COMPARISON OF LEPIDOPTERAN PEST POPULATIONS AND THEIR PARASITOIDS IN THREE VEGETABLE BRASSICAS

N.G. BECK and P.J. CAMERON

DSIR Plant Protection, Private Bag, Auckland

SUMMARY

The location of lepidopterous pests and their rates of parasitism were compared between cabbage, broccoli and cauliflower, and differences correlated with the relative growth patterns of the plant variety. Diamondback moth (DBM) larvae moved into the terminal of cabbage plants early in the season, but in broccoli larvae preferred leaves until after floret initiation. No consistent trend was seen in DBM larvae between the plant varieties, but fewer pupae were observed on broccoli. Parasitism of DBM pupae ranged from 69% to 93%, with the rates being greatest in broccoli. White butterfly (WB) populations were low and there was no difference in WB populations or in percent parasitism between brassica varieties.

INTRODUCTION

Cabbage, broccoli and cauliflower are major vegetable crops of South Auckland at Pukekohe. Growers, on average, plant 10 hectares of brassicas a year, generally in a cabbage-broccoli or cabbage-cauliflower combination. Adjacent blocks of different brassica varieties are continuously replanted, so a range of plant growth stages from seedling to harvestable plant is available at any one time. This allows continuous production of the commodity, but also allows cross-infestation of the insect pests from one variety to another. Brassica crops in New Zealand are hosts to two major introduced lepidopterous insect pests: diamondback moth (DBM) (*Plutella xylostella*) and white butterfly (WB) (*Pieris rapae*).

The literature on pest management of cabbage crops is extensive, but there is little information on the impact of insect pests on either broccoli or cauliflower. Many Pukekohe growers consider that pest infestations differ between brassica varieties — an important consideration in an integrated pest management (IPM) programme. However, in a survey of Pukekohe growers, we found that most growers apply insecticides on a fortnightly basis to all brassica fields regardless of plant variety, plant growth stages, or pest infestation by DBM and WB. In an attempt to reduce the number of insecticide applications applied to these crops, we are developing monitoring systems to detect infestations, as well as examining the effectiveness of parasitoids. In this paper we consider the following interactions of pests and their parasitoids, and brassica varieties: (1) Do the locations on the plant of lepidopterous pest populations differ between cabbage, broccoli, and cauliflower? (2) Are larval pest populations greater on one host variety? (3) Do parasitism rates of the lepidopterous pests differ between the host plant varieties?

METHODS

Seedlings of white cabbage (C) (cv. 'Gourmet'), cauliflower (CF) (cv. 'Dok Elgan'), and broccoli (B) (cv. 'Shogun') were transplanted on 8 November 1989 at the DSIR Research Station at Pukekohe and on 9 November 1989 at Mt Albert Research Centre (MARC), Auckland. Spacing was based on commercial practice with 0.75 m between rows and 0.5 m between plants; at both locations, two rows of cabbage alternated between two rows of either broccoli or cauliflower. At MARC, the field design consisted of three replicates of CC-BB-CC-CFCF-CC; at Pukekohe, a single

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replicate of CC-CFCF-BB was planted. Both trial locations were maintained free of pesticides.

Weekly sampling was initiated on 4 December 1989, when all plants were at 6-8 leaf stage. Sampling continued for 8 weeks at MARC and for 6 weeks at Pukekohe. Samples consisted of four randomly chosen plants from each variety at each location, except for the week of 8 January 1990 when the sample consisted of only two plants from each variety. Each plant was destructively examined in the laboratory. Qualitative observations were made on plant growth stages of the plant varieties over time, and the relative locations of insect pests on the plants. Numbers of eggs, larvae, and pupae of all lepidopterous insects were recorded; instar determination was made by relating head capsule size to body size (Robertson 1939). Larvae and pupae were reared to adult emergence of either moth or parasitoid. DBM larvae were reared on the plant variety on which they were found for 1 week, after which all larvae were fed cabbage. Date of pupation was recorded and individual pupae transferred to plastic tubes until emergence. WB larvae were reared individually in plastic tubes containing a general purpose insect diet.

RESULTS

Pest location and plant growth

Similar plant growth trends were seen at both locations and therefore the data were combined (Table 1); cabbage plants matured more rapidly and initiated heads 1 week before floret production began in broccoli or cauliflower. Eleven weeks after transplanting, cabbage and broccoli were both harvestable (cabbage heads >20 cm diameter, broccoli florets >15 cm diameter) while cauliflower was not (florets <10 cm diameter) (Table 1). Throughout the season in cabbage plants 50-90% of DBM larvae were consistently found in the terminal or head area. DBM larvae (50% or more) moved

TABLE 1: Plant growth phenology and general location of diamondback moth (DBM) or white butterfly (WB). Combined observations from Pukekohe Research Station and MARC. C = cabbage; B = broccoli; CF = cauliflower.

No. of weeks	Plant growth stage	Location on plant	
		DBM larvae	WB larvae
4	C — 7 leaf	Leaf	Leaf
	B — 7 leaf	Leaf	Leaf
	CF — 6 leaf	Leaf	Leaf
5	C — 10 leaf, growth outward	90% terminal*	Leaf
	B — 7 leaf, growth upward	Leaf	Leaf
	CF — 7 leaf, growth upward	Terminal/leaf	Leaf
6	C — 10 leaf	50% terminal**	Leaf
	B — 9 leaf	<20% terminal*	Leaf
	CF — 8 leaf	50% terminal*	Leaf
7	C — cupping	>50% terminal	Leaf/terminal
	B — 12 leaf; floret init.	<50% terminal**	Leaf
	CF — 10 leaf	>50% terminal**	Leaf
8	C — late cupping	>50% terminal	Inner leaves
	B — 15+ leaf; small florets	<50% terminal	Inner leaves
	CF — 15+ leaf; floret init.	>50% terminal	Leaf
9	C — Small heads	Head	Head
	B — 15+ leaf; florets	Leaves/florets	Florets
	CF — 15+ leaf; small florets	Leaves/florets	Florets
11	C — Harvestable heads	Head	Head
	B — Harvestable florets	Florets	Florets
	CF — Head 10 cm or less	Florets	Florets

* Peak of second instar DBM

** First DBM pupae

from leaf surfaces to the terminal/inner leaf area when cauliflower plants were 8-10 leaves. After floret formation in either broccoli or cauliflower, DBM large larvae preferred the floret area while small larvae preferred mid-level leaves. Few WB larvae were found in all plant varieties; eggs were laid primarily on under-leaf surfaces at any plant level. Small WB larvae migrated from their oviposition site to the centre of plants. At head and floret initiation, most large WB larvae on each plant variety were in the terminal area.

Pest populations

DBM populations were high at both sites; mean number of DBM (all instars + pupae) throughout the season was 30.7 per plant. On the first sampling occasion, first and second instar larvae were observed on cabbage and broccoli seedlings at both locations, while only first instar larvae were observed on cauliflower seedlings. Peak populations of DBM larvae on broccoli and cauliflower occurred 1 week later than on cabbage (Table 1). No consistent differences in instar population numbers were identified between varieties or sites. However, when the number of DBM within each instar category at MARC were examined (Fig. 1), the number of fourth instar larvae increased in cabbage and decreased in broccoli, while maintaining their numbers in cauliflower. A disparity in pupal numbers was seen at both sites; cabbage plants produced seven times more pupae than did broccoli, and three times more pupae than did cauliflower (Fig. 1).

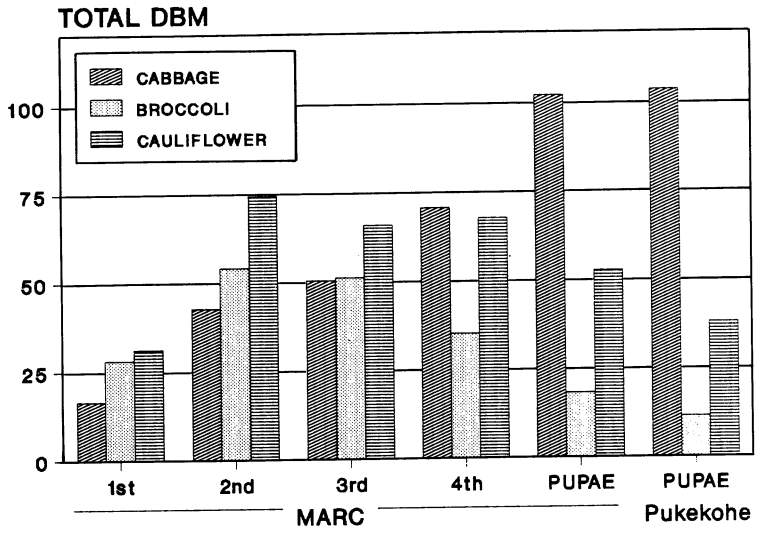

Fig. 1: Total number of DBM pupae and larvae on cabbage, broccoli, and cauliflower as observed in destructive counts. Larval instars and pupae are shown from MARC, and pupae from Pukekohe.

WB populations were low at both sites; mean number of WB (total of all instars) throughout the season was 1.7 per plant, and larvae contributed little to damage. No population peaks of WB eggs or larvae were observed. Throughout the season, slightly more eggs were observed on plants at Pukekohe (mean 2/plant) than at MARC (mean 1.19/plant). More eggs were found on broccoli than on either cabbage or cauliflower, but no clear trends were seen between varieties in either numbers of larvae or their longevity.

Parasitism

We collected 1138 DBM pupae from field samples. Of these, 872 were parasitized by either *Diadegma semiclausum* (Hymenoptera: Ichneumonidae), a parasitoid which attacks larvae and emerges from the pupae, or *Diadromus collaris* (Hymenoptera:

Ichneumonidae), a pupal parasitoid. Total rates of parasitism by *D. semiclausum* from pupae over the sampling period were: cabbage — 62%, broccoli — 91%, and cauliflower — 76%; for *D. collaris:* cabbage — 11%, broccoli — 2%, and cauliflower — 6%. Parasitism of pupae by both parasitoids, combined, is shown in Table 2. Field samples of 6296 DBM larvae were reared to emergence of either DBM moths or *D. semiclausum* (Table 2). Parasitism rates of DBM larvae were higher from Pukekohe than from MARC for all three plant varieties, but the pattern of parasitism between varieties was similar (Table 2). No difference was observed in parasitism rates of small DBM larvae (instars 1 and 2) between the varieties. Large larvae (instars 3 and 4) and pupae were more heavily parasitized in broccoli and least parasitized in cabbage (Table 2).

Eight WB pupae were collected in the field; none were parasitized. Of field collected larvae 217 survived to pupate or to the emergence of *Apanteles glomeratus* (Hymenoptera: Braconidae) larvae (Table 2). Only 2 out of 80 larvae collected from Pukekohe were parasitized, while 47 out of 137 from MARC were parasitized (Table 2). No obvious differences were seen in parasitism rates between the three plant varieties.

TABLE 2: Percent parasitism of diamondback moth (DBM) and white butterfly (WB) collected from the field (pupae) or laboratory reared (larvae). Number in parentheses is the sample size. Stage refers to stage of insect at collection.

		% Parasitism (N)		
Location	Stage	Cabbage	Broccoli	Cauliflower
	DBM			
MARC	Pupae	73 (371)	93 (69)	82 (169)
	3-4 instar	44 (195)	66 (176)	44 (284)
	2nd instar	29 (497)	27 (601)	26 (615)
	1st instar	2 (150)	0 (227)	2 (188)
Pukekohe	Pupae	69 (343)	92 (44)	85 (142)
	3-4 instar	70 (378)	85 (300)	79 (237)
	2nd instar	44 (549)	50 (849)	50 (545)
	1st instar	1 (157)	1 (216)	1 (132)
	WB			
MARC	4-5 instar	43 (7)	44 (16)	39 (13)
	1-3 instar	33 (21)	33 (45)	29 (35)
Pukekohe	4-5 instar	0 (9)	0 (2)	0 (5)
	1-3 instar	5 (20)	0 (27)	6 (17)

DISCUSSION

DBM larvae penetrated to the cabbage terminal area well before head formation was initiated. This type of behaviour would allow larvae to feed in areas well-protected from predation and/or parasitism. Our results show that cabbage produced the greatest number of DBM pupae and had the lowest parasitism rates of those pupae. Broccoli plants, which had the most open framework, produced the least number of DBM pupae and the highest rates of parasitism. However, parasitism cannot account for the small numbers of DBM pupae in broccoli, as the parasitoids emerge from the pupal stage. The source of this specific pupal loss remains to be determined, but its relationship to the open nature of broccoli plants suggests that predation may be important. DBM larvae are highly mobile, but the stationary pupae would be unable to evade predation.

The location of DBM larvae in cabbage terminals, taken in conjunction with the high production of pupae in cabbage, suggest two management options for growers. Firstly, as survival of DBM to the pupal stage appears greater on cabbage, cabbage could be removed from some cropping systems to reduce reservoirs of DBM. Secondly, cabbage could be utilized as an indicator crop in a scouting programme for vegetable

brassicas; infestations of DBM were easier to locate in cabbage and could be used to determine the presence of infestations in either of the other varieties. Then, depending on the plant growth stages of the varieties, a control decision could be made. Our observations indicate that Pukekohe grower practice of applying insecticide to all brassicas, regardless of plant growth stage, may be unnecessary, at least when pest populations consist only of DBM populations. Throughout the season, infestation of broccoli terminals by DBM was not observed until the initiation of florets. This suggests that pre-floret insecticide applications to control lepidopterous pests on broccoli are unnecessary unless there is extreme pest population pressure, as also indicated by Vail *et al* (1989). We are continuing this study to determine whether these observations apply under conditions of high WB populations.

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