The Great Lakes Entomologist

Volume 25
Number 4 - Winter 1992 *Number 4 - Winter 1992*

Article 3

October 1992

Effects of Neighboring Nectar-Producing Plants on Populations of Pest Lepidoptera and Their Parasitoids in Broccoli Plantings

J. Z. Zhao
Michigan State University

G. S. Ayers
Michigan State University

E. J. Grafius
Michigan State University

F. W. Stehr
Michigan State University

EFFECTS OF NEIGHBORING NECTAR-PRODUCING PLANTS ON POPULATIONS OF PEST LEPIDOPTERA AND THEIR PARASITOIDS IN BROCCOLI PLANTINGS

J. Z. Zhao[1,2], G. S. Ayers[1], E. J. Grafius[1] and F. W. Stehr[1]

ABSTRACT

Eggs and larvae of the imported cabbageworm, *Pieris rapae*, were much more abundant in broccoli interplanted with nectar-producing plants than in broccoli monoculture. More diamondback moth larvae, *Plutella xylostella*, occurred in broccoli interplanted with or adjacent to nectar-producing plants than in broccoli monoculture. Density of cabbage looper larvae, *Trichoplusia ni*, was similar among the three types of broccoli plantings. For *Cotesia rubecula*, established in Michigan after introduction from Yugoslavia, pupae were more numerous in broccoli interplanted with nectar-producing plants than in other plots. High parasitism rates of diamondback moth, mainly by *Diadegma insulare*, were observed in every plot, but there were no differences in parasitism of diamondback moth between the treatments. Results indicate that the interactions between pests, parasitoids and nectar-producing plants are complex and may be different for each species.

Diversification of agricultural crops often lowers pest populations. In a summary of 198 herbivore species in 150 published studies, 53% of these species were less abundant in more diversified agroecosystems and only 18% were more abundant (Risch et al. 1983). Herbivore movement patterns related to host-finding may be more important than the activities of natural enemies in explaining the reduction of monophagous pest populations in diverse annual systems (Risch 1981, Risch et al. 1983). Floral nectar is an important source of nutrition to both adult Lepidoptera and Hymenoptera biocontrol agents (Kevan and Baker 1984). Understanding how the abundance of pest Lepidoptera and their parasitoids in crops are affected by neighboring nectar-producing plants is valuable for the design and manipulation of pest management systems.

Pest Lepidoptera, especially the imported cabbageworm, *Pieris rapae* (L.), diamondback moth, *Plutella xylostella* (L.), and cabbage looper, *Trichoplusia ni* (Hübner), are key insect pests in crucifers (cabbage, broccoli, etc.) in North America (Harcourt 1963) and have wide distribution in other regions. Previous studies have reported that some herbs neighboring cabbage may be attractive to imported cabbageworm adults, resulting in higher damage to cabbage (Latheef and Irwin 1979). Population densities of diamondback moth in polycultures are often lower than in monocultures of crucifers (Buranday

[1]Department of Entomology, Michigan State University, East Lansing, MI 48824-1115.
[2]Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, Beijing 100081, P. R. China.

and Raros 1973, Taleker et al. 1986). In Hawaii, monospecific cabbage plots had greater densities of diamondback moth larvae and lower parasitism compared with plots of cabbage interplanted with tomato (Bach and Tabashnik 1990).

Bee forage plots, including nectar-producing plants in 34 genera, were planted in 1989 at the Michigan State University Entomology Research Farm, East Lansing, Michigan (Ayers, unpublished data). The objective of our study was to evaluate the effects of some of these nectar-producing plants interplanted with or adjacent to broccoli on densities of the major Lepidoptera pests of broccoli, i.e. imported cabbageworm, diamondback moth, and cabbage looper. A second objective was to measure the effects of nectar-producing plants on parasitism of imported cabbageworm by *Cotesia rubecula* (Marshall) (Braconidae), and of diamondback moth larvae by *Diadegma insulare* (Cresson) (Ichneumonidae) and *Microplitis plutellae* Muesebeck (Ichneumonidae). *C. rubecula* is a solitary parasitoid that attacks early instar imported cabbageworms. It generally kills the cabbageworm by the third or fourth instar and forms a white cocoon. A related species, *Cotesia* (*Apanteles*) *glomeratus*, also attacks imported cabbageworms, but does not kill the larvae until they are mature, after significant amounts of feeding and foliar damage has occurred. *D. insulare* is a very common parasitoid of diamondback moth in the U.S. and Canada (Harcourt). *M. plutellae* is much more rare (Idris and Grafius 1992).

MATERIALS AND METHODS

Field plot experiment. A plot containing nectar-producing plants in 34 genera was planted in 1989 (20 rows and 2.4 m between rows). Anise hyssop, *Agastache foeniculum*, was among the most prolific nectar producers in this plot. Broccoli seedlings were started in the greenhouse and transplanted to the field on 9 July 1991.

Treatments were: (1) broccoli interplanted between the anise hyssop rows in the nectar-producing plant plot; (2) broccoli adjacent to the the nectar-producing plant plot; (3) broccoli monoculture about 120 m east of the the nectar-producing plant plot. Treatment (1) was one row of broccoli (24 plants and 15 m long) between two of the nectar-producing plant rows. Treatments (2) and (3) were 30 m long and four rows wide. Plant spacing was 0.6 m between plants within rows and 1 m between rows. The numbers of pest Lepidoptera and their parasitoids were counted weekly on 10–20 broccoli plants in each treatment from 30 July to 3 September 1991. Only the middle two rows of broccoli plants in treatments (2) and (3) were sampled.

Diamondback moth larvae release. Because field diamondback moth populations were low, 120 second and third instar diamondback moth from a laboratory culture (reared on broccoli leaves) were released on 15 July 1991 on 12 marked broccoli plants in treatments (1) and (3) to investigate diamondback moth parasitism rates. Larvae, parasitized and non-parasitized pupae were collected on 21 August, 1991. The larvae were reared in the laboratory until pupation. Parasitized pupae were kept in petri dishes until emergence of adult parasitoids for identification.

Data analysis. Since the nectar-producing plants were originally planted in a single block for bee forage research, the treatments were not spatially replicated and could not be statistically compared. Parasitism rates of diamondback moth were calculated as the number of parasitized pupae divided by the total number of parasitized and unparasitized pupae per plant. Differences in parasitism rates based on diamondback moth larvae released

were analyzed using a t test (Zar 1974). Precise parasitism rates of imported cabbageworm by *C. rubecula* could not be calculated because *C. rubecula* pupates on the plants but imported cabbageworm larvae prefer to pupate off the host plants (Harcourt 1963). A relative parasitism rate of imported cabbageworm was calculated as the season-long totals of parasitized pupae divided by the season-long totals of large ICW larvae (fourth and fifth instar) plus parasitized pupae per plant. The parasitoids of the cabbage looper were not investigated.

RESULTS AND DISCUSSION

Lepidoptera pest abundance. The effects of nectar-producing plants on pest abundance were different for imported cabbbageworm, diamondback moth, and cabbage looper. Imported cabbbageworm eggs and larvae were much more abundant in broccoli interplanted with nectar-producing plants than in broccoli adjacent to nectar-producing plants or broccoli monoculture (Fig. 1 a&b, Table 1). Only a few imported cabbbageworm pupae were found during the season in the three broccoli plots because the larvae leave the broccoli plants to pupate.

There were generally more diamondback moth larvae in broccoli interplanted or adjacent to nectar-producing plants than in broccoli monoculture (Fig. 1c). However, the density of diamondback moth pupae in broccoli interplanted with nectar-producing plants was much lower than in broccoli adjacent to nectar-producing plants or monoculture (Table 1).

The season-long total of cabbage looper larvae was similar between the three plots (Table 1), although the density was higher on 20–27 August in broccoli plants interplanted with nectar-producing plants (Fig. 1d).

Most adult Lepidoptera feed extensively on floral nectar (Kevan and Baker 1984), so the attractiveness of nectar-producing plants to imported cabbageworm butterflies and diamondback moths may be an important reason for more eggs and larvae in broccoli interplanted with nectar-producing plants than in broccoli monoculture. Imported cabbageworm butterflies were seen visiting the nectar-producing plants as well as the broccoli. Diamondback moths were observed only on the broccoli. Cabbage looper females were apparently not attracted to nectar-producing plants and may not rely as much on them for food.

Parasitism of imported cabbageworms and diamondback moth larvae. No unparasitized imported cabbageworm pupae were found in broccoli monoculture or interplanted with nectar-producing plants. The relative parasitism rates of imported cabbageworm by *C. rubecula* were 39.9%, 22.2%, or 26.2% in broccoli interplanted with nectar-producing plants, adjacent to nectar-producing plants or broccoli monoculture, respectively. The number of *C. rubecula* pupae was much higher in broccoli interplanted with nectar-producing plants than in other plots (Table 1). It is evident that *C. rubecula* has been established in Michigan after introduction from Yugoslavia in 1985. This is the only known establishment site of *C. rubecula* in the eastern U.S. (initially provided by Dr. B. Puttler, U.S.D.A. Biocontrol Laboratory, Columbia MO; current address, University of Missouri, Columbia, MO).

Diadegma insulare is the major parasitoid of diamondback moth in Michigan (Idris and Grafius 1992). Only *D. insulare* was found on 21 August in this study. However, in the broccoli monoculture on 7 August, the parasitism of diamondback moth was 68.2% by *D. insulare* and 31.8% by *M. plutellae*, indicating that the latter could also be a important parasitoid of diamondback moth in early August in Michigan. High parasitism rates of diamondback

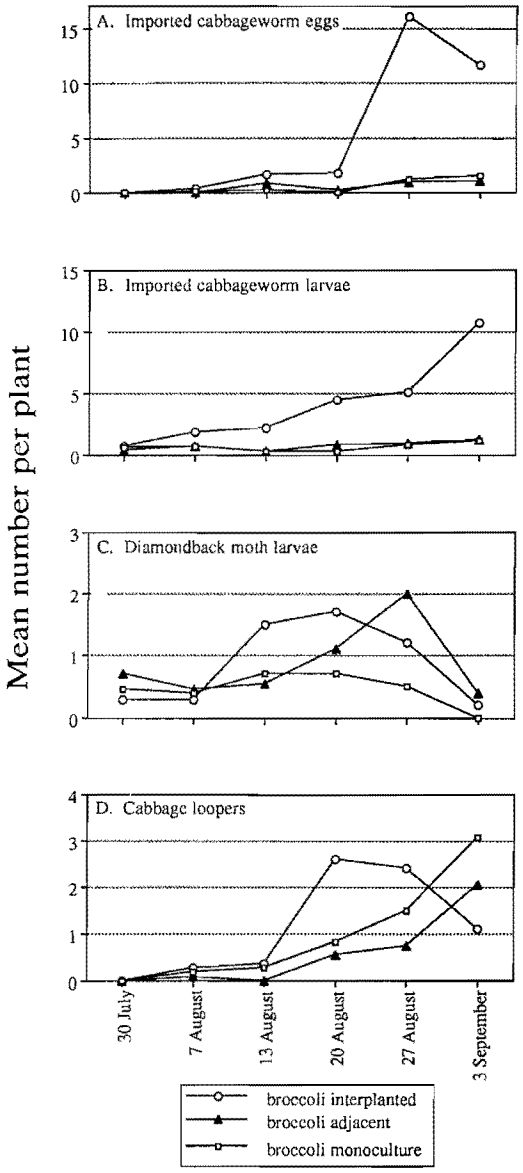

Figure 1. Population abundance of imported cabbageworm, diamondback moth and cabbage looper in broccoli as affected by proximity to nectar-producing plants.

Table 1. — Numbers of imported cabbageworm eggs, larvae, pupae and parasitized pupae; diamondback moth larvae, pupae and parasitized pupae; and cabbage looper larvae in broccoli as affected by nectar-producing plants.

Species/stage	Season-long totals/plant in broccoli[1]		
	interplanted with nectar plants	adjacent to nectar plants	monoculture
Imported cabbageworm			
Eggs	31.6	3.2	1.0
Larvae	25.1	4.4	3.9
Pupae	0.0	0.2	0.0
Cotesia rubecula pupae	5.8	0.6	0.8
Diamondback moth			
Larvae	5.2	5.2	2.8
Pupae	0.1	0.6	0.5
Parasitized pupae[2]	0.8	0.6	0.5
% parasitism	88.9	84.3	78.6
Cabbage looper			
Larvae	6.2	4.3	6.1

[1]Six sample dates.
[2]*Diadegma insulare* and *Microplitis plutellae.*

moth, mainly by *D. insulare*, were observed in every treatment (88.9%, 84.3%, and 78.6% in the plots of broccoli interplanted with nectar-producing plants, adjacent to nectar-producing plants, and broccoli monoculture, respectively, Table 1). *Diadegma insulare* were observed on broccoli plants in all plots and visiting the nectar-producing plants.

Diamondback moth larvae release. In the diamondback moth larvae release experiment, there was no significant difference in parasitism rates of diamondback moth between broccoli interplanted with nectar-producing plants and monoculture (Table 2).

Nectar-producing plants attract and serve as food source for the adults of both biological control agents (Hymenoptera) and the pest Lepidoptera of cruciferous vegetables. Interactions between nectar-producing plants, pests and biocontrol agents are therefore complex and may be different for each pest species. Further research is needed to investigate the effects of nectar-producing plants on specific pest Lepidoptera and parasitoids related with the interplanting patterns and the ratio between nectar-producing plants and cruciferous plants.

Table 2. — Parasitism of diamondback moth after larvae were released in broccoli interplanted with nectar-producing plants or as a monoculture.

Broccoli plot types	Number of diamondback moth larvae			
	released	recaptured	parasitized	% parasitism[1]
Interplanted	60	17	8	47.1
Monoculture	60	14	5	35.7

[1]No significant difference in % parasitism between broccoli plot types ($P > 0.05$, t test).

ACKNOWLEDGMENTS

We wish to thank Beth Bishop, Walter Pett and Abd-Ghani Idris for their help. This work was supported in part by UNDP/FAO Project CPR/88/056, the Michigan Vegetable Council and the Michigan Agricultural Experiment Station.

LITERATURE CITED

Bach, C. E. and B. E. Tabashnik. 1990. Effects of nonhost plant neighbors on population densities and parasitism rate of the diamondback moth. Environ. Entomol. 19:987–994.

Buranday, R. P. and R. S. Raros. 1975. Effects of cabbage tomato intercropping on the incidence and oviposition of the diamondback moth, *Plutella xylostella* (L.). Philipp. Entomol. 2:369–374.

Harcourt, D. G. 1960. Biology of the diamondback moth *Plutella maculipennis* (Curt.) in eastern Ontario. III. natural enemies. Can. Entomol. 92:419–428.

_____. 1963. Biology of cabbage caterpillars in eastern Ontario. Proc. Entomol. Soc. Ont. 93:61–75.

Idris, A. B. and E. J. Grafius. 1992. Field studies on the impact of insecticides on the diamondback moth and parasitism by *Diadegma insulare*. J. Econ. Entomol. (submitted).

Kevan, P. G. and H. G. Baker. 1984. Insects on flowers. *In*:Huffaker, C. B. and R. L. Rabb (eds.). Ecological Entomology. John Wiley & Sons, New York. pp. 607–631.

Latheef, M. A. and R.D. Irwin. 1979. The effect of companionate planting on lepidopteran pests of cabbage. Can. Entomol. 111:863–864.

Risch, S. J. 1981. Insect herbivore abundance in tropical monocultures and polycultures:an experimental test of two hypotheses. Ecology 62:1325–1340.

Risch, S. J., M. Altieri and D. Andow. 1983. Agroecosystem diversity and pest control:data, tentative conclusion, and new research direction. Environ. Entomol. 12:625–629.

Taleker, N. S., S. T. Lee and S. W. Huang. 1986. Intercropping and modification of irrigation method for the control of diamondback moth. *In*:Taleker, N.S. and T.D. Griggs (eds.). Diamondback Moth Management:Proc. of the First International Workshop at AVRDC, Shanhua, Taiwan. pp.145–152.

Zar, J. H. 1974. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J.