Indian J. Plant Prot. 15: 146-151, 1987

FUNGICIDAL CONTROL OF DOWNY MILDEW OF PEARL MILLET

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ABSTRACT

Among the three fungicides tested *in vitro* against *Sclerospora graminicola*, metalaxyl and oxadixyl were effective in completely inhibiting sporangial production and germination at 250 ppm concentration. With mancozeb, complete inhibition of sporangial production was observed only at 1000 ppm concentration while there was no complete inhibition of sporangial germination even at 1000 ppm.

In a field trial conducted during the kharif season of 1985, metalaxyl 25 WP seed treatment protected the pearl millet crop from downy mildew upto 30 days. Seed treatment followed by one foliar spray with metalaxyl or mancozeb was more effective than seed treatment alone. Seed treatment with metalaxyl followed by a single combined foliar spray of metalaxyl + mancozeb was superior to seed treatment with metalaxyl followed by a single foliar spray of either of these fungicides.

INTRODUCTION

Downy mildew of pearl millet caused by *Sclerospora graminicola* (Sacc.) Schoret, is the most widespread and destructive disease. The development of metalaxyl (N–(2 methoxyacetyl)–N–(2, 6–xylyl)–DL–alaninate) in the seventies has resulted in excellent control of downy mildew at many locations (Venugopal and Safeulla, 1978, Rajagopal, 1981, Williams and Singh, 1981) even under high inoculum pressure. There are reports of certain Oomycetes, such as *Peronospora hyoscyami*, *Phytophthora infestans* and *Pseudoperonospora cubensis*, developing resistance to metalaxyl (Bruck *et al.*, 1982, Davidse *et al.*, Reuveni *et al.*, 1980). Thus it is possible that the cereal downy mildew may also have the capacity to develop resistance to this fungicide. One of the ways of coping with acquired fungicide resistance in plant pathogens is by using companion fungicide with different mode of action (Delp, 1980). In the present studies, an attempt was made to study the effect of metalaxyl, oxadixyl and mancozeb in various combinations and the results are reported in this paper.

MATERIALS AND METHODS

In vitro :

Three fungicides viz., metalaxyl 25 WP, oxadixyl 50 WP and mancozeb 75 WP were tested at 2000, 1000, 500, 250, 100 and 50 ppm on sporangial germination (test tube dilution method, Anonymous, 1947) and production. Downy mildew infected leaves of the cultivar 7042 were collected from unirrigated plot and their old downy growth was removed with moist cotton. The leaves were cut into one sq. cm. bits and were floated on fungicidal solution in petridishes with abaxial side up. For control, leaves were floated on distilled water in petri plate. These leaf bits were incubated for 6 hours at 21°C. After 6 hours, sporangia were harvested with cold distilled water. Sporangial concentration was determined using haemocytometer (6 counts/treatment) and the average was

1,2,3 — Scientists of ICRISAT, CPPTI and NAARM, respectively.

calculated. Leaf area involved in sporangial production was measured by an automatic area meter and the number of sporangia produced per cm^2 leaf was determined.

In vivo :

Seeds of three pearl millet cultivars viz., WC–C–75 (resistant) and 7042 and NHB-3 (susceptible) were treated with metalaxyl 25 WP at 2 g a.i. per kg seed and sown in the downy mildew sick plot of Andhra Pradesh Agricultural University, Rajendranagar in a Factorial Randomized Block Design replicated thrice during the kharif season of 1985. The plot size was 4.5 × 2.7m with a spacing of 45 cm × 15 cm. Sporangial inoculum was continually provided throughout the experimental period from the infector rows planted on two sides of each plot 21 days before planting the test rows. Thirty days after planting the test rows, one foliar spray of metalaxyl at 0.1% a.i. and mancozeb at 0.2% a.i. was given separetely and in combination. Per cent downy mildew incidence was recorded at 25, 45 and 70 days after sowing. Infection index (%) was calculated according to the scale given by Williams and Singh (1981). Yield measurements were recorded by taking the weights of sun-dried grain. The data were subjected to statistical analysis.

RESULTS AND DISCUSSION

In Vitro :

It is evident from Table 1 that sporangial production was effectively inhi-

TABLE 1. ***In Vitro*** **evaluation of the effect of fungicides on sporangial production and germination of** ***Sclerospora graminicola.***

Fungicide	Concentration	Sporangial production	Percent sporangial germination
Metalaxyl 25 WP	25 ppm	—	27.30 (32.21)
Metalaxyl 25 WP	50 ppm	56854 (10.94)	21.00 (27.23)
Metalaxyl 25 WP	100 ppm	14540 (9.58)	—
Metalaxyl 25 WP	125 ppm	—	9.25 (17.77)
Metalaxyl 25 WP	250 ppm	0 (0)	0.00 (0.00)
Metalaxyl 25 WP	500 ppm	0 (0)	0.00 (0.00)
Metalaxyl 25 WP	1000 ppm	0 (0)	0.00 (0.00)
Oxadixyl 50 WP	25 ppm	—	30.00 (33.03)
Oxadixyl 50 WP	50 ppm	58550 (10.98)	22.60 (28.35)
Oxadixyl 50 WP	100 ppm	16695 (9.72)	—
Oxadixyl 50 WP	125 ppm	—	10.90 (19.50)
Oxadixyl 50 WP	250 ppm	0 (0)	0.00 (0.00)
Oxadixyl 50 WP	500 ppm	0 (0)	0.00 (0.00)
Oxadixyl 50 WP	1000 ppm	0 (0)	0.00 (0.00)
Mancozeb 75 WP	25 ppm	—	46.50 (42.99)
Mancozeb 75 WP	50 ppm	238325 (12.38)	36.30 (37.00)
Mancozeb 75 WP	100 ppm	195720 (12.18)	—
Mancozeb 75 WP	125 ppm	—	29.60 (32.76)
Mancozeb 75 WP	250 ppm	123492 (11.72)	25.30 (28.22)
Mancozeb 75 WP	500 ppm	31563 (10.28)	14.10 (20.67)
Mancozeb 75 WP	1000 ppm	0 (0)	5.30 (13.31)
Check (water)		41239 (12.93)	72.30 (58.13)
'F'Test		Sig.	Sig
S.Em		0.08	0.72
C.D. at 5%		0.214	2.058

Mean of 9 replications
Figures in parenthesis are transformed values and log values.

bited by metalaxyl and oxadixyl at 250 ppm whereas mancozeb inhibited sporangial production only at 1000 ppm. Further, metalaxyl and oxadixyl completely inhibited sporangial germination at 250 ppm while mancozeb could not completely inhibit even at 1000 ppm. This clearly indicates the systemic nature of metalaxyl and oxadixyl which were able to penetrate the host tissue and prevent the sporangial formation. Similar observations were made by Muthusamy and Narayanasamy (1985) who reported effective inhibition of sporangial germination at 0.02 per cent concentration and sporangial production at 0.01 per cent concentration.

In Vivo :

It is evident from Table-2 that metalaxyl seed treatment reduced the disease in the early stages of plant growth (30–45 days) but the effect did not persist long enough. This was probably due to airborne infection coming into the plots from infector rows of from neighbouring infected crops, the loss of fungicide with time, or its dilution within the plants as they grow, or a combination of these factors (Dang *et. al*, 1983). At harvest time, the plants raised from treated seeds have less downy mildew than plants raised from the untreated seeds and had significantly better grain yield than checks. This is because initial disease development and build up of inoculum was checked due to metalaxyl seed treatment.

One foliar spray of metalaxyl 0.1% in combination with seed treatment resulted in excellent disease control and increased grain yield. The ratio of healthy tillers to diseased ones was very high, the disease intensities were only 7.13, 15.66 and 0.79 per cent as against 74.04, 81.42 and 3.21 per cent in the corresponding checks of NHB–3, 7042 and WC–C75 cultivars respectively. The grain yields were 12.45 and 9.77 q/ha as against 5.99 and 3.29 q/ha in the corresponding checks of NHB–3 and 7042, respectively. Dang *et. al.* (1983) recorded a less disease intensity of 5.4 per cent in plots given with one foliar spray of metalaxyl 0.25 per cent a.i. in combination with seed treatment as against 78.8 per cent in the untreated plots of NHB–3. It has to be noted that in the present study, metalaxyl was sprayed only at 0.1 per cent a.i. even then, it was quite effective in reducing the disease intensity and increasing grain yield.

One foliar spray of mancozeb 0.2 per cent in combination with metalaxyl seed treatment, though significantly superior to the untreated check, was found to be less effective when compared with metalaxyl seed treatment plus one foliar spray with metalaxyl. Obviously, because mancozeb is a protectant fungicide, it was not as effective as metalaxyl which is curative in action.

The results obviously show that a combined foliar spray of metalaxyl plus mancozeb mixture with metalaxyl seed treatment provided a much better control of downy mildew of pearl millet than either metalaxyl or mancozeb alone with metalaxyl seed treatment. These findings stand in accordance with those of Samoucha and Cohen (1984). In their study on downy mildew of cucumbers incited by *Pseudoperonospora cubensis*, the relative increase in control of metalaxyl-mancozeb mixtures was found to be 1.06 – 24.41 times greater than that of the individual fungicides combined. Their results also showed that a fungal sub-population resistant to metalaxyl could still be controlled by metalaxyl if appropriate mixtures with mancozeb are applied. The mechanism governing syner-

TABLE 2. Effect of seed treatment with metalaxyl plus foliar sprays of metalaxyl and mancozeb on downy mildew incidence, severity, and grain yield in three pearl millet cultivars.

Cultivar	Treatment	Downy mildew (%) at 25 days	Downy mildew (%) at 45 days	Downy mildew (%) at 70 days	Infection index % at 70 days	Grain yield (Q/ha)
NHB-3 (Susceptible)	Metalaxyl seed treatment	0.6 (3.7)	9.8 (18.2)	22.3 (28.2)	16.3 (23.8)	10.09
	Metalaxyl seed treatment + metalaxyl spray	0.4 (3.0)	6.2 (14.7)	11.9 (20.2)	7.1 (15.4)	12.45
	Metalaxyl seed treatment + mancozeb spray	0.8 (4.1)	9.1 (17.6)	18.4 (25.4)	11.5 (19.9)	11.37
	Metalaxyl seed treatment + metalaxyl + mancozeb spray	0.2 (1 .5)	3.0 (9.9)	8.8 (17.2)	6.0 (14.0)	13.53
	Check	56.4 (48.7)	79.8 (63.3)	83.8 (66.2)	74.0 (59.5)	5.99
7042 (Susceptible)	Metalaxyl seed treatment	0.2 (1 .5)	31.0 (33.7)	45.7 (42.5)	40.2 (39.3)	7.90
	Metalaxyl seed treatment + metalaxyl spray	0.4 (2 .0)	11.4 (19.7)	20.4 (26.9)	15.7 (23.3)	10.11
	Metalaxyl seed treatment + mancozeb spray	0.6 (2 .6)	19.8 (29.7)	29.8 (33.1)	27.3 (29.2)	9.03
	Metalaxyl seed treatment + metalaxyl + mancozeb spray	0.2 (1 .5)	6.9 (14.8)	12.3 (20.5)	11.5 (19.6)	11.64
	Check	49.7 (4 .8)	89.0 (70.8)	91.9 (73.5)	81.4 (64.5)	3.29
WC-C75 (Resistant)	Metalaxyl seed treatment	0.2 (1 .5)	1.8 (7 .0)	3.3 (10.4)	1.0 (5 .7)	15.25
	Metalaxyl seed treatment + metalaxyl spray	0.2 (1. 5)	0.6 (4 .4)	1.6 (6 .9)	0.8 (4 .4)	15.68
	Metalaxyl seed treatment + mancozeb spray	0.2 (1 .5)	1.0 (5 .6)	2.9 (9 .8)	1 .2 (6 .3)	15.55
	Metalaxyl seed treatment + metalaxyl + mancozeb spray	0.2 (1 .5)	0.2 (1 .5)	0.6 (3 .6)	0.2 (1 .7)	15.76
	Check	2.0 (8 .03)	5.2 (13.0)	6.5 (14.7)	3.2 (10.2)	15.66
	'F' test	Sig	Sig	Sig	Sig	Sig
	S.Em±	1.75	1.18	1.42	1.49	0.29
	C.D. at 5%	5.08	3.41	4.12	4.33	0.8296

Figures in parenthesis are transformed values.

gism between the fungicides is not known. A reasonable speculation would be that since metalaxyl and mancozeb have diff- rent modes of action (the former mostly inhibits fungal RNA synthesis while the later impairs energy production), exposure of sporangia to sub-lethal concentrations of one fungicide weakens them to an extent that sublethal doses of the second fungicide will be detrimental. Fisher and Hayes (1982) showed that the primary effect of metalaxyl on *Phytophthora palmivora* probably involves impaired biosynthesis of RNA so that mitosis is inhibited.

The present study clearly indicates that out of the three cultivars tested, the disease development was more in plots sown with CV 7042 treated seed followed by NHB-3. Variations 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 level of downy mildew control in all but the most highly susceptible cultivar 7042. For cultivars WC-C75, NHB-3 and 7042 the variations in grain yield are readily explained by the differences in the level of downy mildew. In the resistant cultivar WC-C75, the downy mildew incidence increased from 1.97 per cent to only 6.49 per cent between 25 and 70 days after planting. Hence, no significant difference in grain yield could be observed between plots sown with treated seed and untreated plots. In cultivars NHB-3 and 7042, the early infection levels in the untreated plots were considerably higher than in cultivar WC-C75 and there was a considerably greater increase in downy mildew incidence at final scoring, particularly in the highly susceptible 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 (Singh, 1983).

Hence, keeping in view the development of resistance by fungi belonging to Peronosporales against metalaxyl, a combined foliar spray of metalaxyl and mancozeb will be very much useful to minimise the risk of crop losses.

ACKNOWLEDGEMENTS

The facilities provided by the authorities of Andhra Pradesh Agricultural University and ICRISAT are greatfully acknowledged.

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Received : 29–3–1987

Accepted : 1–8–1987