Suppression of Symptoms of Rice Tungro Virus Disease by Carbendazim

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ABSTRACT

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High concentrations of carbendazim (Bavistin WP) markedly reduced leaf chlorosis, stunting, and decreased number of tillers by tungro virus disease in rice plants. The pathogen was present in carbendazim-treated plants and could be easily transmitted to healthy rice seedlings by the green leafhopper *Nephotettix virescens*. Treated plants showed more vigorous growth and gave better grain yield than did tungro-infected untreated plants. Low concentrations of carbendazim applied before inoculation of tungro virus delayed the onset of symptoms.

Tungro disease of rice commonly occurs in India (4), the Philippines (10), Thailand (15), Malaysia (7), and Indonesia (11). The disease is caused by rice tungro virus (RTV), which is transmitted by the green leafhopper, *Nephotettix virescens*. Symptoms of tungro include orange yellow coloring of leaves, stunting, reduction in tiller number, and poor panicle emergence. Tungro affects some rice cultivars in all stages of growth; early infection reduces green matter and causes yield losses up to 68% (2). Attempts to eradicate tungro disease have been unsuccessful.

Recently, benzimidazole compounds such as carbendazim (2-methyl benzimidazole carbamate) effectively suppressed symptoms of tobacco mosaic virus in tobacco and beet western yellows virus in lettuce (13). Ferulic acid inhibited RTV in vivo (12), but no chemical treatments effectively suppressed tungro symptoms.

This article summarizes our study of the effect of carbendazim on symptoms of RTV disease in rice plants.

MATERIALS AND METHODS

Seedlings of rice cultivar Taichung (Native) 1 were grown in plastic pots, each containing five plants, and maintained in the greenhouse. Two sets of experiments with 15-day-old seedlings were done, each with three replicates. Carbendazim (Bavistin WP, 50% w/w) was applied before inoculation and after inoculation with RTV. Each concentration of carbendazim (0.12, 0.25, 0.50, 0.75, and 1.0%) was prepared in water and applied directly to the soil, and each concentration was tested on 30 plants. Each set received 75, 150, 300, 450, and 600 mg of carbendazim per plant.

Carbendazim was applied to plants on three occasions at 4-day intervals. In the postinoculation set, plants were treated with carbendazim 5 days after inoculation; in the other set, plants were inoculated 2 days after the last application of carbendazim. Controls received an equal volume (200 ml) of water without the chemical.

Inoculations were performed by confining five viruliferous green leafhoppers (*N. virescens*) per test plant and withdrawing the insects after 24-hr inoculation feeding. Plants were kept in insectproof cages in the greenhouse for periodic observations and infectivity assays. Symptom severity was assessed according to the standard evaluation system for rice (3). The results are presented in Tables 1, 2, and 3.

RESULTS AND DISCUSSION

Appearance of symptoms was delayed 2–5 days in rice plants treated before inoculation with low concentrations of carbendazim (75, 150, and 300 mg per plant). About 15 days after inoculation, these plants showed typical symptoms of RTV disease, including yellow orange coloration of leaves, reduced tillering, twisting of younger leaves, and stunting.

Most of the plants treated with 450 and 600 mg of carbendazim remained free of symptoms. The number of plants with symptoms and the severity of symptoms decreased proportionately with increasing concentrations of the chemical. Disease symptoms were suppressed in about 97% of the plants that received 600 mg of carbendazim, and only about 3% showed

Table 1. Suppression of tungro virus symptoms in rice plants treated with carbendazim (preinoculation treatment)

Carbendazim (mg/plant)	Plants with symptoms (%)	Incubation (days)	Severity[a]	Infectivity[b] assay
75	94.30 (76.28)[c]	11	7	+
150	78.80 (62.68)	10	5	+
300	63.30 (52.91)	14	5	+
450	23.30 (28.85)	15	3	+
600	3.50 (10.83)	25	1	+
Control	97.43 (80.94)	10	9	+
	SEM	2.86		
	CD at 5%	6.37		

[a] Scaled according to standard evaluation system for rice (3).
[b] + Indicates transmissibility of virus in infected plants.
[c] Numbers in parentheses are transformed values.

Table 2. Suppression of tungro virus symptoms in rice plants treated with carbendazim (postinoculation treatment)

Carbendazim (mg/plant)	Plants with symptoms (%)	Incubation (days)	Severity[a]	Infectivity assay[b]
75	90.30 (72.22)[c]	10	7	+
150	83.70 (66.28)	10	5	+
300	60.10 (50.93)	12	5	+
450	38.70 (38.44)	14	3	+
600	24.30 (29.51)	13	3	+
Control	91.80 (73.96)	10	9	+
	SEM	2.92		
	CD at 5%	6.50		

[a] Scaled according to standard evaluation system for rice (3).
[b] + Indicates transmissibility of virus in infected plants.
[c] Numbers in parentheses are transformed values.

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yellow orange coloration 25 days after treatment.

Plants pretreated with 600 mg of carbendazim showed masking of leaf chlorosis and more tillers, greater plant height, and increased grain yield, compared with tungro-infected untreated plants. However, the carbendazim-treated plants had fewer tillers, shorter height, and lower grain yield than healthy untreated control plants. In these plants, leaf chlorosis appeared about 3 mo after treatment, when plants were in the flowering stage. Symptoms, primarily yellow orange coloration of foliage, reappeared in about 70% of treated plants. Plant height and tiller numbers were not reduced as markedly as they were in severely affected plants. Carbendazim-treated plants gave better yield than did tungro-infected untreated plants.

Infectivity assay showed RTV in all carbendazim-treated plants whether or not they had symptoms. Subinoculations made from carbendazim-treated plants showed that the chemical did not interfere with infectivity and transmissibility of RTV in treated plants. Because virus titer in treated plants could not be directly measured, it is difficult to say whether or not carbendazim interfered with virus multiplication. However, subinoculations from carbendazim-treated plants and from tungro-infected untreated control plants infected about the same number of plants.

Infiltration with dimethyl sulfoxide has suppressed symptoms of peach mosaic and necrotic ring spot virus diseases in peach trees (8), but symptoms reappeared the next season. Various compounds of plant growth regulators prevent virus-induced symptoms in plants; naphthalene acetic acid (6), indole butyric acid (5), gibberellic acid (9), and 2,4-dichlorophenoxy acetic acid (1) effectively reduce virus content and mask the symptoms. Benzimidazole derivatives such as carbendazim can bind to chloroplast membranes and prevent senescence (16). Beet western yellows virus infection of lettuce plants resulted in destruction of chloroplast grana and stroma lamellae (14), and perhaps tungro infection causes similar breakdown of chloroplast lamellae, resulting in premature senescence. Carbendazim may suppress symptoms by preventing or delaying chloroplast destruction. The growth-promoting property of this chemical may be the reason that carbendazim-treated plants show greater tillering and plant height than tungro-infected plants. Leaf chlorosis was suppressed less effectively in plants that received carbendazim after inoculation. Possibly, tungro infection in these plants has already resulted in initiation of chloroplast destruction and other metabolic alterations, and such plants may fail to bind carbendazim in their chloroplast lamellae. Further investigation is needed, however, to ascertain the mode of action of carbendazim in preventing chloroplast breakdown. Work also must be done to explain the mechanism of reappearance of symptoms at a later stage of infection. Although diseased plants could not be freed from virus, carbendazim treatment may enable infected plants to retain the functioning of photosynthetic machinery and thereby produce more green matter content and increased grain yield.

Table 3. Plant height, tillering, leaf chlorosis, and grain yield in tungro-infected rice plants, 90 days after treatment with carbendazim

Treatment	No. of plants	Plant height (cm)	Tillers per plant	Grain yield (g)	Symptoms
Healthy controls, not infected, not treated	30	55.84	15.2	565.8	Normal plants, dark green leaves
Tungro-infected, not treated	30	31.60	4.1	105.0	Severely stunted plants, reduced number of tillers, orange-yellow leaves
Tungro-infected, 600 mg of carbendazim	30	53.60	11.4	264.0	Slightly stunted plants, pale green to orange-yellow leaves

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