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YIELD RESPONSES OF CABBAGE AND MUNGO TO INJURY BY IMPORTANT INSECT PESTS IN RELATION TO INSECTICIDAL CONTROL EFFICIENCY[1]

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Evaluation of cabbage yield in relation to the effects of insecticidal protection (*Bacillus thuringensis* sprays) during different growth periods of the crop revealed that the injuriousness of *Plutella xylostella* was most critical during the period from 4 to 5 weeks after transplanting. Feeding injuries by the insect during earlier and later growth periods were relatively less critical to yield.

A similar evaluation on mungo, using insecticidal protection with acephate, also revealed that insect pest injury, mainly by aphids and leaf rollers, was most critical to yield when inflicted during the vegetative growth stage (3-4 weeks after seedling emergence). Insecticidal protection of the seedling, flowering and pod stages provided decreasing yield benefits, in that order.

Towards more judicious pesticide use, it is recommended that insecticidal applications should provide protection during critical periods of crop growth but not necessarily for the entire crop growth.

INTRODUCTION

One of the fundamental foundations of integrated insect control is knowledge of economic injury levels. Defined as the lowest pest population that will cause economic damage, and often referred to as economic damage threshold, it is important in determining the need for pest control and in developing effective pest management procedures (Smith, 1968; Stern, 1973). However, local research efforts have yet to be harnessed for the specific purpose of defining economic injury levels for our important crop plants and their major insect pest species. In addition, the effort requires relatively long-term data gathering and concerted interaction between workers involved with crop production and crop protection.

Thus, until economic injury levels shall have been defined, prophylactic insecticidal protection will continue to prevail in our chemical control recommendations. Unfortunately, however, this may lead (if not already) to indiscriminate use of pesticides and to more serious problems of soil and water pollution, insecticide resistance, pest resurgences and disruption of ecological systesm as experiences

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in the developed countries foretell (Chant, 1966; Kennedy, 1968; Odum, 1969; Smith and van den Bosch, 1967).

In the absence of economic damage thresholds to serve as guidelines to pesticide application, a practical means to minimize indiscriminate pesticide treatments is to base the timing of application according to differential sensitivity to insect injury, of the different growth stages of the crop. The sensitive or critical growth stages, as reflected by degree of yield loss, may be identified by comparing the yield among plants receiving insecticide protection at different growth stages. Likewise, growth stages which are relatively insensitive to insect feeding injury, either by virtue of tolerance or the capacity to recover, can be identified also. Accordingly, prophylactic insecticide treatments may be limited to the sensitive stages and minimized (if not eliminated) during the insensitive growth stages.

For instance, in analyzing the effects of aphid infestation on the yield of bush sitao, Bernabe (1973) found that as aphid control (0.1% malathion sprays) was delayed with plant maturity up to flowering, yield reduction increased. One or two strategically timed treatments during the period from seedling to flowering stages reduced yield losses significantly. Insecticide treatments after flowering and during the pod stage contributed little to increased yield and thus need not be applied.

This study was conducted to identify growth periods of cabbage and mungo which critically require maximum crop protection from feeding injury by their respective insect pests. The study was conducted at the Central Experiment Station and the Department of Entomology, University of the Philippines at Los Baños, from December 1973 to June 1974.

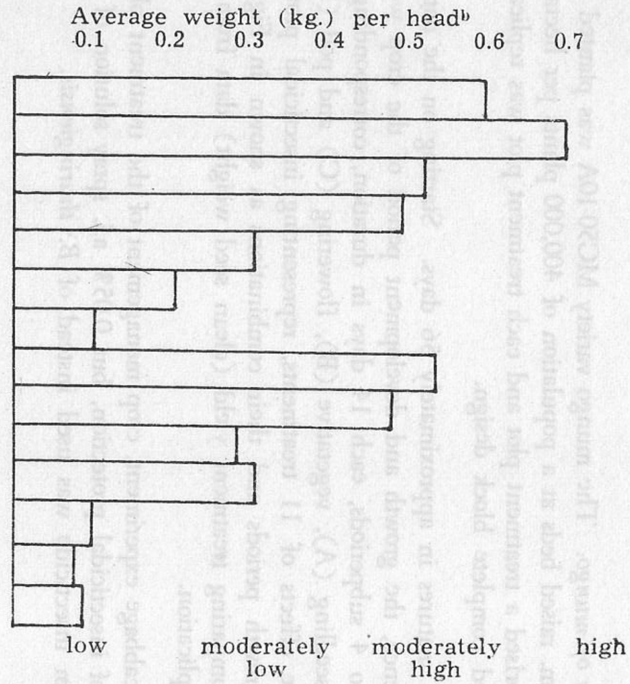
MATERIALS AND METHOD

The diamond-back moth, Plutella xylostella (L.) on cabbage. Cabbage seedlings (KK Cross) were planted at spacings of 50 x 75 cm. in 5 x 6 m. treatment plots. Fourteen such treatment plots, each replicated twice in a completely randomized design, were managed as uniformly as possible for tillage, weeding, fertilizing, and irrigation requirements. The treatments represented insecticidal protection with *B. thuringiensis* (10 g. Dipel in 15 liters of water) at different periods of growth (in weeks after transplanting) except for the untreated control (Fig. 1).

Although the variety matures in 8-9 weeks after transplanting, the experimental treatments covered only the first 7 weeks of growth. This incomplete coverage of crop growth and development was intentional. To safeguard consumers, no pesticide treatments should be made from 1 to 3 weeks before harvests, depending on the chemical.

Fig. 1. The effects on the yield of cabbage of insecticidal protection from injury by *Plutella xylostella* (L.) during various stages of crop growth.

Treatment number	Weeks after transplanting[a] 1	2	3	4	5	6	7	Stat.[c] diff. 5%
1	x	x	x	x	x	x	x	a
2	3.7	x	x	x	x	x	x	a
3	1.1	4.9	x	x	x	x	x	ab
4	1.9	4.1	2.7	x	x	x	x	ab
5	1.7	4.4	2.5	8.3	x	x	x	bc
6	1.9	4.0	4.4	13.3	8.8	x	x	cd
7	1.6	4.5	3.1	11.0	6.5	17.7	x	de
8	x	x	x	x	x	x	5.9	a
9	x	x	x	x	x	3.1	45.4	ab
10	x	x	x	x	2.3	11.2	49.4	c
11	x	x	x	1.1	6.5	18.9	51.0	bc
12	x	x	1.0	11.9	5.9	18.4	24.0	e
13	x	0.4	3.5	14.5	6.5	19.0	26.1	e
14	1.7	5.0	3.5	11.9	5.0	21.0	25.0	e



[a] x denotes spray application with *B. thuringiensis*; figures are average no. of larvae and pupae/plant.
[b] Based on 40 plant samples per treatment, average of 2 replications.
[c] Any two treatments followed by the same letter are not significally different at 5% level of significance, Duncan's New Multiple Range Test.

The population build-up of *P. xylostella* was monitored by weekly counts of larvae and pupae on treatment plots receiving no insecticidal protection for any given week. At harvest, the weights of marketable heads were obtained and compared.

Insect pests of mungo. The mungo variety MC50-10A was planted in double rows on 1 x 5 m. raised beds at a population of 400,000 plants per hectare. Four such beds comprised a treatment plot and each treatment plot was replicated twice in a randomized complete block design.

MG50-10A matures in approximately 56 days. Starting on the date of 50% seedling emergence, the growth and development period of the crop was arbitrarily divided into 4 subperiods, each 14 days in duration, corresponding approximately to the seedling (A), vegetative (B), flowering (C) and pod (D) stages (Fig. 2). The effects of 11 treatments, representing insecticidal protection of the different growth periods and their combinations as shown in Fig. 2, were evaluated by comparing treatment yield (clean seed weight) data from 25 plant samples per replication.

As in the cabbage experiment, crop management of the treatment plots varied only in terms of insecticidal protection, but 0.05% a.i. spray solution of acephate, a broad-spectrum insecticide was used instead of *B. thuringiensis*.

RESULTS AND DISCUSSION

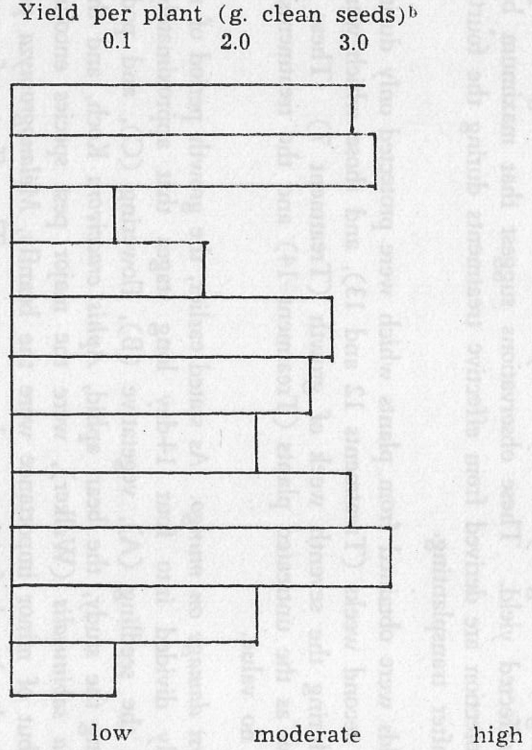
The diamond-back moth (Plutella xylostella) on cabbage. The effects on the yield of cabbage of feeding injury by *Plutella* during various stages of crop growth are illustrated in Fig. 1. Based on average weight (kg) per cabbage head, four yield levels are recognizable: high, moderately high, low and low yields.

High yield levels were obtained from plants which were protected with *B. thuringiensis* treatments throughout growth (Treatment 1) and those unprotected (no *B. thuringiensis* treatment) during the first (Treatment 2) or the seventh (Treatment 8) week of growth. During the period of no protection, an average of 3.7 (Treatment 2) and 5.8 (Treatment 8) *Plutella* larvae/pupae were found on each plant but, apparently, their feeding injury did not affect yield.

Moderately high yields were obtained from plants which were otherwise protected throughout growth except the first 2 or 3 weeks (Treatment 3 and 4) or during the sixth or seventh weeks (Treatment 9) of growth. These yields were not, however, significantly different from the high yields just discussed above. Thus in the absence of protection during the first 3 weeks, or during the sixth or seventh weeks of growth, yield levels were not markedly reduced in spite of feeding injury incurred during the early growth. The plants apparently can tolerate feeding damages incurred during late growth. These observations

Fig. 2. The effects on the yield of mungo of feeding injuries by important insect pests during various stages of crop growth treated differentially with Acephate (0.05% a.i. sol.).

Treatment no.	Growth stages[a] A	B	C	D	Statistical[c] differences 5%
1	x	x	x	x	a
2	-	x	x	x	a
3	-	-	x	x	c
4	-	-	-	x	b
5	x	x	x	-	a
6	x	x	-	-	a
7	x	-	-	-	ab
8	-	x	x	-	a
9	-	x	x	-	ab
10	-	-	x	-	ab
11	-	-	-	-	c



[a] A, B, C, & D correspond approximately to seedling vegetative, flowering and pod stages, respectively; x denotes spray application.

[b] Based on 25 plant samples per treatment in two replications.

[c] Any two treatments followed by the same letter are not significantly different at 5% level of significance, Duncan's New Multiple Range Test.

also imply that if the farmer wishes to economize on crop protection costs by decreasing spray applications, skipping treatments during early or late or in both growth stages may not significantly reduce production yield.

Moderately low yields were obtained from plants which received protection starting from the fifth to the seventh weeks of growth (Treatments 5 and 6) and those with protection only from the first to the fourth weeks of growth (Treatments 10 and 11). Between treatments 5 and 11, the unprotected growth period was the fourth week, while between Treatments 6 and 10 the unprotected growth period was the fifth week. Thus, with unprotected fourth or fifth or both weeks, as in Treatments 7, 12, 13 and 14, marked reductions in yield were obtained. The fourth and fifth weeks of growth thus appear to be the critical stages; feeding injuries by *P. xylostella* larvae during these periods considerably affected yield. These observations suggest that maximum benefits from crop protection are derived from effective treatments during the fourth and fifth weeks after transplanting.

Low yields were obtained from plants which were protected only during the first and the second weeks (Treatments 12 and 13), and those which were protected only during the seventh week of growth (Treatment 7) These plants yielded as low as the untreated plants (Treatment 14) and the treatments were, therefore, of no value.

Insect pest damage on mungo. As stated earlier, the growth period of mungo was arbitrarily divided into four 14-day long stages that approximately corresponded to the seedling (A), vegetative (B), flowering (C), and pod (D) stages. During the study, the bean aphid, *Aphis craccivora* Koch, and the leaf roller, *Sylepta sabinusalis* (Walker), were the major pest species encountered; also present but of minor importance were the beanfly, *Melanogromyza phaseoli* (Tyron), flea beetles, leafminers, and cutworms. The effects of protection with the broad-spectrum insecticide, acephate, during the various crop growth stages are reflected in Fig. 2. Expressed in terms of average yield (clean seed weight, g./plant) from 25 sample plants per treatment, three general yield levels were observed: high, moderate, and low.

High yields were obtained with Treatment Numbers 1, 2, 5, 6, 8, and 9 in which the plants were provided varying periods of insecticidal protection during growth but all received one common treatment: insecticidal protection during the vegetative growth stage (B), that is, during the third and fourth weeks after seedling emergence. It is significant to note further that high yield was obtained with protection during vegetative growth (B) regardless of protection or non-protection of the preceding (seedling stage, A) and/or the following (flowering, C and pod, D) growth stages.

Moderate yields were obtained from plants in which insecticidal protection was confined to the early seedling stage (Treatment 7) or to the late stages (flowering and pod stages, Treatment 4 and 10). On the other hand, low yields were obtained with unprotected plants throughout growth (Treatment 11) or protected only during the late growth stages (Treatment 3). These plants with moderate to low yields were not provided insecticidal protection during vegetative growth (B).

Thus, the growth stage most susceptible to insect injury in mungo is the vegetative growth stage which approximately covers the period from 3 to 4 weeks after seedling emergence. During this period, insect feeding injuries apparently affect yield more strongly than injuries earlier (seedling) or later growth stages (flowering, pod). It follows that yield benefits from insecticidal protection are greatest with effective treatments during this particular period of growth.

The order of decreasing yield benefits from differential protection of the growth stages appears to be as follows: vegetative stage (B), seedling stage (A), flowering stage (C), and pod stage (D). Therefore, a farmer who may wish to economize by decreasing the number of spray applications may skip treatments during the late growth stages of the crop.

SUMMARY AND CONCLUSIONS

To improve the efficiency of insecticidal treatments, timing of insecticide applications to provide protection to critical growth periods of crops seems appropriate in the absence of guidelines based on economic injury levels.

Insecticidal protection with *Bacillus thuringiensis* of the different growth periods of cabbage from injury by the diamond-back moth, *Plutella xylostella,* revealed that the critical growth period covers the period from 4 to 5 weeks after transplanting. Insecticidal applications during early (1-3 weeks after transplanting) and late (6-7 weeks after transplanting) growth periods were found relatively inefficient; these periods were considered non-critical because during the early and late periods the plants can apparently recover from and tolerate feeding injuries, respectively.

It is recommended, therefore, that insecticidal protection of cabbage against the diamond-back moth be maximized during the period from 4-5 weeks after transplanting while protection against the insect may be minimized during the period from 1-3 weeks and 6-7 weeks after transplanting.

A similar evaluation of yield benefits due to protection of mungo from its pest species (mainly aphids and leaf rollers) with acephate revealed that the critical growth period was the period from 3-4 weeks after seedling emergence; this period corresponds approximately to the vegetative growth stage. Insecticidal protection of the seedling, flowering and pod stages provided decreasing yield benefits, in that order. Thus it is recommended that for mungo, insecticidal protection may be maximized during seedling and vegetative growth, but may be minimized during flowering and pod growth stages.

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