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IDENTIFICATION OF PEARL MILLET LINES WITH MULTIPLE RESISTANCE TO ERGOT, SMUT AND ORIENTAL ARMYWORM

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ABSTRACT

Pearl millet lines resistant (<10% mean severity) to ergot (*Claviceps fusiformis* Lov.) and/or smut (*Tolyposporium penicillariae* Bref.) and showing moderate resistance (damage rating 6 on a 1 to 9 scale) to oriental armyworm (*Mythimna separata* Wlk·) under natural field conditions during the 1984 rainy season' were evaluated by artificial infestation/inoculation in greenhouse and field experiments at ICRISAT Center. Pearl millet lines ICMPES 28, ICMPES 29, and ICMPES 38 showed combined resistance to ergot, smut, and the armyworm, and ICMPS 600-3-2-1 showed resistance to both smut and the armyworm. The possible utilization of these lines in pear millet improvement is discussed.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R. Br) is a major grain and forage crop in the semi-arid tropics of Asia and Africa. Downy mildew, ergot, smut and rust are important diseases of pearl millet (Thakur, 1987). White grubs, shoot fly, stem borers, grass-hoppers and locusts, army worms, ash weevil, aphids, shoot bug, midge and head caterpillars are the important insect pests damaging this crop (Sharma and Davies, 1988).

At ICRISAT Center, major emphasis has been on developing varieties and hybrids resistant to downy mildew, ergot, and smut (Andrews *et al.*, 1985). However, there has not been a major effort towards screening and breeding for insect resistance, although occasional pest outbreaks, particularly of armyworm, have been observed at ICRISAT Centre and several other locations in India (Sharma and Davies, 1983).

The objective of this investigation was to identify resistance to the armyworm in pearl millet lines with known resistance to ergot and/or smut.

MATERIALS AND METHODS

During the 1984 rainy season, 75 pearl millet lines showing high levels of resistance to ergot and/or smut, and some degree of resistance (10% leaf feeding) to the armyworm (*Mythimna separata* Wlk.) under natural infestation in the ergot and/or smut nurseries at ICRISAT Center were selected. These lines were screened three times under artificial infestation for resistance to the armyworm under greenhouse conditions, and 11 lines showing a moderate level of resistance (damage ratings 3.1 - 6.0) were selected for further evaluations under greenhouse and field conditions. The techniques used to screen for resistance to different traits are described below :

Greenhouse screening :

Seedlings of 11 lines were raised in plastic pots (15-cm dia) filled with a mixture of farmyard manure and soil (3:1 v/v), maintaining a density of 5 plants per pot. Fifteen-day-old seedlings were exposed to third instar larvae at the rate of 1 larva/plant in a cage (Sharma *et al.*, 1982) for 48h. Leaf damage was visually

evaluated on a 1 to 9 scale (1—10% leaf area consumed, and 9—80% leaf area consumed). This rating scale was also used to classify the lines into resistant (1-3), moderately resistant (3.1-6.0), and susceptible (6.1-9.0).

Leaf-disc assay :

Plants were grown in pots outside the greenhouse during June-July 1986. Thirty-five days after emergence, third leaf from the top was picked up from five plants selected at random and brought to the laboratory. Five leaf discs of uniform size were cut from the middle of each leaf with a no. 7 corkborer. Each leaf disc was then placed in a petri dish (9-cm dia), lined with a layer of moistened filter paper. Third instar larvae, which had been starved for 4 h, were confined with the leaf discs at the rate of 1 larva/leaf disc for 24h. The leaf discs were rated visually for leaf feeding on a 1 to 9 scale. The experiment was repeated, and the observations were recorded on leaf damage, unconsumed leaf area (by passing the leaf discs through an automatic leaf area meter), and larval weight. The larvae were starved for 2 h in glass vials and then weighed on a Mettler balance.

Field screening :

Fourteen pearl millet lines, including 11 lines that showed moderate resistance to the armyworm in the above tests, one resistant (Souga local 4), one susceptible (SAR 57), and a commercial check (WC-C75) were grown in the smut nursery during the 1988 rainy season. Each line was grown in a 4 -row-plot (4 m-long ridge, 75-cm apart), with 4 replications in a randomized block design. Plants were thinned 15 days after sowing to a 10-cm spacing.

Armyworm :

At the pre-boot stage, plants in the central two rows in each plot were infested with armyworm larvae (5 larvae/plant) in two replications. Plants were rated for armyworm damage 15 days after infestation on a 1 to 9 scale.

Ergot :

In each plot, 10 plants in the border row were used to screen for resistance to ergot. Plants were bagged with parchment selfing bags at the boot-leaf stage and spray-inoculated at protogyny with a honeydew conidial suspension (10^6 conidia/ml) by briefly opening the bags (Thakur *et al.*, 1982). High humidity, essential for disease development, was maintained by operating overhead sprinkler irrigation on rainfree days. Bags were removed 15 days after inoculation and ergot scores were taken on a severity rating scale of 0 to 100% (Thakur and Williams, 1980).

Smut :

Plants in the other border row of each plot were used for confirmation of smut resistance. Ten plants in each plot were inoculated with a sporidial suspension (10^6 spordia/ml) of *T. penicillariae*, by injecting the panicles at the boot leaf stage, and covering them with parchment selfing bags (Thakur *et al.*, 1983). Bags were removed 20 days after inoculation and smut scores were recorded on a severity rating scale of 0 to 100% (Thakur and King, 1988).

Data analysis :

Data were subjected to analysis of variance to determine the significance of genotypic susceptibility to the armyworm, ergot and smut.

RESULTS AND DISCUSSION

Greenhouse tests :

At the seedling stage, damage ratings varied from 4.0 for ICMPS 600-3-2-1 to 8.2 for ICMPES 35, compared with 9.0 for the susceptible check SAR 57, 4.5 for the resistant check Souga local 4 (behaved as moderately resistant in this test), and 6.0 for the commercial check, WC-C75 (Table 1). Eight of the 11 lines tested showed ratings significantly lower than the susceptible check, and were comparable to Souga local 4. Ten of the 11 lines were moderately resistant (3-6 ratings) and one line was susceptible (rating 6).

In leaf-disc assays, seven of the 11 lines were moderately resistant in experiment 1, as were 3 of 10 lines in experiment 2, and these were comparable to Souga local 4 (Table 1). Only two lines, ICMPES 35 and ICMPES 600-3-2-1, were moderately resistant in both experiments. In three moderately resistant lines, unconsumed leaf area was significantly larger than in the susceptible check, SAR 57 and the commercial check, WC-C75. Larval mass was significantly lower in two lines (ICMPES 28, ICMPS 600-3-2-1) than in the susceptible check (Table 1).

Field screening

Damage ratings for the oriental armyworm in 11 lines varied from 3.8 for ICMPES 35 to 8.1 for P 489-5-3, compared with 8.0 for SAR 57, the susceptible check, 5.4 for Souga local 4, the moderately resistant check, and 7.7 for WC-C75, the commercial check (Table 2). Differences in damage ratings for the armyworm amongst the lines tested were not significant. However, four lines (ICMPES 28, ICMPES-29, ICMPES-38 and ICMPS 600-3-2) showed moderately resistant reaction (Table 2). Resistance to both ergot and smut (5% mean severity) were confirmed in six lines and to smut alone in five lines (Table 2). Three lines (ICMPES 28, ICMPES-29, and ICMPES-38) showed multiple resistance to ergot, smut and the armyworm, while ICMPS 600-3-2 showed resistance to both armyworm and smut (Table 2).

Although it is relatively difficult to obtain lines resistant to leaf-feeding insects, the results of this study indicate that less susceptible lines at the seedling stage and/or in the filed can be identified. Screening of pearl millet lines at the seedling stage, and at the pre-boot stage under no-choice conditions, indicated differences in genotypic susceptibility to the armyworm. Of 10 lines that were moderately resistant to the armyworm at seedling screening, only two (ICMPES 35 and ICMPES 600-3-2-1) showed non-preference to feeding in the leaf-disc assay at the pre-boot stage. This variation in reaction could be due to nutritional changes in the leaf tissue with plant growth. The armyworm damage is generally more severe at the pre-boot stage of the crop when there is maximum foliage available for the larvae to feed on. The seedling resistance or tolerance could be of value to quickly distinguish genotypic variations for suceptibility levels to the armyworm, and the selected lines can be further screened at the pre-boot stage. Leaf-disc assay provided a well controlled screening, and only 2 of the 11 lines showed moderate resistance to the armyworm (Table 1).

Screening in the field by artificial infestation is influenced by several factors, including migration of larvae from one plot to the other, variation in infestation levels, weather conditions, and larval sur-

TABLE 1. Reactions to oriental armyworm (*Mythimna separata*) of selected pearl millet lines resistant to ergot (ER) and smut (SR) in different green house and laboratory tests at ICRISAT Centre, 1986.

Line		Seedling screening Damage rating (1–9)	Leaf-disc assay (pre-boot) Expt.1 Damage rating (1–9)	Leaf-disc assay (pre-boot) Expt.2 Damage rating (1–9)	Expt.2 Unconsumed leaf area (cm^3)	Expt.2 Larval mass (mg)
ICMPES 28	(ER+SR)	5.2 MR	6.6 S	7.0 S	1.6	34.3
ICMPES 29	(ER+SR)	6.0 MR	6.3 S	9.0 S	0.5	48.0
ICMPES 30	(ER+SR)	6.5 S	5.7 MR	6.3 S	2.6	38.3
ICMPES 35	(ER+SR)	8.2 S	5.4 MR	5.0 MR	4.1	44.0
ICMPES 38	(ER+SR)	5.0 MR	5.4 MR	7.0 S	2.8	43.7
ICMER 153	(ER+SR)	5.5 MR	4.5 MR	7.3 S	1.7	45.3
P 18-S-1	(SR)	6.0 MR	6.7 S	7.0 S	1.7	46.0
P 489-S-3	(SR)	4.5 MR	5.4 MR	—	—	40.3
P 489-S-2-2-1	(SR)	5.5 MR	4.9 MR	7.0 S	4.0	43.0
ICMPS 1100-2-1-3	(SR)	4.5 MR	7.6 S	5.0 MR	4.6	41.0
ICMPS 600-3-2-1	(SR)	4.0 MR	4.0 MR	5.3 MR	3.4	34.7
SAR 57 (S-check)[c]		9.0 S	7.7 S	8.0 S	1.3	51.7
Souga local (MR-check)[c]		4.5 MR	3.6 MR	4.0 MR	5.0	31.0
WC-C75 (C-check)[c]		6.0 MR	5.4 MR	7.3 S	2.2	38.3
LSD ($P = 0.05$)		1.18	1.60	2.24	2.70	16.9

a Mean severity 10% based on several tests at ICRISAT Center.

b Based on a 1 to 9 rating scale, 1-3=resistant (R) 3.1-6.0=moderately resistant (MR) 6.1-9.0=susceptible (S).

c S = susceptible, MR = moderately resistant, and C = commercial checks for oriental armyworm

d Data not available

TABLE 2. Reactions to oriental armyworm, ergot and smut of selected pearl millet lines resistant to ergot (ER) and/or smut (SR) in a field test at ICRISAT Center, 1988 rainy season.

Line		Armyworm Damage rating (1–9)		Severity (%)[a]	
				Ergot	Smut
ICMPES 28	(ER+SR)	5.4	MR	2	0
ICMPES 29	(ER+SR)	5.2	MR	2	0
ICMPES 30	(ER+SR)	7.7	S	1	1
ICMPES 35	(ER+SR)	6.3	S	1	0
ICMPES 38	(ER+SR)	3.8	MR	4	1
ICMER 153	(ER+SR)	7.0	S	5	3
P 18-S-1	(SR)	7.7	S	67	8
P 489-S-3	(SR)	8.1	S	56	0
P 489-S-2-2-1	(SR)	6.8	S	56	1
ICMPS 1100-2-1-3	(SR)	6.1	S	66	10
ICMPS 600-3-2	(SR)	4.5	MR	71	0
SAR 57 (S-check)[c]		8.0	S	75	65
Souga Local (MR-check)[c]		5.4	T	77	51
WC-C75 (C-check)[c]		7.7	S	76	32
LSD ($P = 0.05$)		2.76		15.9	7.2

a Mean of 10 inoculated panicles in each of three replications.

b Based on a 1 to 9 rating scale, 1-3 = resistant (R); 3.1-6.0 = moderately resistant (MR); and 6.1-9.0 = Susceptible (S).

c S = susceptible, MR = moderately resistant, and c = commercial checks for the armyworm, and WC-C75 is a susceptible check for ergot and smut as well.

vival. The leaf damage ratings of lines from the field evaluation clearly indicated this effect. Leaf damage under field conditions is also influenced by the presence of non-flowering tillers, which provide hiding space to the larvae; also the late-flowering plants tend to harbour more larvae in leafwhorls. Lines which are basically unpalatable to the insect because of thick hairs, brittle or leathery leaves, but are late flowering and produce unproductive tillers, may suffer higher damage than early flowering and less tillering lines.

Six lines showed high levels of resistance to both ergot and smut, and three of these were also moderately resistant to the armyworm. ICMPES 600-3-2 was highly resistant to smut and moderately resistant to the armyworm. Identification of these lines with multiple resistance to armyworm, ergot and smut is a major step forward. Although it is relatively difficult to utilize multiple resistance in breeding lines by directly transferring resistance, it offers a good opportunity to utilize such lines in population improvement programs through recurrent selection to develop pearl millet varieties with multiple resistance to insects and diseases.

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