ENTOMOPHAGA 36 (3) 1991, 379-389

A SIMPLE ACTION TRESHOLD FOR TIMING APPLICATIONS OF A GRANULOSIS VIRUS TO CONTROL *PIERIS RAPAE* [*LEP. : PIERIDAE*]

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Pieris rapae (L.) an important pest of cole crops in the northeastern United States, is susceptible to a granulosis virus, *Pieris rapae* GV (PrGV), that has been shown to be an effective control measure by researchers in several countries. As an alternative to weekly applications of virus to protect cabbage, we tested the use of an action threshold of one small (first-third instar) larva per plant. Results were compared with those obtained using the same threshold with permethrin, and with weekly applications of virus. Plots treated weekly with virus received 5 applications but the action threshold was exceeded only once. In all virus-treated plots, numbers of large (fourth-fifth instar) larvae remained below 0.35 per plant, and were lower at the end of the season (0.07 in plots treated weekly and 0.1 in plots treated once) than in either the untreated or permethrin-treated plots (0.5). In late August, numbers of large larvae in the check plots reached almost 3 per plant. At harvest the number of feeding holes over 0.3 cm in diameter in the 4 innermost frame and the 4 wrapper leaves were counted. Check plots differed from treated plots by an average of 124.2 $\pm$ 6.5 holes per plant in the frame and wrapper leave ; virus-treated plots had 51.1 $\pm$ 6.9 holes more than the permethrin plots. The difference in overall damage between plots treated 5 times with virus during the season and those treated once was not significant. Plots treated once with virus had significantly more damage (7.6 $\pm$ 2.7) to wrapper leaves than those treated five times and marketability ratings were somewhat lower, based on fresh market standards. There were no significant differences in head weight among the treatments. At harvest, a high proportion of larvae collected from the check plots were diseased (77 % versus an average of 46 % in the treated plots). Because of the high numbers of large larvae in the check plots in late August and the extensive damage to plants, we assumed that virus did not affect a significant number of larvae in these plots until late in the growing season.

These results indicate the usefulness of PrGV in a cabbage IPM program and that the use of action thresholds can be highly effective, particularly when insect numbers only occasionally reach damaging levels. While cabbage treated with permethrin had the least amount of injury, that treated weekly with virus was not significantly different by fresh market standards, and all cabbages treated with virus met processing standards. For the fresh market, in which cosmetic standards are more important, PrGV may have to be used weekly or with an action threshold lower than one small larva per plant.

KEY WORDS : *Pieris rapae,* microbial control, granulosis virus, cabbage.

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Pieris rapae (L.), is an important pest of cole crops in the northeastern United States. Although 2 other lepidopteran pests, *Trichoplusia ni* (Hübner), the cabbage looper, and *Plutella xylostella* (L.), the diamondback moth, also cause damage, in New York *P. rapae* will often be the dominant pest species until late July or early August (**Andaloro** *et al.*, 1982). A granulosis virus, *Pieris rapae* GV (PrGV) has been shown to effectively control *P. rapae* (**Hostetter** *et al.*, 1973 ; **Jaques,** 1972, 1977 ; **Sears** *et al.*, 1983) and has been combined with a virus, *Autographa californica* NPV (AcNPV), affecting both *P. xylostella* and *T. ni,* to provide control of all 3 pests (**Jaques,** 1972, 1977 ; **Sears** *et al.*, 1983).

Several researchers have demonstrated the value of action thresholds for timing chemical insecticide treatments to control Lepidoptera on cabbage (**Chalfant** *et al.*, 1979 ; **Shelton** *et al.*, 1983 ; **Sears** *et al.*, 1985). Microbial insecticides, however, are generally applied on a weekly schedule to compensate for the loss in activity caused by exposure to sunlight (**Jaques,** 1975 ; **Payne,** 1982). Only **Sears** *et al.* (1983) have tested action thresholds for combined applications of viruses and *Bacillus thuringiensis* (Bt) to control lepidopteran pests of cabbage. Although they clearly demonstrated the usefulness of this approach, the threshold they propose is somewhat complicated and requires sampling larval populations twice weekly. If they found 2 or more eggs of *A. rapae* or *T. ni,* or one small (1^{st} or 2^{nd} instar) larva, or 2 eggs and small larvae on 2 consecutive occasions they applied treatments within 1 day. Treatment decisions were based on 1 sampling if populations (of both species combined) per plant equaled or exceeded 0.5 large larvae or 2 small larvae. We wanted to test a simpler criterion for treatment and, because we were primarily interested in the efficacy of 1 virus, the granulosis virus of *A. rapae,* we did not include Bt or AcNPV in our field trial. We also wished to compare the effect of weekly treatments with those applied on the basis of an action threshold.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN

Three treatments and an untreated control were arranged in a randomized complete block design with 6 blocks. The treatments were as follows : (a) an untreated control, (b) virus applied when the density of *P. rapae* exceeded an action threshold, (c) virus applied on a weekly schedule, (d) permethrin (Ambush®, 0.056 kg of AI/ha) applied as in (b) above. Each of the 24 plots consisted of 8 rows spaced 1.0 m apart, each containing 9 cabbages spaced 0.5 m apart, with 6 m of bare ground separating all plots. Cabbage seedlings (cv « Roundup ») were transplanted on 19 June 1986 at the Robbins Vegetable Research Farm, Geneva, New York, in fields previously untreated with granulosis virus.

PURIFICATION OF VIRUS AND PRODUCTION OF ANTISERUM

Groups of 20-30 newly-molted 5^{th} instar *P. rapae* larvae were fed wheat germ diet surface-contaminated with a North American isolate of PrGV (originally obtained from Dr. **Robert Jaques,** Harrow, Ontario), *ca.* 50 occlusion bodies (OBs) per mm^2. Larvae, harvested in an advanced stage of disease but before they died and melanized, were stored at − 20 °C.

The method used to extract virus from larvae was similar to that of **Tweeten** *et al.* (1977) with minor modifications (**Webb,** 1988). Enveloped virions were released from gradient-purified OBs and further purified as described by **Dwyer & Granados** (1987). Protein

concentration was estimated by Bio-Rad® protein assay using bovine serum albumin as a standard. A sample of the final virus preparation, negatively stained and examined with an electron microscope, showed a mixture of enveloped virions and nucleocapsids. Antiserum was raised in a New Zealand white rabbit according to the method of **Volkman & Falcon** (1982) except that *ca.* 100 µg of the virus preparation described above was used for each injection. Immunoglobulins were purified from crude serum and conjugated to alkaline phosphatase as described by **Clark & Adams** (1977).

ENZYME-LINKED IMMUNOSORBENT ASSAY (ELISA)

A double antibody sandwich ELISA was used following the procedure of **Clark & Adams** (1977) with minor adaptations (e. g., polyvinyl pyrrolidone, PVP-40, was not added to extraction buffer). The optimum concentration of coating antibody was 1 µg/ml and enzyme conjugate was used at a 1 : 5,000 dilution. A homogenate of 5th instar *P. rapae* larvae, 4 days post-infection, diluted 1 : 50 (w/w) in 0.02 M phosphate buffered saline, pH 7.4, containing 0.5 % Tween 20 and frozen in 3 ml aliquots was used as a standard positive control. Six to 8 negative controls (individual larvae reared on whole broccoli plants in the greenhouse, collected and frozen as 5th instars) were included on each plate. Sample preparation has been described in detail previously (**Webb & Shelton,** 1990). After substrate was added, plates were incubated at room temperature for 30-60 min, or until the standard positive control reached an absorbance reading of 1.00 at 405 nm (A405) as measured by a Dynatech ELISA Reader (MR580)®.

The mean absorbance of the negative controls plus 2 standard deviations (**Clark & Bar-Joseph,** 1984) was used as a cutoff point between negative and positive readings. Samples were routinely tested in 2 nonadjacent wells in each plate — absorbance values for both wells had to be above the cut-off value for the sample to be considered positive. Earlier work (**Webb,** 1988) showed that neonate larvae could be used in bioassays of larval homogenates to confirm the presence of virus in samples with absorbance values that were statistically positive but visually negative. Preliminary work also established that virus could be detected within 36 h after the insect ingested virus-contaminated leaf material when reared at 25 and 28 °C (**Webb,** 1988).

VIRUS FOR FIELD APPLICATION

Virus for field use was purified from infected larvae as described above, by differential centrifugation and treatment with 1 % SDS, but was not purified further. The concentration of OBs was estimated by comparing counts of OBs in the final suspension with counts of latex spheres of known concentration using an electron microscope (**Williams & Backus,** 1949 ; **Watson,** 1962). For both virus treatments, an aqueous suspension of virus was used at a concentration of 2.6×10^{10} OBs/liter, with 15 g/liter of skim milk powder to protect the virus from UV inactivation and 0.75 ml/liter of Agway® spreader-sticker.

ACTION THRESHOLD

Each week, from 3 July to 9 September, 12 plants were randomly chosen from the inner 6 rows in each plot and examined for *P. rapae* eggs, small (1st-3rd instar) and large (4th-5th instar) larvae, *T. ni* small and large larvae, and *P. xylostella* larvae. Counts of *P. rapae* eggs and larvae were averaged for each plot and then for the 6 blocks in each treatment ; results were used to make treatment decisions. Larvae obviously infected with granulosis virus (pale and puffy) were not included in these counts.

The action threshold of 1 small larva per plant was modified from one proposed by **Shelton** *et al.* (1982) of 0.5 cabbage looper equivalents per plant (0.5 CLE = 0.75 *P. rapae*). We did not consider eggs as a criterion for timing virus applications unless treatment had to be delayed for more than 4 days (approximately the time it takes for *P. rapae* eggs to hatch at 21 °C) after sampling. In this case eggs were considered as small larvae, even though all eggs may not have hatched. We reasoned that if treatments were applied within 4 days, larvae that hatched and survived to the next sampling period would be included in a treatment decision before causing much damage to the crop. Fourth and 5th instar larvae, on the other hand, may cause unacceptable feeding damage before succumbing to viral infection (**Tatchell** 1981), thus we did not include them in treatment decisions (i.e., it was not worthwhile to try to control them with virus). We also rounded the threshold to one because the lower threshold of **Shelton** *et al.* (1982) included large larvae on the same basis as small larvae. We used the same threshold in order to compare the virus and permethrin treatments. A CO_2-powered backpack sprayer was used to apply virus (498 liters/ha or 1.3×10^{13} OBs/ha) and permethrin.

Evaluation of treatments at harvest

We harvested 18 plants per plot during the week of 9-16 September (1 block per day) as soon as the heads matured, in order to avoid excessive damage by *T. ni* larvae which become serious pests late in the season in western New York (**Andaloro** *et al.*, 1982). Larvae of all 3 lepidopteran pests were counted on 12 of these plants and all *P. rapae* larvae were collected by plot and combined by treatment (we collected an average of fewer than 7 larvae per plot) and stored at − 20 °C to be later analyzed for GV infection using ELISA as described above. Because larval populations were so low we did not collect larvae at other times during the season.

We used several methods to compare the effectiveness of the treatments. First, we used the method of **Sears** *et al.* (1983), counting all feeding holes > 0.3 cm in diameter in the 4 innermost frame leaves (leaves loosely surrounding the head and wrapper leaves) and in the 2 outer and 2 inner wrapper leaves (the leaves that enclose the head). In addition we evaluated damage using the method of **Shelton** *et al.* (1983) for fresh market cabbage. Four categories were used in this rating system : (1) marketable No. 1 — no lepidopterous injury ; (2) marketable No. 2 — damage did not exceed (a) one 1.5-cm-diameter hole or series of holes equalling that area on the head, (b) four wrapper leaves had a total of not more than four 1.5-cm-diameter holes, or (c) presence of any insect frass or parts on head or 4 wrapper leaves ; (3) not marketable — moderate damage (more than category 2, but no damage to the head) and (4) not marketable — severe damage (i.e., damage to the head). Finally, we weighed the head and 4 wrapper leaves so that we could detect any difference in yield, the most important factor determining the value of cabbage destined for processing.

RESULTS

P. rapae populations remained low, < 0.5 per plant, until the beginning of August (fig. 1). Because of rain (a total of 4.7 cm between 30 July and 2 August, including 1 cm on 2 August) and the resulting very wet soil, we knew that we would be unable to spray plots for several days after the 2 August sampling ; therefore we included eggs in the treatment decision as small larvae. All plots (except the checks) were treated on 6 August ; we began weekly treatments of virus at this time, continuing for 4 additional treatments, the last on 2 September. The action threshold was not exceeded on any other sampling date, thus the permethrin and virus threshold plots were treated only once.

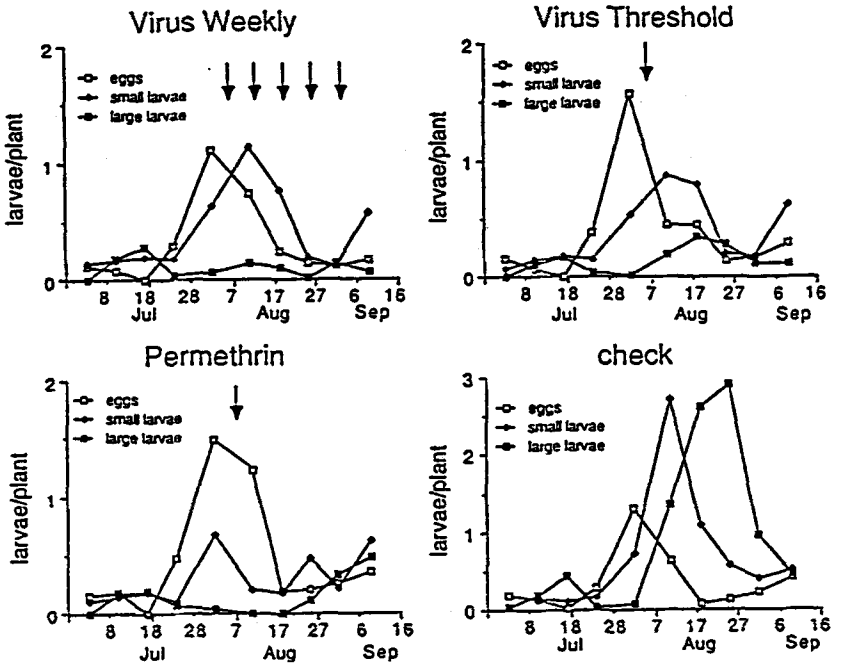

Fig. 1. Populations of *A. rapae* in treated and check plots of cabbage at Geneva, New York, 1986. Points are means of 6 replicates (counts from 12 plants per replicate). Arrows indicate treatment with either granulosis virus or permethrin.

After the initial treatment, *P. rapae* oviposition decreased, the number of eggs per plant dropping to less than 1, except in those plots treated with permethrin (1.3 per plant), but larval populations in this treatment dropped below 0.25 through most of August, increasing only at the beginning of September. In both virus-treated plots, numbers of large larvae remained below 0.35 per plant, and were lower at the end of the season (0.07 in plots treated weekly and 0.1 in plots treated once) than in either the untreated check (0.5) or the permethrin-treated plots (0.5). Numbers of large larvae in the check plots, however, before declining in early September, did increase rapidly during August, reaching levels of almost 3 larvae per plant. Numbers of small larvae in virus-treated plots decreased over the 3 week period following the initial treatment, to 0.2 per plant for both virus treatments; levels were similar in all treatments at harvest (0.6 per plant in the permethrin-treated plots, 0.5 in the check).

Cabbage looper numbers did not increase until the last sampling date (at harvest) when the numbers of small (1^{st}-3^{rd} instar) larvae per plant were as follows: check, 1.8; permethrin and weekly virus, 1.9; and threshold virus, 2.3. Numbers of diamondback moth larvae also reached almost 2 per plant at harvest (check, 1.4; weekly virus, 1.9; threshold virus, 1.7), except in the plots treated with permethrin in which numbers were significantly lower (a difference of 1.13 ± 0.31 larvae per plant, $t = -3.61$; $df = 284$; $P = 0.0004$) than the average of check and virus-treated plots (orthogonal contrast, SAS GLM procedure, **SAS Institute**, 1985).

The level of viral infection (as detected by ELISA) in *P. rapae* larvae collected at harvest was as follows : check, 77 % (n = 47) ; virus threshold, 42 % (n = 43) ; virus weekly, 50 % (n = 16) ; permethrin, 20 % (n = 55). Seven of the 11 infected larvae in the permethrin treatment were collected from 1 plot in the southwest corner of the field in which populations were much higher (1.8 per plant vs < 0.5) than in the other 5 replicates. There were no infected larvae in 3 of the 6 permethrin plots, all of which were adjacent to at least one of the plots that was treated with virus on a weekly basis.

DAMAGE RATINGS

There were large differences between check and treated plots (Fig. 2) in the number of feeding holes > 0.3 cm found in the wrapper and frame leaves. Orthogonal contrasts (generalized linear models procedure, SAS Institute 1985) were used to estimate differences among treatments. On the basis of totals for the 4 frame and 4 wrapper leaves, plants from check plots differed from the average treated plant (virus weekly, virus threshold, and permethrin) by 124 ± 6.5 holes (mean ± SE), (t = 19.06 ; df = 15 ; P = 0.0001), virus-treated plants averaged 51 ± 6.9 holes (t = − 7.39 ; df = 15 ; P = 0.0001) more than those treated with permethrin, but plants that had been treated weekly were not significantly less damaged than those treated once (t = 1.54 ; df = 15 ; P = 0.1453). If only the total damage in the 4 wrapper leaves was considered, plants from the check plots averaged 54 ± 2.18 holes (t = 24.85 ; df = 15 ; P = 0.0001) more than treated plants, virus-treated plants had 11 ± 2.3 holes (t = − 4.68 ; df = 15 ; P = 0.0003) more than the chemical check, and plants treated once had 7.6 ± 2.7 holes (t = 2.86 ; df = 15 ; P = 0.012) more than plants treated weekly.

To compare fresh market damage ratings, a « proportional odds » model was fitted (**McCullagh,** 1980) of the form $\text{logit}(\gamma_i) = \theta_i + \beta_x$ where γ_i is the probability that an individual is classified in a category ≤ i. θ_i are the cutpoints between categories, and β are the parameters describing the effect of x, the treatments. The ordinal response categories

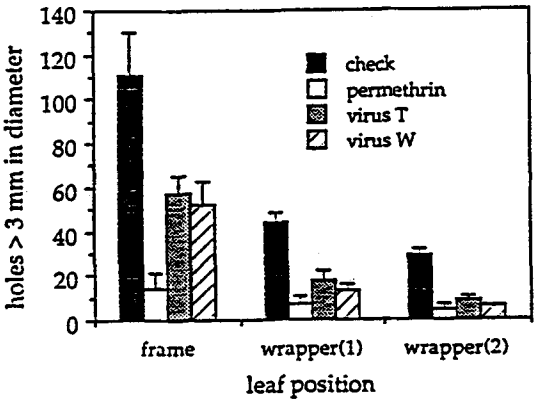

Fig. 2. Comparison of damage to cabbage among 3 treatments and an untreated check. Bars show the sum of holes counted in 4 frame leaves and 2 outer (1) and 2 inner (2) wrapper leaves (means of 6 replicates, 18 plants per replicate). Vertical bars are 95 % confidence intervals.
Treatments are : permethrin — applied at threshold ; virus T — virus applied at threshold, and ; virus W — virus applied weekly.

(damage) are assumed to represent an underlying continuous variate, observations being grouped between arbitrary (but constant for all treatments) cutpoints. Thus the model does not depend on assigning interval-type scores to categories, an advantage when comparing damage ratings that are not linearly related.

Table 1 shows the actual percentage of cabbage in each marketability category and the fitted values. The parameter estimates (β and standard errors) obtained were as follows: check, 17.6 (36.1); virus weekly, 2.850 (0.322); virus threshold, 3.879 (0.354); permethrin, 2.381 (0.305). Differences between the β values can be interpreted as follows. Consider the 2 virus treatments. The odds of a cabbage being classified in a higher class (i.e., the odds of being classified in category 3 instead of categories 1 or 2, and the odds of being classified in category 2 instead of category 1) are exp(3.87 − 2.85) = 2.8 times higher for the virus threshold treatment than for the virus weekly treatment. The permethrin and weekly virus treatments were not significantly different. For processing purposes all cabbage was marketable as only decreased yield is considered important (**Shelton & Andaloro,** 1982). Results of analysis of variance showed no significant differences in head weight among the 4 treatments (F = 1.10; df = 3.15; P = 0.38), the overall average being 2.62 ± .03 kg (mean ± SE).

TABLE 1

Observed and fitted percentages (proportional odds model) of cabbage in marketability categories 1-4 in different treatments. Geneva, 1986.

	Cabbage Marketability Categories (a)			
	1	2	3	4
Observed percentages				
Check	0	0	78	30
Weekly virus	1	61	46	0
Threshold virus	1	32	75	0
Permethrin	15	52	41	0
Fitted percentages				
Check	0.0	0.0	78.0	30.0
Weekly virus	5.9	53.3	48.8	0.0
Threshold virus	2.2	30.4	75.4	0.0
Permethrin	9.1	62.1	36.8	0.0

(a) For descriptions of categories, see text.

DISCUSSION

In the field trials reported by **Sears** *et al.* (1983) in Canada, insect pressure was much greater than in our trial, making it necessary to apply virus and Bt as often as 7 times during the growing season. In New York, with lower populations, our results with 1 timed application of virus were similar to those achieved with 5 weekly treatments. Even if we had used the same criteria for treatment as **Sears** *et al.* (1983), we would have treated only once. Clearly, thresholds are of even greater value when insect numbers only occasionally reach damaging levels.

TABLE 2

*Damage to cabbage in plots from Cambridge, Ontario (***Sears** *et al., 1983) and from Geneva, New Yor*

Location	Holes/10 leaves		
	Frame leaves	Outer wrapper	Inner wrapper
Cambridge, Ontario [a]			
Nontreated check	163	151	78
Microbial [b]	68	49	25
Permethrin	4	2	4
Geneva, New York			
Nontreated check	277	221	144
Microbial, threshold	141	89	44
Microbial, weekly	131	65	29
Permethrin	35	37	23

[a] Data are from **Sears** *et al.* (1983).
[b] One application of PrGV and 3 of PrGV and AcNPV combined.

Pest management based on microbial insecticides is particularly suitable for cabbage grown for processing. For fresh market cabbage, action thresholds for timing virus treatments need to be more conservative as much less damage can be tolerated. A small difference in feeding damage to the wrapper leaves between plants from plots treated once and plots treated weekly with virus decreased marketability.

In general, damage levels were higher than those reported by **Sears** *et al.* (1983) even when treatments had similar numbers of *P. rapae* larvae. Table 2 shows data from **Sears** *et al.* (1983) for plots that most closely matched ours in insect numbers, except that no *T. ni* were present and *P. xylostella* larvae were not counted. Bt was not used in this trial although AcNPV, effective against *P. xylostella* larvae as well as *T. ni* larvae, was included in 3 of 4 applications. Corresponding data for feeding damage in our plots are also given (calculated by dividing treatment means for 4 leaves by 4 and multiplying by 10). If we assume that the difference in damage between plots treated with permethrin is due mainly to the late season appearance of *T. ni* and *P. xylostella* larvae after the effectiveness of the single permethrin application (6 August) was lost, then subtracting this difference from the damage to the virus-treated plots gives results similar to those of **Sears** *et al.* (1983), particularly for wrapper leaves. For example, the difference between the permethrin-treated plots for outer wrapper leaves is 37 − 2 or 35. If this amount is substracted from 89, the damage to the Geneva threshold treatment, the result (54) is close to the Ontario value (49). In the same manner, if the difference between the permethrin treatments for inner wrapper leaves (19) is subtracted from the Geneva threshold value (44), the result is equal to the Ontario value of 25. The large differences in numbers of feeding holes in the check plots may reflect differences in defining a hole when large sections of leaf were missing. We counted « scallops », semicircular indentations on the margins of large missing areas. This problem was only encountered with plants that were very heavily damaged.

Both the work of **Sears** *et al.* (1983) and our study show that insect viruses need not be applied on a weekly basis in order to control lepidopterous pests of cabbage used for processing. **Jaques** (1977) also found in Canada that 1 application of PrGV at a high rate (8.9×10^{12} OBs/ha) effectively controlled *A. rapae* for the entire growing season. Proper

timing may help compensate for rapid inactivation of virus but, in addition, secondary inoculum from dying larvae may carry over sufficiently to help reduce insect numbers. *P. rapae* larvae seem to die in their normal feeding sites (**S. E. W.**, unpublished data) thus the virus would be retained on the plant where it would most likely be encountered by other larvae. Viral inoculum gradually released from disintegrating cadavers may be available longer than that applied as a partially purified suspension (**Entwistle & Adams,** 1982).

In our trial, at the time of harvest, *P. rapae* populations from plots treated over 1 month earlier with virus had levels of infection similar to those from plots treated weekly. The final level of disease in the check plots, however, was much higher than in the plots actually treated with virus. In other experiments (**Webb & Shelton,** 1990) in an adjacent field in which we monitored disease incidence for a week after treatment we did not find any infected larvae in untreated plots, suggesting that spread of disease was not due to spray drift. In the 4 years prior to this experiment we never found evidence of naturally occurring granulosis virus in the area where this research was conducted (**S. E. W.**, unpublished). It is thus likely that viral infections in untreated plots developed from secondary inoculum, perhaps spread by predators (**Boucias** *et al.*, 1987) or parasitic wasps (**Levin** *et al.*, 1979 ; **Young & Yearian,** 1990) from diseased and dying larvae in the treated plots.

Although we did not assess the incidence of virus infection earlier in the season, it is probable, because of the extensive damage to the check plots and the high numbers of larvae found, that significant numbers of larvae were not affected until late in the growing season. The high density of large larvae in the check plots (> 3 per plant in late August) may have contributed to the gradual buildup of viral infection. In the same manner, the number of infected larvae increased in 1 of the 6 plots that had been treated with permethrin, one in which numbers of larvae reached almost 2 per plant. In contrast, no infected larvae were found in 3 of 6 permethrin-treated plots that had fewer than 0.5 larvae per plant, suggesting that the final level of infection was dependent upon density.

We believe that our comparisons and conclusions are not affected by the appearance of virus late in the season in the check plots. When the action threshold was first exceeded (2 August) populations of larvae were similar in the threshold and check plots (fig. 1). Numbers in the threshold plots never increased to the levels in the check, and in the case of small larvae were lower than in the plots treated weekly. The initial application of virus seems to have been enough to sustain the epidemic at an economically useful level, perhaps because enough larvae survived the initial treatment to then function as hosts for new infections. The much later development of widespread disease in the check plots (based on plant damage and counts of larvae) was more likely the result of spread from limited foci of infection, originating from the introduction of virus at very low levels from the treated plots. While this undoubtedly happened in other treatments, the effect on damage and numbers of larvae, as in the check plots, was probably minimal.

ACKNOWLEDGEMENTS

We thank **W. T. Wilsey** and **G. Van Orman** for excellent technical support, and **J. Barnard** for statistical advice and for his analysis of marketability ratings. We also thank **A. J. Sawyer** for helpful comments on the manuscript. This research was conducted by **S. E. W.** in partial fulfillment of the requirements for the Ph. D. degree at Cornell University.

RÉSUMÉ

Simple seuil d'intervention pour fixer les applications d'un virus de la granulose pour lutter contre *Pieris rapae* [*Lep. : Pieridae*]

Pieris rapae, un important ravageur du Chou aux Etats-Unis, est sensible à un virus de la Granulose, *Pieris rapae* GV (PrGV), dont les chercheurs de plusieurs pays ont démontré l'efficacité en tant qu'agent de lutte. Nous avons testé l'efficacité d'un seuil d'intervention correspondant à une larve au 1er stade larvaire par plante en comparaison avec des applications hebdomadaires du virus. Le même seuil d'intervention et un traitement avec la perméthrine, ainsi que des applications hebdomadaires de virus ont été également évalués. Cinq applications hebdomadaires de virus furent effectuées alors que le seuil d'intervention n'a été dépassé qu'une seule fois. Dans le cas de tous les traitements impliquant le virus, le nombre de larves aux 4^{e} et 5^{e} stade ne dépassa pas 0,35 par plante. Cette valeur fut inférieure en fin de saison (0,07 pour les 5 traitements hebdomadaires, 0,1 pour le traitement unique) à celles correspondant aux parcelles non traitées et traitées à la perméthrine (0,5). Fin août, il y avait presque 3 larves aux 4^{e} et 5^{e} stade par plante dans la parcelle non traitée. A la récolte, les trous dus aux larves d'un diamètre supérieur à 0,3 cm dans les 4 feuilles internes et dans les 4 feuilles externes furent comptés. En absence de traitement les plantes présentèrent en moyenne 124,2 $\pm$ 6,5 trous de plus. Les plantes correspondant aux 2 types de traitements avec le virus présentèrent 51,1 $\pm$ 6,9 trous de plus que celles traitées avec la perméthrine. Aucune différence significative ne fut observée entre les parcelles traitées 5 fois avec le virus et celles n'ayant reçu qu'un seul traitement. Toutefois les feuilles internes étant plus endommagées (7,6 $\pm$ 2,7) dans le cas du traitement unique, la valeur marchande du produit frais correspondant fut affectée. Les différents traitements ne semblèrent pas influencer le rendement (poids).

Ces résultats démontrent l'efficacité de PrGV dans un programme de lutte intégrée contre ce ravageur du chou et l'avantage des seuils d'intervention surtout dans le cas où le nombre d'insectes ne dépasse que rarement le seuil de nuisibilité. Bien que les choux les moins affectés furent ceux traités avec la perméthrine, leur qualité marchande en tant que produit frais n'apparut pas différer de façon significative de celle des choux traités hebdomadairement. Tous les choux traités avec le virus apparurent adéquats pour la mise en boîte. En conclusion, dans le cas où l'esthétique a une certaine importance, PrGV devrait être utilisé hebdomadairement ou avec un seuil d'intervention inférieur à une larve au premier stade par plante.

MOTS CLÉS : *Pieris rapae,* lutte microbiologique, virus de la granulose, chou.

Received : 11 April 1989 ; Accepted : 10 April 1990.

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