DEVELOPING AN ACTION THRESHOLD FOR LEPIDOPTEROUS PESTS OF CABBAGE

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SUMMARY

Three treatment threshold levels of lepidopterous pests were compared in permethrin-treated cabbage plots to determine action thresholds. Insect population pressure was expressed as Feeding Damage Equivalents (FDE), a weighted scale giving a larger size larva a higher rating. The fortnightly permethrin treatment resulted in the least damage. The permethrin low threshold treatment had two fewer applications and had no difference in damage to inner wrapper leaves, head, and weight of head. Timing of insecticide applications to coincide with insect populations allowed a 40% reduction in insecticide use with no yield difference.

INTRODUCTION

Although control of insect pests on cabbages at Pukekohe largely relies on calendar spraying, there is increasing interest in developing reduced-spray programmes aimed at fresh market produce. However, market quality standards are stringent and require that the whole plant including wrapper leaves is free from damage and pests. The major lepidopterous pests are diamondback moth (DBM) (*Plutella xylostella*) and white butterfly (WB) (*Pieris rapae*). Other occasional lepidopterous pest species include the soybean looper (SBL) (*Thysanoplusia orichalcea*), and the tomato fruitworm (TFW) (*Helicoverpa armigera*). At Pukekohe, growers apply insecticides for control of these pests on a fortnightly schedule. Calendar scheduled applications, while achieving good yields, often result in unnecessary insecticide use and increased production costs to the grower. Long-term costs include health concerns of grower and consumer, development of insecticide resistance in DBM, and environmental effects on non-target organisms. DBM has shown the ability to rapidly develop resistance to major chemical groups in several areas of the world (Talekar 1985).

A reduced spray program was initiated in 1989, as part of an Integrated Pest Management programme for vegetable brassica crops. In this paper we discuss results leading to the development of an action threshold, the level of pest populations at which an action must be taken to avoid significant crop damage. We compared efficacy of a synthetic pyrethroid, the material most frequently used by Pukekohe growers, at varying action threshold levels based on modification of techniques used by Shelton *et al* (1982, 1983) and Workman *et al* (1980).

METHODS

Experiments were conducted at the DSIR Research Station at Pukekohe in 1989. Cabbage transplants, cv. 'Gourmet', from a commercial supplier were transplanted by hand on 20 January 1989. Five treatments were replicated four times in a randomized complete block design. Plots consisted of 36 plants, set in six rows; rows were spaced 0.75 m apart, with plant spacing of 0.5 m, as in standard commercial practice. For all samples, outer rows in each plot were treated as borders, to minimize edge effect. Treatments consisted of permethrin (Ambush 50 EC) applied at three threshold levels of (1) low, (2) medium, and (3) high population densities of lepidopterous larvae as calculated in Feeding Damage Equivalents (FDE); these were compared to an unsprayed control and a fortnightly application of permethrin regardless of insect pest pressure.

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FDE is a population assessment technique whereby WB or noctuid larvae are assigned values dependent on relative size. DBM damage was assigned a value of 0.25 FDE per hole or for the presence of any DBM larva; a damage hole was classed as any fresh DBM larval feeding window greater than or equal to 0.3 cm diameter. WB, SBL, and TFW larvae were each assigned values of: third instar = 0.5 FDE, fourth instar = 1.0 FDE, and fifth instar = 1.5 FDE. The FDE counts were summed for the four replicates; permethrin was applied at the rate of 100 ml/ha in 750 litres water/ha upon attainment of the action threshold of low (10 FDE), medium (20 FDE), or high (40 FDE) population densities. Material was applied with a backpack sprayer and a hand-held boom with three 70° flat fan nozzles (T54).

Weekly samples of 10 non-destructive (FDE) field counts were made in each plot from 1 week after transplanting until harvest on 21 April 1989. Pre-heading samples consisted of whole plant examinations; post-heading samples were of the head and four wrapper leaves. Laboratory counts consisted of weekly samples of one cabbage plant from each untreated plot; these plants were destructively examined for larvae to determine accuracy of field sampling and provide information on the larval species composition.

Plants were evaluated at harvest on the basis of damage to outer (horizontal) wrapper leaves, inner (vertical) wrapper leaves, and head. Wrapper leaves (both outer and inner) were scored from 1-3, where 1 = perfect, 2 = minor damage, and 3 = major damage. Heads were scored from 1-6, where 1 = perfect, 3 = minor damage, 5 = major damage, and 6 = little retrievable head. Developmentally delayed cabbages, classed as those under 0.6 kg head weight at time of harvest, were eliminated from the sample as these were too small to be harvested in a commercial situation. All heads were weighed to the nearest 100 g. Marketability of heads was evaluated using a cumulative score (outer + inner + head) of: 3-4 = premium, 4-6 = acceptable, and >6 = not acceptable to the fresh-produce market. Statistical analyses were done using SAS (SAS Institute 1985). Statistical differences were calculated using LSD ($P < 0.05$).

RESULTS

Lepidopteran populations in untreated control plots (Figure 1a) were present in small numbers 1 week after transplanting, when plants were at a 6-7 leaf stage. FDE counts remained relatively low in untreated control plots (less than 36 FDE per 40 plants) until after cupping stage (Figure 1a). The population reached a maximum (FDE = 463) 1 week after uniform head production (heads greater than a 10 cm ball) then dropped off sharply. Larval counts from destructive and non-destructive sampling showed similar trends in species abundance (Table 1). WB was the dominant species, consisting of 75% (destructive counts) to 73% (field counts) of the total control larval populations (Table 1). Neither DBM or TFW reached damaging population levels; their larval numbers ranged from 1% to 4% of total larval populations (Table 1). SBL populations were less than one per plant until mid-March, when SBL populations increased rapidly. SBL comprised 18% (destructive counts) to 25% (field counts) of the total larval populations throughout the season in the control plots (Table 1).

TABLE 1: Comparison of season total of lepidopterous larvae found in non-destructive (field) and destructive (laboratory) observations in control vs fortnightly application of permethrin treatments. Field counts are of instars 3-5 only; lab counts are of instars 1-4 for DBM and instars 1-5 for TFW, SBL, and WB.

Insect	Control		Permethrin	
	Field	Lab	Field	Lab
DBM	41	4	7	0
TFW	24	19	7	5
SBL	170	306	39	7
WB	717	887	298	33

Fig. 1: Feeding Damage Equivalent (FDE) counts. 1a. Control vs low action threshold (10 FDE/40 plants) (dashed line) vs fortnightly treatments. 1b. Control vs medium action threshold (20 FDE/40 plants) (dashed line) vs high action threshold (40 FDE/40 plants) (solid line). Arrows indicate timing of insecticide applications.

TABLE 2: Cabbage damage assessment at harvest of outer (horizontal), inner (vertical), and head components. See text for damage ratings. Numbers are totals within each category for each treatment.

Treatment	N	Wrapper leaves									
		Outer			Inner			Head			
		1	2	3	1	2	3	1	2	3	4
Fortnight	48	16	22	10	23	22	3	40	5	3	0
Low	48	2	31	15	24	22	2	41	6	0	0
Medium	44	0	14	30	4	23	17	16	19	6	3
High	51	0	7	44	1	16	34	10	19	12	10
Control	39	0	0	39	0	0	39	1	4	10	11

All permethrin treatments had larval populations similar to the untreated control until after the second sample when fortnightly applications were initiated; on this date the low and medium thresholds were reached (Figure 1a, 1b). Two of the five permethrin applications in the fortnightly treatment were applied when no lepidopterous larvae were observed (Figure 1a). For all treatments, application of permethrin reduced FDE counts to zero or near-zero at the following sampling occasion. No significant difference ($P < 0.05$) was seen in cumulative larval populations between fortnightly and low threshold treatments although the low threshold received two fewer sprays (3 cf. 5 in fortnightly treatment). No differences in damage assessment at harvest were seen between blocks; damage scores were summed across plots (Table 2) and data did not require transformation. All damage scores (Table 2) showed that the permethrin treatments at fortnightly intervals and at the low threshold were the most effective treatments in producing marketable cabbages (Table 3). Control plants consistently exhibited major damage in all categories; in the category 'outer wrappers', the permethrin high threshold treatment also allowed major damage (Table 2).

Lepidopteran pest pressure, predominantly from WB and SBL, was severe; mean number of larvae per control plant (averaged across the 10 week sample period) as observed in destructive observations were: DBM = 0.1; TFW = 0.5; SBL = 7.65; and WB = 22.2. Plants unprotected from larval feeding were completely unmarketable (Table 3); indeed, feeding by WB on wrapper leaves in control plots resulted in complete lamina consumption. Head weight appeared to be affected by damage; the control and high threshold had head weights significantly less than the head weights of the fortnightly and low threshold treatments (Table 3).

TABLE 3: Damage totals, head weight and the percentage of cabbages within each treatment scored as "Premium" (cumulative score of 3-4) and "Acceptable" (cumulative score of 3-6). Damage totals and head weight (kg) are means for each treatment. Numbers followed by the same letter are not significantly different ($P > 0.05$).

Treatment	Damage Total	Head Weight	% P	% A
Fortnight	4.80d	2.19a	45	86
Low	5.04d	2.18a	43	86
Medium	7.00c	1.98ab	2	43
High	7.92b	1.88bc	0	15
Control	9.95a	1.58c	0	0

DISCUSSION

The timing of permethrin applications to correspond with varying levels of pest populations allowed insight into when damage occurred to the different components of the plant during the plants' growth and development. The low threshold plots received two fewer sprays, and exhibited greater damage to the outer wrapper leaves than the fortnightly plots; the larval population differences between the treatments occurred just before head-formation (Figure 1a). The low and medium threshold plots received an equal number of sprays, but the medium action threshold allowed a serious reduction in marketable heads due to greater damage to inner wrapper leaves and to the heads. The population differences here occurred just after head formation (Figure 1a, 1b). The 1989 summer season had large populations of WB and no DBM; we recorded 86% acceptable cabbages in fortnightly sprayed plots and 0% acceptable cabbages in unprotected plots. However, Cameron (1989) found these pest populations reversed; in 1988, he recorded high populations of DBM (mean 14.4/plant) and low populations of WB (mean 1.9). Pest pressure from DBM alone allowed 100% acceptable cabbages in permethrin fortnightly plots and 18% acceptable cabbages in unsprayed control plots (Cameron 1989). Our data suggests that when WB is the dominant pest, a low action threshold is necessary once the plants have headed. The action threshold of 10 FDE/40 plants produced good results for this season, but it needs to be tested further under conditions of high DBM populations to determine its commercial feasibility. In

addition, extrapolation of these results from small-scale plots to commercial fields needs to be validated; it has been shown that WB females distribute their eggs in an aggregated pattern at low host densities (Jones 1977).

The Feeding Damage Equivalent system was not intended as a scouting technique; instead, its purpose was to maximize data input on pest damage potential. It accurately reflected presence of damaging larval populations as shown by both destructive sampling and damage assessment results. Our next step is to project this preliminary action threshold of 10 FDE/40 plants into a more practical scouting system. One possibility is to determine the relationship between FDE counts and a simple population estimate such as the percent of plants in a field which are infested. If the FDE counts for the permethrin low threshold treatments are converted to a percent infested basis, the low action threshold is comparable to a threshold of 15% to 35% infested plants. A simpler scouting system, coupled with an action threshold sensitive enough to prevent significant damage, is necessary for commercial acceptance.

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