THE EFFICACY OF *BACILLUS THURINGIENSIS* AND LUFENURON AGAINST LEPIDOPTERAN PESTS IN BRASSICAS

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ABSTRACT

The efficacy of *Bacillus thuringiensis* (Bt) GC91 and lufenuron against brassica lepidoptera pests was evaluated on cabbages. Bt GC91 applied at 1000 g/ha either on a 7 day or 15% infestation threshold programme gave equivalent harvest quality and damage scores to the standard Bt HDI (7 day interval) or cyhalothrin (14 day or 15% threshold). Reducing the rate of Bt GC91 to 500 g/ha increased the level of damage and reduced the harvest quality. Lufenuron 25 g/ha on a 14 day programme had lower damage scores and higher harvest quality than the standard cyhalothrin (14 day) treatment and was comparable to a 7 day Bt programme. Both Bt GC91 and lufenuron are promising alternatives to the standard insecticides used in brassica crops.

Keywords: *Bacillus thuringiensis* (GC91), lufenuron, brassicas, Lepidoptera

INTRODUCTION

Control of lepidopteran pests in brassicas is still based largely on calendar spraying but there is increasing interest in the reduced spray programme developed by Beck and Cameron (1990) who reported the major pests in brassicas to be diamondback moth (*Plutella xylostella*) and white butterfly (*Pieris rapae*), with soya bean looper (*Thysanoplusia orichalcea*) and tomato fruitworm (*Helicoverpa armigera*) being important at times. This paper looks at two new insecticides for the control of these pests in horticultural brassicas. *Bacillus thuringiensis* GC91 (Agree WP) is a natural transconjugation of the *aizawai* and *kurstaki* strains being developed by Ciba-Geigy. It combines the delta endotoxins of both strains giving a broader range of activity (Senn *et al.* 1992) and has particular efficacy against *Plutella* and *Spodoptera* species (Nordmeyer *et al.* 1994). Lufenuron (Match EC) is a highly active insect growth inhibitor belonging to the benzoylurea group (Follas *et al.* 1994). It interferes with chitin synthesis in larva of Lepidoptera. These insecticides offer advantages for developing integrated pest management programmes in vegetable crops due to their specific range of activity and selectivity to natural beneficials. The aim of the trials reported here was to evaluate Bt GC91 and lufenuron for the control of lepidopteran pests in brassica crops, with applications based on a calendar or threshold monitoring programme.

METHODS

Two trials were carried out for the control of lepidopteran pests in brassicas in the 1993-1994 season in the Pukekohe region on the cabbage variety 'Gourmet'. The trials evaluated *Bacillus thuringiensis* (Bt) GC91 and lufenuron for efficacy against lepidopteran pests compared with the standard *Bacillus thuringiensis* HDI (Thuricide HP), a synthetic pyrethroid cyhalothrin (Karate EC), and an untreated control.

The trials were of a randomised complete block design, consisting of 15-30 m^2 plots with four replicates. Applications commenced at the six true leaf growth stage (GS106 BBCH scale), after transplanting on 24 January 1994, and treatments were applied until 21 March. In trial 1 the Bt treatments were applied at weekly intervals (a total of nine) while the lufenuron and cyhalothrin treatments were applied at 14 day intervals (a total of five). Rates of application are in Table 1. Trial 2 was a reduced spray programme trial. Bt GC91 applications at 1000 g/ha were made at either weekly intervals or at a 15% plant infestation threshold set out by Beck *et al.* (1992), whereas cyhalothrin at 10 g/ha was applied only according to the 15% threshold. Weekly assessments of the percentage infestation were carried out on 100 plants/treatment to determine if the application threshold was reached. A plant was recorded as infested upon sighting (a) any larvae of diamondback moth, (b) any large (3-5th instar) larvae of white butterfly, soya bean looper or tomato fruit worm, and (c) any fresh feeding or frass. All applications were made in the equivalent rate of 800 litres of water/ha using a CO_2 pressurised backpack sprayer operating at 300 kPa with a 3 m boom. A wetting agent (Citowett) was added to all treatments at 0.025% v/v concentration.

Assessments were made on the cabbages at harvest (25 March) for damage and harvest quality. The sample size was 10 plants/plot in Trial 1 and 25 plants/plot in Trial 2. Lepidoptera were identified to give the composition of the pest population. Damage was visually assessed using a system of scoring outer and inner wrapper leaves; 1 = perfect, 2 = minor damage, 3 = major damage, and the head; 1 = perfect, 3 = minor damage, 5 = major damage, 6 = little retrievable head (Beck and Cameron 1990). Heads were graded on the basis of the total damage score into percentage premium (3-4 score), marketable (3-6 score) and not acceptable to the fresh market (>6) (Beck and Cameron 1990). Developmentally small heads (below 100 g) were discarded from the evaluation. Statistical analysis was done by ANOVA after angular transformation. The separation of means was according to Duncans multiple range test. All results are reported as untransformed means. A Chi square test was carried out on the lepidopteran population counts.

RESULTS AND DISCUSSION

Trial 1

The lepidopteran population at harvest consisted of 87% diamondback moth, 3% white butterfly, 9% soya bean looper and 1% tomato fruit worm. There were no significant differences in the ratios of the Lepidoptera species between the treated and control. Head weight of the cabbages was increased by all treatments, though significantly so only by lufenuron and cyhalothrin (P<0.05), compared with the untreated. There was no significant difference in the head weights between the insecticide treatments.

TABLE 1: Mean damage score, percentage number of premium and unacceptable cabbage heads, and head weight at harvest in Trial 1.

Treatment	Rate g ai/ha	Spray interval (days)	Mean damage score	% Premium heads	% Unacceptable heads	Mean head wt (kg)
Bt GC91	500[1]	7	5.3 bcB[2]	22.5 cdBC	17.5 bB	2.06 ab
Bt GC91	1000[1]	7	4.4 deBC	65.0 abAB	5.0 bB	1.99 ab
Bt HDl	1000[1]	7	4.7 cdBC	57.5 abcAB	7.5 bB	1.95 ab
lufenuron	25	14	3.6 eC	82.5 aA	2.3 bB	2.16 a
cyhalothrin	10	14	5.0 bcdB	37.5 bcABC	12.5 bB	2.10 a
untreated control	-	-	8.8 aA	0.0 dC	90.0 aA	1.84 b

[1] Product
[2] Any two means in a column without a letter in common are significantly different (P<0.05 in lower case, P<0.01 in capitals).

All insecticide treatments reduced the level of damage and the percentage of unacceptable heads compared with the untreated (P<0.01). The percentage of premium heads was increased by all treatments (P<0.05) except the 500 g/ha treatment of Bt

GC91 compared with the untreated. In reducing the rate of Bt GC91 by half, the level of damage increased (P<0.05), and the percentage of premium heads decreased (P<0.05) with a consequent increase in the percentage of unacceptable heads compared with the 1000 g/ha rate of Bt GC91. The Bt GC91 1000 g/ha treatment gave damage scores and harvest quality equivalent to the standard Bt HDl treatment. The lufenuron treatment showed the highest level of premium heads and lowest level of unacceptable heads, with a significantly lower damage score than the standard cyhalothrin or Bt HDl treatment (P<0.05).

Applications of Bt GC91 1000 g/ha at 7 day intervals gave comparable efficacy to a standard synthetic pyrethroid or Bt programme for the control of lepidopteran pests. The use of lufenuron 25 g/ha on a 14 day programme gave superior efficacy and harvest quality to the synthetic pyrethroid programme and was comparable to Bt 7 day treatments. Both Bt GC91 and lufenuron are suitable alternatives for standard insecticides for the control of lepidopteran pests in brassica crops using standard calendar spraying.

Trial 2

The larval lepidopteran population at harvest consisted of 62% diamondback moth, 12% white butterfly and 26% soya bean looper. There was no significant difference in the ratios of Lepidoptera species between treated and control. Head weight of the cabbages ranged from 1.9-2.0 kg/head with no significant difference between the treatments or compared with the control.

TABLE 2: Mean damage score, percentage number of premium and unacceptable cabbage heads at harvest in Trial 2.

Treatment	Rate g ai/ha	% Spray threshold	Mean damage score	% Premium heads	% Unacceptable heads
Bacillus thuringiensis GC91	1000[1]	-[2]	4.3 B[3]	67.5 B	1.2 B
Bacillus thuringiensis GC91	1000[1]	15	4.6 B	49.5 B	3.7 B
cyhalothrin	10	15	4.7 B	48.7 B	6.2 B
untreated control	-	-	8.3 A	0.0 A	87.5 A

[1] Product
[2] 7 day spray interval
[3] Any two means in a column without a letter in common are significantly different, (P<0.01 in capitals).

A total of nine weekly applications of Bt GC91 were made compared with the 15% threshold treatments of five for the Bt GC91 and four for the cyhalothrin treatments.

All insecticide treatments reduced the damage score compared with the untreated (P<0.01) (Table 2). There was no difference in the damage score between the weekly or threshold applications of Bt GC91 or between the Bt GC91 and cyhalothrin treatments. The percentage of premium heads harvested was increased by all insecticide treatments compared with the untreated (P<0.01). The Bt GC91 weekly treatment had a higher level of premium heads compared with the threshold insecticide treatments though due to variance in this parameter it was not significant. There was no difference between the two threshold insecticide treatments in the level of premium heads harvested. The percentage of unacceptable heads was decreased in all insecticide treatments compared with the control (P<0.01). There were no significant differences between the insecticide treatments.

The use of the 15% infestation threshold for insecticide application reported by Beck *et al.* (1992) is suitable for use with Bt GC91 where the majority of the lepidopteran population is diamondback moth. This monitoring system takes account of early larval instars of diamondback moth on which the *Bacillus thuringiensis* group, and Bt GC91 in particular, are most effective. In this monitoring system white butterfly, soya bean looper and tomato fruitworm are only recorded as late instar larvae (3-5th), and the *Bacillus thuringiensis* group are less effective against these older larvae. If white butterfly or the other secondary lepidopteran pests form the majority of the pest population it is possible that the threshold may need refinement either in the larval instar recorded or by lowering of the threshold level.

The use of a 15% threshold level for Bt GC91 applications gave harvest quality and damage levels equivalent to a weekly spray programme of Bt GC91 with a saving of four sprays. The use of Bt GC91 under a 15% threshold programme will give equivalent damage scores and harvest quality to the standard cyhalothrin although needing one or more extra applications.

ACKNOWLEDGEMENTS

Thanks are due to P. Brookbank and S. Bland for providing the technical expertise and time to carry out the trials, and H. Young for generously providing the trial sites.

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