EVALUATION OF FUNGICIDES FOR CONTROL OF RINGSPOT ON CABBAGE

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SUMMARY

Three fungicides (benomyl, chlorothalonil, and cyproconazole) were evaluated for control of ringspot on cabbage in field trials at Pukekohe. Cyproconazole was shown to be the most effective, followed by chlorothalonil, and then benomyl. Cultures of *Mycosphaerella brassicicola* isolated from Pukekohe-grown cabbages were found to be insensitive to benomyl when tested *in vitro*. Brassica growers that use cyproconazole are advised to employ management strategies that combat the development of DMI (demethylation inhibitor) fungicide resistance. Pukekohe meteorological data (1986-92) were examined and fewer ringspot "infection periods" were found to occur in the months of December-April than in May-November. In the field trials at Pukekohe, the lowest incidence of ringspot was recorded on crops that had been both planted and harvested in November-April.

Keywords: ringspot, *Mycosphaerella brassicicola*, cabbage, fungicide evaluation, benzimidazole resistance, epidemiology.

INTRODUCTION

Ringspot, caused by the fungus *Mycosphaerella brassicicola* (Duby) Lindau, has been considered the most serious disease of winter brassica crops in New Zealand (Hartill and Sutton 1980). Only the ascospores of the fungus are infectious, and these are usually produced on dead or dying leaves of the host (Snyder 1946; Dring 1961). Infection is generally confined to the older (fully expanded) leaves; a volatile metabolite present in young expanding leaves is believed to inhibit ascospore germination (Hartill 1977; Hartill and Sutton 1980). Fungicide applications are therefore not generally required for ring spot control until the oldest (first-formed) leaves have fully expanded (Hartill 1977). No resistant varieties have been reported (Sherf and MacNab 1986).

In New Zealand, benomyl, chlorothalonil, copper oxychloride, and cyproconazole are the only fungicides which are currently registered for use on vegetable brassicas with label claims for ringspot control. Although benomyl has been shown to give effective control of ringspot (Hartill 1977; Wicks *et al.* 1987), a population of *M. brassicicola* insensitive to carbendazim (a related benzimidazole fungicide) has been reported in South Australia (Wicks *et al.* 1987). Hartill (1977) also showed that plants sprayed with copper oxychloride were no less infected than untreated plants.

In this paper, I report results obtained from recent fungicide evaluation trials, benzimidazole sensitivity tests and meteorological studies related to the control and epidemiology of ringspot on cabbage at Pukekohe.

MATERIALS AND METHODS

Fungicide evaluations

Three fungicides (benomyl, chlorothalonil, and cyproconazole) were evaluated for ringspot control at Pukekohe Research Centre. Six separate field trials were carried out over a 1-year period at 2-month intervals. Cabbages were planted in plots of three rows x 12 cabbages (plants were spaced at 0.5 m in the rows and rows were 0.75 m apart). Trials were set out in an incomplete block design incorporating six blocks (four

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plots/block) and four replicates per treatment; cv. 'County Green' was planted in May and July 1992 and cv. 'Gourmet' was planted in September and November 1992, and in January and March 1993.

The same six treatments were used in each of the trials:

1. Benomyl (Benlate) at 250 g/ha (lowest recommended rate) plus 500 ml all-purpose spraying oil/100 litres of water, applied at 21-day intervals.
2. Benomyl at 400 g/ha (highest recommended rate) plus 500 ml all-purpose spraying oil/100 litres of water, applied at 14-day intervals.
3. Chlorothalonil (Bravo 500F) at 1000 g/ha (recommended rate), applied at 14-day intervals.
4. Cyproconazole (Alto 100 SL) at 40 g/ha (recommended rate) plus 500 ml all-purpose spraying oil/100 litres of water, applied at 21-day intervals (with a maximum of four applications per crop).
5. Cyproconazole alternating with chlorothalonil (at the above rates), applied at 14-day intervals.
6. Unsprayed plots of plants as controls.

All fungicide treatments were applied in 600 litres of water/ha. Fungicide applications were begun in each trial 4-8 weeks after the cabbages were planted out; spraying either began at the first sign of ringspot, or after 8 weeks (if no sign of ringspot was evident at that stage).

The trials were harvested in November 1992, December 1992, January 1993, February 1993, April 1993, and July 1993. Data were collected from cabbages that had been trimmed of any leaves that emerged at an angle of $<45^\circ$ from the base of the cabbage head. The severity of ringspot and head weight were assessed on 10 "trimmed" cabbages collected from the centre of each plot. The number of ringspot lesions on each cabbage was estimated on the outer wrapper leaves and then assigned a disease score (see Table 1).

Benzimidazole sensitivity tests

Cultures of *M. brassicicola* were isolated from young ringspot lesions on cabbages grown at Pukekohe (ICMP isolates 12053, 12054, 12055) and Hastings (ICMP isolates 12056, 12057, 12058). Mycelial plugs taken from colonies growing on potato dextrose agar (PDA) were placed mycelium side down on fungicide-amended and non-amended PDA plates. Three isolates from each location were plated on media amended with 0, 5, 10, 50, and 100 ppm benomyl. After 3 weeks incubation at about 20°C, the plates were examined for mycelium growing from the mycelial plugs.

Since *M. brassicicola* does not readily sporulate on artificial media, pathogenicity tests with the cultures isolated from both Pukekohe- and Hastings-grown cabbages were carried out on glasshouse-grown cabbage plants to confirm the identity of the fungal isolates. Fully expanded leaves were inoculated with ground-up mycelium and agar obtained from cultures grown on PDA, using methods described by Nelson and Pound (1959). Ground-up PDA was also applied to leaves as controls.

Study of meteorological data

Meteorological data from Pukekohe Research Centre (1986-92) were examined to determine the number of ringspot "infection periods" that are likely to occur in any given month of the year. "Infection periods" were defined as periods of 24 h or more continuous leaf wetness (Wicks and Vogelzang 1988); short, dry periods (<8 h) between periods of leaf wetness were included as hours of leaf wetness provided the relative humidity remained above 90%.

RESULTS AND DISCUSSION

Fungicide evaluations

The most effective fungicide used for the control of ringspot on cabbage in the Pukekohe field trials was cyproconazole, followed by chlorothalonil and then benomyl (Table 1). In the trial planted in September 1992 (the planting with the greatest incidence of ringspot), the mean number of ringspot lesions on the outer wrapper leaves of cabbages that had received applications of cyproconazole was between 11

and 20 spots per leaf; those that had received applications of benomyl had >100 spots per leaf; high disease scores were also recorded on cabbages that had received applications of chlorothalonil. In the trial planted in May 1992 (when the disease incidence was less severe), benomyl (low rate) still had little effect on the disease, while benomyl (high rate) and chlorothalonil were shown to provide some disease control.

TABLE 1: The effect of fungicide treatments on the control of ringspot on cabbage at Pukekohe.

Treatment	Planting and (harvest) times of cabbage field trials						Overall estimate
	May 92 (Nov 92)	Jul 92 (Dec 92)	Sep 92 (Jan 93)	Nov 92 (Feb 93)	Jan 93 (Apr 93)	Mar 93 (Jul 93)	
	Mean disease score ¹						
benomyl 250 g/ha	4.1	3.7	6.0	0.9	0.3	5.8	3.5
benomyl 400 g/ha	2.1	2.7	6.0	0.9	0.1	5.3	2.8
chlorothalonil 1000 g/ha	1.0	2.2	5.6	0.4	0.4	4.2	2.3
cyproconazole 40 g/ha	0.1	1.4	3.1	0.5	0.2	1.5	1.1
chlorothalonil/ cyproconazole (at above rates)	1.2	0.6	3.3	0.9	0.1	2.0	1.4
unsprayed (control)	5.0	5.6	6.0	1.1	0.7	5.8	4.0
LSD (P<0.05)	0.9	0.9	1.6	0.3	0.4	0.9	0.4

¹ 0 = (0), 1 = (1-5), 2 = (6-10), 3 = (11-20), 4 = (21-50), 5 = (51-100), and 6 = (>100 spots per leaf).

There was some evidence of a reduction in mean cabbage weight in plots treated with cyproconazole or benomyl (high rate) in the July 1992 planting, and also in the combined analysis of all plantings (Table 2). However, no overall difference in mean cabbage weight was shown between any of the fungicide treatments in the combined analysis.

Cyproconazole is a systemic triazole DMI (demethylation inhibitor) fungicide that has protectant, curative and eradicative activity. Resistance to DMI fungicides has been reported in several pathogens, both in New Zealand and overseas; growers who use DMI fungicides are advised to employ management strategies that combat the development of DMI fungicide resistance (Hartill 1993). Brassica growers should employ the following resistance management strategies when using cyproconazole: comply with label rates at all times; restrict the number of applications per season; confine use to a portion of the crop cycle (and/or season) where disease risk is high (i.e. after the first-formed leaves have fully expanded and/or during cool wet seasons) and use non-DMI fungicides (eg. chlorothalonil) for the remainder of the season; where practical, always apply in a mixture with a non-DMI fungicide; practise crop hygiene and cultural control (since older leaves are more susceptible to ringspot, harvest delays should be avoided: crop residue which may become a source of ascospore inoculum should be disposed of, or at least buried, as soon as possible after harvest).

TABLE 2: The effect of fungicide treatments on cabbage weight at harvest.

Treatment	Planting and (harvest) times of cabbage trials						Combined analysis
	May 92 (Nov 92)	Jul 92 (Dec 92)	Sep 92 (Jan 93)	Nov 92 (Feb 93)	Jan 93 (Apr 93)	Mar 93 (Jul 93)	
	Mean cabbage weight (kg)						
benomyl 250 g/ha	1.5	4.7	3.9	3.6	2.7	2.1	3.1
benomyl 400 g/ha	1.2	4.0	4.0	3.5	2.6	2.1	2.9
chlorothalonil 1000 g/ha	1.5	4.6	3.9	3.8	2.7	2.1	3.1
cyproconazole 40 g/ha\	1.3	4.1	4.2	3.8	2.6	1.8	2.9
chlorothalonil/ cyproconazole (at above rates)	1.8	4.3	4.2	4.0	2.7	2.1	3.2
unsprayed (control)	1.9	5.0	4.0	3.9	2.9	2.1	3.3
LSD (P<0.05)	1.0	0.6	0.6	1.0	0.7	0.4	0.3

Benzimidazole sensitivity tests

All *M. brassicicola* cultures isolated from Hastings-grown cabbages and used in the tests grew on un-amended media, but failed to grow on media containing ≥ 5 ppm benomyl. Cultures isolated from Pukekohe-grown cabbages, however, all grew on media containing 0, 5, 10, and 50 ppm benomyl, but failed to grow on media containing 100 ppm benomyl. Strains of *Botrytis cinerea* Pers. that grow on media containing 10 ppm benomyl have been considered to be insensitive to the fungicide (Pepsin and MacPherson 1982). Fungicide sprays are not generally used at Hastings to control ringspot on cabbage, but are used in the Pukekohe district. The overuse of benomyl by Pukekohe brassica growers in the past is likely to have been responsible for the development of the benomyl-insensitive population of *M. brassicicola* in the district.

Ringspot lesions developed on the leaves of cabbage plants inoculated with cultures of *M. brassicicola* isolated from both Pukekohe- and Hastings-grown cabbages. No ringspot lesions developed on leaves on which just agar was applied.

Study of meteorological data

At Pukekohe Research Centre (1986-92) the mean number of ringspot "infection periods" found in each month of the year was between 1.0 and 1.9 in December-April, 3.8 and 4.9 in May-August (with the greatest number occurring in August), and 2.2 and 2.5 in September-November. The lowest incidence of ringspot recorded on unsprayed cabbages in the 1992-93 Pukekohe field trials occurred on crops that had been both planted and harvested in November-April (Table 1). The conditions required for the release and germination of *M. brassicicola* spores are more likely to be met in the winter and spring months, and this is when epidemics of ringspot occur (Hartill 1977); summer crops are seldom infected except in cool wet years (Hartill and Sutton 1980).

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