Variable Cultivar Response to Metalaxyl Treatment in Pearl Millet

S. D. SINGH, International Crops Research Institute for the Semi-Arid Tropics, Patancheru P.O., A.P. 502 324, India

ABSTRACT

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Two formulations of metalaxyl were tested as seed treatments for control of downy mildew and for their effects on germination, emergence, time of flowering, and grain yield with four pearl millet (*Pennisetum americanum*) cultivars that varied in susceptibility to this disease. Germination was reduced significantly ($P = 0.05$) in all cultivars at the higher rate of fungicide application but emergence was reduced in only one of the four cultivars; however, metalaxyl gave significant ($P = 0.05$) grain yield increases only on the two most susceptible cultivars. In the field trial, significant ($P = 0.05$) reductions in downy mildew were obtained with all fungicide treatments.

The systemic fungicide metalaxyl (Ridomil) has been used successfully to control several plant diseases caused by Oomycetes (6,7) and was first reported to be effective in controlling cereal downy mildews in 1978 (2,8). Effective control of downy mildew, caused by *Sclerospora graminicola* (Sacc.) Schroet., in a highly susceptible pearl millet (*Pennisetum americanum* (L.) Leeke) hybrid by seed treatment with three metalaxyl formulations was reported in 1981 (9). The fungicide was also effective as a seed treatment in controlling downy mildew in pearl millet hybrid NHB-3 at several locations in India and West Africa in 1978 (1). It was reported from Mali (J. F. Scheuring, *personal communication*), however, that in field trials in that country, considerable reduction in plant stand occurred with some pearl millet cultivars treated with a seed-treatment formulation of metalaxyl. Previous trials with metalaxyl at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) had been conducted with a single F_1 hybrid and information was needed on the usefulness of metalaxyl with other genotypes. In 1979, effects of two metalaxyl formulations on downy mildew development and on several plant-growth parameters were examined using four pearl millet cultivars that varied considerably in susceptibility to downy mildew. The results are reported in this paper.

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MATERIALS AND METHODS

Test cultivars. The four pearl millet cultivars were 1) 7042, ultrasusceptible to downy mildew (develops >90% downy mildew under relatively low inoculum pressure); 2) NHB-3, highly susceptible (develops >80% downy mildew under high-inoculum pressure in disease nurseries); 3) BJ-104, intermediately susceptible (develops <10% downy mildew under low-inoculum pressure in farmers' fields but >60% under high-inoculum pressure in disease nursery); and 4) ICH-105, mildly susceptible (develops <10% downy mildew, even under high inoculum pressure in disease nurseries). These cultivars were used both in field and laboratory trials.

Fungicide formulations and treatments. The two metalaxyl formulations used were a 25% a.i. wettable powder (WP) and a 35% a.i. seed-treatment formulation (ST). For germination and emergence study, the two formulations were applied

Table 1. Effect of seed treatment with two formulations of metalaxyl at two rates by two methods on germination of four pearl millet cultivars

Rate (g a.i./kg)	Application method	Formulation[a]	Percent germination in pearl millet cultivar[b] NHB-3	7042	ICH-105	BJ-104
2	Dust	ST	95	96	85	77
		WP	98	97	83	71
	Slurry	ST	94	92	78	66
		WP	95	97	78	62
4	Dust	ST	90	87	71	56
		WP	90	86	71	55
	Slurry	ST	92	70	66	53
		WP	91	85	68	44
Untreated checks	...	...	97	96	86	90
LSD ($P = 0.05$)			(4.8)	(7.8)	(7.1)	(6.6)
Mean separation						
Formulation (F)			NS[c]	*[c]	NS	**[c]
Application method (A)			NS	**	**	**
Rate (R)			**	**	**	**
F × A			NS	*	NS	NS
F × R			NS	NS	NS	NS
R × A			NS	NS	NS	NS
F × R × A			NS	NS	NS	NS

[a] ST = 35% a.i. dry seed treatment formulation, WP = 25% a.i. wettable powder formulation.
[b] Mean of 21 replicates in eight experiments for BJ-104 and mean of nine replicates in four experiments for NHB-3, 7042, and ICH-105.
[c] * = Comparison significant at $P = 0.05$, ** = comparison significant at $P = 0.01$, and NS = not significant.

to pearl millet seed at 2 and 4 g a.i/kg seed as dust (dry seeds were thoroughly shaken with the fungicide) and as slurry (required amount of fungicide per kilogram of seed was added to 10 ml water and shaken with the seed until evenly coated).

In the field trial for downy mildew control, WP was used as a dust at 2 g a.i./kg seed and the ST formulation was used as a slurry at 2 and 4 g a.i./kg seed. Untreated seed of all cultivars was used as a check.

Effect on seed germination. Treated and untreated seed of each cultivar were planted on moist blotting paper in petri dishes (50 seeds per dish) and were incubated at 25 ± 2 C in the dark for 5 days. Each treatment had three replicates. Numbers of germinated seeds were recorded at the end of the incubation period. The experiment was repeated several times with each cultivar.

Effect on seedling emergence. Treated and untreated seed of each cultivar were planted 2–3 cm deep in native red soil in pots maintained at 25–30 C in a greenhouse. Each treatment was planted in three replicates. Emergence counts were made 15 days after planting (DAP). The experiment was repeated twice with the same seed lot.

Effects on downy mildew and grain yield. The field trial to determine effects of seed treatments on downy mildew development and grain yield was conducted during the 1979 rainy season. The soil type, fertilizer usage, methods of inoculum provision, downy mildew incidence and severity rating, and yield measurements were the same as described previously (9). The number of days from planting to 50% flowering and 50% grain maturity was also recorded.

A split-plot design was used, with cultivars as main-plot treatments and the three fungicide treatments and the untreated check as randomized subplots. Each subplot consisted of four 4-m rows 75 cm apart. Plants were about 5 cm apart within the rows. There were four replicates. Yield data were collected from the central 3.8 m of the two center rows (net plot size = 5.7 m^2).

Table 2. Effect of seed treatment with two formulations of metalaxyl on emergence of four pearl millet cultivars

Rate (g a.i./kg)	Application method	Formulation	Emergence[b] (%) NHB-3	7042	ICH-105	BJ-104
2	Dust	ST	95	94	74	65
		WP	85	95	58	83
	Slurry	ST	91	90	80	78
		WP	95	95	81	83
4	Dust	ST	95	89	83	81
		WP	83	93	76	85
	Slurry	ST	82	92	78	86
		WP	95	95	72	85
Untreated (check)			88	88	89	79
LSD ($P = 0.05$)			(14.8)	(12.8)	(16.7)	(14.5)

[a]ST = 35% a.i. dry seed treatment formulation, WP = 25% a.i. wettable powder formulation.
[b]Means of two tests.

Table 3. Downy mildew incidence 26, 47, and 73 days after planting, infection indices 73 days after planting, and grain yield of four pearl millet cultivars grown from seed treated with two formulations of metalaxyl and from untreated seed

Cultivar	Formulation[a]	Rate (g a.i./kg)	Downy mildew (%) 26 Days	47 Days	73 Days	Infection index (%) at 73 days[b]	Grain yield (kg/ha)
ICH-105	ST	4	0	0	0	0	1,649
	ST	2	0	0	0	0	1,432
	WP	2	0	0	0	0	1,496
	Untreated	...	3.2	3.3	3.5	2.7	1,696
	LSD ($P = 0.05$)		(1.3)	(1.2)	(1.4)	(1.3)	(340)
BJ-104	ST	4	0	0	0.6	0.2	1,746
	ST	2	0	0.9	0	0.4	1,728
	WP	2	0	0.7	1.5	0.9	1,704
	Untreated	...	63.9	64.3	65.0	64.3	1,567
	LSD ($P = 0.05$)		(4.4)	(4.2)	(4.3)	(4.0)	(351)
NHB-3	ST	4	0	1.9	9.9	4.2	1,458
	ST	2	0.1	5.5	14.7	6.4	1,389
	WP	2	0.1	4.6	18.2	7.4	1,354
	Untreated	...	80.4	81.7	87.5	83.2	1,018
	LSD ($P = 0.05$)		(4.2)	(7.6)	(7.8)	(6.0)	(368)
7042	ST	4	0	7.9	47.0	25.3	672
	ST	2	0	43.1	72.0	54.2	465
	WP	2	0	49.5	76.0	59.9	374
	Untreated	...	70.8	95.7	98.1	96.8	169
	LSD ($P = 0.05$)		(36.1)	(20.4)	(21.0)	(21.0)	(219)

[a]ST = seed treatment (35% a.i. dry formulation as a slurry), WP = wettable powder (25% a.i. formulation as a dust application to the seed).
[b]Derived from the data on the number of plants in each of the five reaction categories: 1 = no downy mildew, 2 = only aerial tillers infected, 3 = less than 50% of the basal tillers infected, 4 = more than 50% of the basal tillers infected, and 5 = no productive earhead produced at the final scoring by the following formula: $[(x(2) + 2x(3) + 3x(4) + 4x(5))/(4N)] \times 100$, $x(2) - x(5)$ = number of plants in disease categories 2–5 and N = total number of plants.

RESULTS

Effect on germination. The effect of fungicide treatment on seed germination varied with the cultivar (Table 1). BJ-104 was the most sensitive, with significant ($P = 0.05$) germination reduction in all fungicide treatments. NHB-3 and 7042 showed significant ($P = 0.05$) reductions in germination only in treatments at the higher application rate. The major factor reducing germination among the fungicide treatments was increased in application rate, which was significant ($P = 0.05$) for all cultivars. Significant ($P = 0.05$) formulation differences were detected with only 7042 and BJ-104 but without a consistent pattern. Significant ($P = 0.05$) application method differences occurred with all cultivars except NHB-3, with germination in slurry treatments consistently lower. The only significant ($P = 0.05$) interaction (formulation by application rate) was detected between the two formulations at the higher application rate with 7042.

Effect on emergence. There were no significant ($P = 0.05$) effects of fungicide treatment on seedling emergence of cultivars NHB-3, 7042, and BJ-104 (Table 2). In cultivar ICH-105, however, two treatments reduced emergence but without a consistent pattern (Table 2).

Effects of flowering and maturity. There were no significant ($P = 0.05$) effects of treatments on time of first flower to 50% flowering or on time of first grain filling to 50% grain maturity.

Effect on downy mildew. There were major effects of cultivar and fungicide treatment on downy mildew development (Table 3). The cultivar ICH-105 did not develop downy mildew in any of the plots grown from treated seed (treated plots). In all other cultivars, all treated plots had some downy mildew at the final scoring, and for all cultivars, the order of treatments from least to most downy mildew incidence was 1) ST formulation 4 g a.i./kg seed, 2) ST formulation 2 g a.i./kg seed, and 3) 25 WP formulation. Downy mildew levels in all treated plots for BJ 104 were extremely low (0.2–0.9 infection indices), and even in NHB-3, which was highly susceptible to the downy mildew pathogen, the range of downy mildew infection indices in treated plots was only 4.2–7.4% compared with 83.2% in the untreated plots. In cultivar 7042, however, none of the treatments were effective in keeping downy mildew at a low level throughout crop development (treated plot infection indices ranged from 25 to 60%, with an infection index of 97% in the untreated plots), but the onset of the disease was delayed for about 1 mo in treated plots.

Effect of treatment on yield. In the two most susceptible cultivars, 7042 and NHB-3, the rank order for yield was the reverse of the rank order for downy mildew infection index, and grain yield of the plots treated with ST formulation was significantly ($P = 0.05$) greater than that of the untreated checks (Table 3) ie, the lower the index, the higher the yield. One plot each of 7042 and NHB-3 that just failed to reach the level of statistical significance, yielded 221 and 133% of the untreated plots, respectively. In BJ-104, yield of treated plots ranged from 109 to 111% of the untreated check, but these differences were not statistically significant ($P = 0.05$).

DISCUSSION

Genotypes vary considerably in their sensitivity to metalaxyl, but the marked disparity of results on germination and emergence indicates that sensitivity of a genotype is likely to vary with environment. In the germination trials, there was little opportunity for the fungicide to rub off or leach away from the seed, whereas in the emergence trials with pots watered daily, less fungicide probably remained closely associated with the seed. In view of the report of the detrimental effect of metalaxyl treatment on establishment of certain genotypes in the field in Mali, there is a need to further evaluate conditions that predispose to plants to possible phytotoxic effects of this fungicide, eg, the possibility of low soil moisture and drought stress increasing phytotoxicity problems.

Variation among cultivars in the effectiveness of fungicide treatments in controlling downy mildew indicated that the lower the resistance of a cultivar to the pathogen, the more fungicide or more effective treatment is needed to provide acceptable control. This phenomenon is similar to the reported complementation between degree of resistance to the pathogens and the amount of fungicide needed to provide acceptable control of potato late blight (3,4), which has led to development of a more efficient fungicide-use strategy for control of that disease.

This study clearly indicated that dusting pearl millet seed with 25 WP at only 2 g a.i./kg seed provided an acceptable level of downy mildew control in all but the most highly susceptible cultivar, 7042.

For cultivars ICH-105, NHB-3, and 7042, the intracultivar variations (or lack of variations) in grain yield are readily explained by the differences (or lack of differences) in the level of downy mildew among treatments. In cultivar BJ-104, however, the large variations in downy mildew levels between the untreated plots and all treated plots are not associated with statistically significant differences in yield though the untreated plots did have the lowest yield. This can probably be attributed to the capacity of pearl millet hybrids to compensate for stand reduction (mainly by increased tillering), providing more yield per plant, in the range of 30,000–250,000 plants per hectare (5). In this study, the initial plant population was relatively high (about 266,000 plants per hectare), and in the untreated plots of cultivar BJ-104, virtually all downy mildew infections were manifested by 26 DAP (incidence increased from 63.9 to only 65% between 26 and 73 DAP). Because many early infected plants died and disappeared at an early stage of crop development, there would have been ample opportunity for the remaining plants to compensate. In cultivars NHB-3 and 7042, the early infection levels in the untreated plots were considerably higher than in cultivar BJ-104, which had less downy mildew, and there was a considerably greater increase in downy mildew incidence after the 26-day scoring, particularly in the ultrasusceptible cultivar 7042. The later development of symptoms would have resulted in plants competing for light and nutrients throughout crop development and yet producing heads without grain.

LITERATURE CITED

1. Anonymous, 1979. Report of the 1978 International trial for the control of pearl millet downy mildew, Progress Report: PMPDM 7904. Int. Crops Res. Inst. Semi-Arid Trop., Hyderabad, India.
2. Exconde, O. R., and Molina, A. B. 1978. Note: RIDOMIL (Ciba-Geigy), a seed dressing fungicide for the control of Philippine corn downy mildew. Philip. J. Crop Sci. 3:1-5.
3. Fry, W. E. 1977. Integrated control of potato late blight-effects of polygenic resistance and techniques of timing fungicide applications. Phytopathology 67:415-419.
4. Fry, W. E. 1978. Quantification of general resistance of potato cultivars and fungicide effects for integrated control of potato late blight. Phytopathology 68:1650-1655.
5. ICRISAT. 1977. Annual Report, 1976–1977. Int. Crops Res. Inst. Semi-Arid Trop., Patancheru, India. 240 pp.
6. Locke, J. C., Papavizas, G. C., and Lewis, J. A. 1979. Seed treatment with fungicide for the control of Pythium seed rot of peas. Plant Dis. Rep. 63:725-728.
7. Urech, P. A., Schwinn, F. J., and Staub, T. 1977. CGA 48988, a novel fungicide for the control of late blight, downy mildews and related soil-borne diseases. Pages 623-631 in: Proc. Br. Crop Prot. Conf.
8. Venugopal, M. N., and Safeeulla, K. M. 1978. Chemical control of the downy mildew of pearl millet, sorghum and maize. Indian J. Agric. Sci. 48:537-539.
9. Williams, R. J., and Singh, S. D. 1981. Control of pearl millet downy mildew by seed treatment with metalaxyl. Ann. Appl. Biol. 97:263-268.