.18	±0.34	±0.87	±0.28	±0.36	-	±1.16	±0.44	±0.38	±0.26

a/ = Damage ratings: 1 = <10% incidence (<10% chaffy florets), 2 = 10-25% (A few pupal cases on heads), 3 = 25-40% (Most of the earheads with pupal cases showing considerable affect on seed set), 4 = 40-60% (Large number of pupal cases and heads with 50% seed set), 5 = >60% (Heads severely attacked).

(R) = Resistant check; (S) = Susceptible check.

TABLE 2

Performance of midge resistant lines under different midge infestation levels (1984 rainy season)

	Damage rating[a/]								
	Natural conditions			Headcage testing					
	Patancheru		Dharwad	Patancheru			Dharwad		
Cultivar	1st planting	2nd planting		10[b/]	20	N	10	20	N
PM 6751	2.0	2.5	3	2	2	3	3	3	3
PM 7363	3.0	2.5	3	3	3	3	3	3	3
PM 7317-5	2.5	2.0	2	3	3	3	2	2	3
PM 7422-2	3.0	2.5	3	2	1	2	1	3	2
PM 8787-2	2.0	2.5	3	2	3	3	2	3	3
PM 6958	3.0	2.5	3	2	2	3	3	3	3
PM 7061	2.5	2.5	1	2	3	3	2	2	2
ICSV 197	1.0	1.0	1	1	1	1	1	1	1
DJ 6514	1.0	1.0	1	1	1	1	1	1	1
AF 28 (R)	1.0	1.0	2	2	2	2	2	2	2
Swarna (S)	5.0	5.0	4	5	5	5	5	5	5
CSH 1 (S)	5.0	5.0	5	5	5	5	5	5	5

a/ = Damage rating: See Table 1; b/ = Number of primary branches retained on the head;
N = Normal head tested under standard procedure; R = Resistant check; S = Susceptible check.

TABLE 3

Performance of ICSV 197 for midge resistance under natural and no-choice conditions (1984 rainy season)

	% seet set				
	Head cage		Natural infestation		
	Patancheru	Dharwad	Patancheru I	Patancheru II	Dharwad
ICSV 197	93	94	79	85	90
DJ 6514 (R)	89	94	87	90	64
CSH 1 (S)	14	1	16	20	26
SE	±1.5	±4.4	±6.4	±10.4	±4.7
CV%	4	7	10	16	8

(R) = Resistant check; S = Susceptible check.

TABLE 4

Performance of promising midge resistant breeding lines during 1984 rainy season (Dharwad)[a]

Cultivar	Days to 50% flowering	Plant height (cm)	Grain yield kg/ha	% yield over DJ 6514	Midge damage at Dharwad (% seed set)
ICSV 197	66	263	5844	54	79
PM 7322	54	126	5222	33	61
PM 7400-1-3	62	216	4844	23	66
CSH 1 (S)	48	158	3944	--	34
DJ 6514 (R)	73	241	3911	--	67
SE	±0.75	±7.4	±427	--	±4.7
CV%	1.3	4.6	10	--	8.0

a = Data presented for five entries out of a 36 lines trial.

S = Susceptible check, R = Resistant check.

FIGURE 1

Scheme for pest resistance breeding in sorghum