BACILLUS THURINGIENSIS FOR INTEGRATED PEST MANAGEMENT IN PROCESSING TOMATOES

P.J. CAMERON¹, G.P. WALKER¹, T.J.B. HERMAN¹
and J.D. FLETCHER²

Crop & Food Research, ¹Private Bag 92169 Auckland and

²Private Bag 4704 Christchurch

ABSTRACT

The efficacy of a *Bacillus thuringiensis* (Bt) formulation, MYX 7275, was compared with other Bt formulations and a synthetic pyrethroid (SP) standard for control of tomato fruitworm in a small plot trial with processing tomatoes. Treatments were applied in response to an action threshold determined by scouting of plants. MYX 7275 and MYX 7544 required fewer treatment applications than Dipel 2X to achieve similar levels of fruit damage, but damage was significantly greater than the SP treatment. In a commercial trial, an IPM strategy using MYX 7275 against early season infestations of tomato fruitworm followed by an SP application for later infestations provided acceptable control of tomato fruitworm and other pests, while minimising potential selection for SP resistance.

Keywords: *Bacillus thuringiensis*, *Helicoverpa armigera*, tomatoes, integrated pest management, synthetic pyrethroid

INTRODUCTION

Tomato fruitworm (TFW) *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) is the major pest of outdoor processing tomatoes in New Zealand. For the last decade, synthetic pyrethroids (SPs) have been the most commonly used insecticide group for processing tomatoes, largely because of their effectiveness, low cost and low mammalian toxicity. *Bacillus thuringiensis* (Bt) is rarely used in vegetable crops and is registered only for use on glasshouse tomatoes and brassicas. Increased interest in Bts overseas coincides with environmental concerns over use of conventional insecticides and the development of insecticide resistance. In Australia, resistance in *H. armigera* has been reported for SPs, endosulfan, carbamates and organophosphates (eg. Forrester *et al.* 1993). In cotton, where *Helicoverpa* populations are high, Bt is used in mixtures with endosulfan or SPs to enhance its activity (Forrester 1994). In New Zealand, Bts have been shown to provide effective short-term control of *H. armigera* (Cameron and Walker 1988) but their short persistence can require frequent applications. The development of resistance to SPs in New Zealand (Cameron *et al.* 1995, this volume) is now encouraging interest in the commercial use of Bts to provide an alternative to conventional insecticides and to reduce selection for resistance to SPs. An Integrated Pest Management (IPM) programme (Walker and Cameron 1990) provides the opportunity to apply insecticides only when TFW populations reach an economic threshold. Studies of aphids and thrips and the viruses they transmit (Cameron *et al.* 1992) also suggest that control of these virus vectors may often be unnecessary. Implementation of the IPM programme has reduced insecticide use (Herman and Cameron 1993) while maintaining fruit damage below the economic threshold of 5%. The trials in this study aimed to compare the efficacy of several Bts and integrate the use of MYX 7275 into the IPM programme to provide an alternate insecticide group while maintaining economic control of TFW and viruses.

METHODS

Efficacy trial

Tomatoes, cv. UC82B, were transplanted at the Pukekohe Research Centre on 15 December 1992 into plots consisting of 22 plants in a double row at commercial spacing

Proc. 48th N.Z. Plant Protection Conf. 1995: 289-293

in a 6 x 6 latin square design with double guard rows between treatments. Fungicides were applied weekly. The decision to apply the treatments for TFW control was based on weekly scouting of six to 10 plants in all six replicates of one randomly selected treatment. Scouting consisted of a timed search of one minute per plant as described in Walker and Cameron (1990) with an action (spray) threshold of one larva/plant. When the action threshold was first exceeded all plots were scouted and all treatments were applied. Subsequently, insecticides were applied when any one treatment exceeded the threshold. Eggs and larvae were collected from guard rows for rearing to confirm species identification and parasitism levels.

The four test Bts (Table 1) were applied at 4.5 litres/ha, the Bt standard (Dipel 2X) was applied at 500 g/ha and the SP standard esfenvalerate (Hallmark) at 175 ml/ha. The insecticides were applied using a backpack sprayer fitted with a 60 cm, three-nozzle boom using hollow cone nozzles, at a water rate of 1000 litres/ha. A final damage assessment was made when the crop would normally be sprayed with Ethrel (about 2 to 3 weeks before harvest). The number of fruit with major and minor TFW damage and the total number of fruit per plant was assessed for six plants per plot. Minor damage, defined as slight feeding damage that would heal, is acceptable for processing so analysis was based on major damage. Analysis of variance was carried out on mean larvae/plant and arcsine transformed percentage major fruit damage.

IPM trial

This experiment was conducted in a 24 ha field of processing tomatoes in Gisborne (var. Cannery Row) transplanted on 1 December 1993. Apart from the timing and choice of insecticides, crop management followed normal commercial practice. Each block in the randomised block design extended the full 357 m width of the field and each plot was 18 beds wide with an average area of 1.18 ha. The four treatments were: 1. SP (lambda cyhalothrin - Karate) applied as a calendar spray (calendar SP); 2. SP applied at the IPM threshold (IPM SP); 3. Bt (MYX 7275) applied at the IPM threshold (IPM Bt); 4. Bt first then SP applied at IPM threshold (IPM Bt/SP). The SP was applied at 0.2 litres/ha and the Bt at 4 litres/ha. Treatment 1 was applied at 10-14 day intervals and treatments 2, 3 and 4 were applied when the mean infestation for the four replicates determined by scouting (usually 10 plants from each of two locations per plot) exceeded 1 larva/plant. A headland strip at one end of the experiment, was left unsprayed to provide an untreated reference. Treatments were applied with a commercial spray rig (SAM 2000) using 250 to 400 litres/ha of water for the SP, and 500 litres/ha for the Bt. Fruit damage by TFW was assessed as in the efficacy trial from 10 plants from each of two locations/plot 1 week prior to harvest. Analysis of variance was carried out on $\log_{10}$ transformed mean larvae/plant and arcsine transformed percentage major fruit damage.

Aphids and thrips were sampled weekly by beating insects off one upper canopy stem per plant into a tray (Cameron *et al.* 1992) using 10 plants from each of two or four locations/plot. Subsamples were identified to species. Fifty-leaf samples were taken from all plots each fortnight and ELISA serological tests used to detect any of six common tomato viruses: alfalfa mosaic virus, cucumber mosaic virus, tomato spotted wilt virus (TSWV), potato virus Y and tomato yellow top virus.

RESULTS AND DISCUSSION

Efficacy trial

TFW larval populations exceeded the action threshold 9 weeks after transplanting, when larval numbers averaged 1.55 per plant, and all treatments were applied. Minor variation in implementing the threshold resulted from field calculations based on rounded numbers. Larval infestations were high (>3.2 per plant) in the untreated plants providing very heavy reinfestation pressure from 10 weeks onwards (Table 1). An average parasitism rate of 88% indicated that *Cotesia kazak* contributed substantially to control of TFW in the trial. TFW population levels in the various treatments depended primarily on the frequency and efficacy of applications. Whereas two of the Bt formulations and Dipel 2X required weekly applications, one and two applications were saved with MYX 7275 and MYX 7544 respectively. The amount of economic damage in the MYX 7275 treatment was similar to that obtained with Dipel 2X, whereas MYX 7544 produced

significantly less damage than Dipel 2X and was not significantly different from that in the SP treatment. Esfenvalerate gave the best control with only two applications. This result confirmed the reliability of the IPM threshold proposed by Walker and Cameron (1990) used in conjunction with esfenvalerate. Although MYX 7275 and MYX 7544 allowed economic damage, the increased spray interval by comparison with Dipel 2X suggested increased persistence. One source of damage in the Bt treatments was the survival of 69% of larvae in later treatments to damaging size (>15 mm), by comparison with 13% large larvae in the esfenvalerate treatment. This could be avoided by using an SP as a second treatment to ensure control of later populations containing a range of size classes. As MYX 7275 was commercially available, a MYX 7275/SP alternation was proposed for testing in a field scale IPM programme.

TABLE 1: Number of tomato fruitworm larvae per plant, major fruit damage and number of spray applications.

Weeks after transplant	Dipel 2X	MYX 7275	MYX 7544	MYX 8033	MYX 8037	esfenvalerate	Untreated	LSD (0.05)
7		0.43						
8			0.27					
9	1.53 ¹	1.75 ¹	1.62 ¹	1.48 ¹	1.90 ¹	1.73 ¹	1.38	0.80
10	1.45 ¹	0.93 ¹	1.05 ¹	3.72 ¹	3.23 ¹	0.40	3.57	1.03
11	1.38 ¹	0.70	1.07 ¹	4.02 ¹	4.13 ¹	1.42 ¹	4.23	0.77
12	1.38 ¹	1.50 ¹	0.95	3.85 ¹	3.60 ¹	0.28	4.02	0.58
13	1.28 ¹	1.17 ¹	0.85	4.25 ¹	3.88 ¹	0.40	4.77	0.85
Damage (%)	14.5	11.5	7.1	31.5	28.2	3.5	32.7	5.73
Applications	5	4	3	5	5	2	0	

¹ Treatment applied following assessment.

* Significant at P<0.05.

IPM trial

TFW populations appeared in the crop in January and peaked in mid-February and again in March (Fig. 1). These infestations were typical of those in late planted crops and provided potentially damaging mid and late season populations consistently over 2 larvae/plant. Six applications of esfenvalerate were sprayed in the calendar SP treatment and this maintained the infestation of TFW below 0.12 larvae/plant (Fig. 1). Larval infestations in the three IPM treatments exceeded the threshold on 16 February and all three IPM treatments were applied. Following the IPM SP application the number of TFW larvae dropped below the threshold and did not exceed 0.1 larvae/plant for the remainder of the trial. This demonstrated the value of timing applications and showed that most calendar applications were unnecessary. The initial Bt application in the IPM treatments reduced larval infestations for 2 weeks, then another application was required on 8 March. For this second application, the alternation to an SP (ie. IPM Bt/SP) was more effective than the use of Bt alone (IPM Bt). The Bt also required 2 more days to act than the SP (Fig. 1). The parasitoid *C. kazak* produced 73 to 97% mortality of small larvae in unsprayed and Bt treatments and therefore reduced the proportion of larvae that reached sufficient size to cause major damage. Larval populations were too low to obtain reliable estimates of parasitism in SP treatments.

Comparisons of major fruit damage (Table 2) confirmed that the control achieved with one application of SP (IPM SP) was not significantly different from that achieved with six calendar applications. Both Bt treatments allowed significantly more damage than IPM SP, but the use of the Bt/SP sequence allowed significantly less damage than Bt alone. The use of the SP as the later season treatment provided better control when more large damaging larvae were present. All treatments met the 5% economic damage threshold.

FIGURE 1: Infestation of tomato fruitworm larvae on processing tomatoes in four spray programmes, Gisborne 1993/94. Selected SEM bars are shown.

Thrips (predominantly *Thrips tabaci*) were present from early January but aphid populations did not increase until mid February. Both these virus vectors were present when the plants were small and susceptible to virus damage to the vegetative and fruit stages. The calendar SP treatment maintained both thrips and aphids below 0.6/plant whereas insect numbers in the three IPM treatments ranged from 0.3 to 1.6 thrips/plant and from 0.6 to 1.2 aphids/plant. These population levels are typical for the Gisborne area (Cameron *et al.* 1992) and are associated with minor virus infection and minimal crop damage. Infection levels for TSWV, which is transmitted by thrips, were low throughout the trial and fruit distortion symptoms were rarely found. Infection by aphid transmitted viruses was similarly low. The calendar SP treatment had the lowest infection levels of TSWV but there was no measurable difference in plant symptoms between treatments. This result suggests that early season insecticide applications for virus-vector control may be of little economic benefit.

TABLE 2: Tomato fruitworm damage to fruit and virus infection in response to the number and timing of insecticide applications.

	Calendar SP	IPM SP	IPM Bt	IPM Bt/SP	LSD
TFW Damage (%)	0.1	0.8	5.0	2.3	1.37
TSWV (%)	1.5	2.7	5.0	4.2	-
Other viruses (%)	2.7	4.7	4.2	4.2	-
Applications	6	1	2	2	-

The combined results of these experiments suggest that with moderate TFW infestations the use of MYX 7275 alone in an IPM scouting programme can give adequate control, but with heavy infestations control may be uneconomic. In Australia, Bt/SP mixtures are favoured in cotton with dense populations of *Helicoverpa* spp. (Forrester 1994) and single Bt treatments are used in crops where pest pressure is lower. In New Zealand, the use of MYX 7275 as an alternative to one SP in tomatoes is favoured because

the Bt treatment produces no selection for SP resistance. The use of MYX 7275 against the first TFW infestations ensures that it is directed mostly against small susceptible larvae and allows the survival of parasitoids. This strategy reserves SPs for any late season application that may be necessary for control of infestations that include large damaging larvae.

ACKNOWLEDGEMENTS

The efficacy assessments were funded by Cyanamid of New Zealand. The IPM trials were supported by Cyanamid, Cedenco Foods and J. Wattie Foods. We thank Cedenco field staff for their cooperation. Dr A.R. Wallace carried out statistical analysis of the IPM trial data.

REFERENCES

- Cameron, P.J. and Walker, G.P., 1988. *Bacillus thuringiensis* for control of tomato fruitworm. *Proc. 41st N.Z. Weed and Pest Control Conf.*: 99-100.
- Cameron, P.J., Herman, T.J.B. and Fletcher, J.D., 1992. Incidence of thrips and aphids as potential virus vectors in field tomatoes. *Proc. 45th N.Z. Plant Protection Conf.*: 38-42.
- Cameron, P.J., Walker, G.P. and Herman, T.J.B., 1995. Status of resistance to fenvalerate in tomato fruitworm. *Proc. 48th N.Z. Plant Protection Conf.*: this volume.
- Forrester, N.W., 1994. Use of *Bacillus thuringiensis* in integrated control, especially on cotton pests. *Agriculture, ecosystems & environment* 49: 77-83.
- Forrester, N.W., Cahill, M., Bird, L.J. and Layland, J.K., 1993. Management of pyrethroid and endosulfan resistance in *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Australia. *Bull. Ent. Res. Suppl. 1*: 132 pp.
- Herman, T.J.B. and Cameron, P.J., 1993. The value of IPM in processing tomatoes. Pp 61-67 *In*: Plant Protection: Costs, Benefits and Trade Implications, Suckling, D.M. and Popay, A.J. (eds): Proc. N.Z. Plant Protection Soc. Symp.
- Walker, G.P. and Cameron, P.J., 1990. Pheromone trapping and field scouting for tomato fruitworm in tomatoes and sweet corn. *Proc. 43rd N.Z. Weed and Pest Control Conf.*: 17-20.