Factors Involved in Carbaryl-Induced Population Buildups of *Myzus persicae* (Sulzer) (Homoptera: Aphididae) on Potato

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**ABSTRACT** The phenomenon of population buildups of green peach aphid (GPA), *Myzus persicae* (Sulzer), on potato following foliar applications of the insecticide carbaryl (1-naphthyl methylcarbamate) was examined in the field and laboratory. In field tests, weekly applications of carbaryl at a label rate of 1.12 kg (AI)/ha and 4× rate (4.48 kg (AI)/ha) resulted in significantly higher GPA population densities than in untreated plots, with peak densities more than ten times those in the untreated control. The greatest effect was seen after 3-4 weekly applications. In 1980, GPA population densities were similar in plots treated with carbaryl at 1.12 and 4.48 kg/ha, while in 1981 population densities were significantly higher with the 4.48 kg (AI)/ha rate. Carbaryl only slightly reduced population densities of coccinellids and delayed their population buildups by about 1 wk, while chrysopid numbers were similar in treated and untreated plots. Aphid parasitization was low (< 3%) in both carbaryl-treated and untreated potatoes. Predator counts in field and exclusion cage trials showed that GPA population density increases in carbaryl-treated potatoes were not primarily due to natural enemy reduction. In laboratory experiments, adult GPA placed on potato leaves treated with carbaryl at 500 and 1000 ppm produced significantly more nymphs/day than at 250 and 0 ppm, indicating that stimulation of reproduction is the primary factor responsible for increases in population density. Additionally, carbaryl may improve the nutritional quality of potato foliage to aphids by increasing the nitrogen content.

**KEY WORDS** *Myzus persicae*, potato, carbaryl, hormoligosis, population buildups, Homoptera, Aphididae.

The green peach aphid (GPA), *Myzus persicae* (Sulzer), is an important worldwide pest of potatoes both directly, and indirectly as a vector of several plant viruses. GPA population buildups following carbaryl applications have been reported on potato (Bauernfeind 1977), pepper (Shorey 1961, Elmore and Magor 1962) and collards (Root and Skelsey 1969). Additional aphid species which have been shown to be positively affected by carbaryl applications include *Aphis gossypii* Glover on cotton (Bartlett 1968), *Brevicoryne brassicae* (L.) on

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broccoli (Granett and Reed 1960) and collards (Root and Skelsey 1969), *Rhopalosiphum maidis* (Fitch) on corn (Randell 1970), *Lipaphis erysimi* (Kaltenbach) on turnip (Granett and Reed 1960), *Myzocallis coryli* (Goetze) on filbert (Messing et al. 1988), and *Melanocallis caryaefoliae* (Davis) and *Monelliospis pecanis* Bissell on pecan (Dutcher 1983, 1985, Dutcher and Payne 1983). Several of the studies cited above attributed aphid population increase to natural enemy destruction by carbaryl (Shorey 1961, Randell 1970, Dutcher 1983) while others (Bartlett 1968, Root and Skelsey 1969, Bauernfeind 1977, Messing et al. 1988) have suggested that other, unexplained, factors are involved.

There are examples of insect and mite population buildups following insecticide applications that cannot be attributed to natural enemy destruction. Lowery and Sears (1986a,b) reported that GPA population increase on potato following azinphosmethyl applications was due to a 20-30% increase in reproduction, caused by the direct effect of the insecticide on the insect and not from changes in host plant suitability. Gordon and McEwen (1984) also reported that azinphosmethyl stimulated GPA reproduction on potato. The above examples may be explained by the hormoligosis concept of Luckey (1968), which suggests that sublethal quantities of any stressing agent will be stimulatory to an organism by providing it with increased sensitivity to changes in the environment and increased efficiency to develop new or better systems to fit a suboptimum environment. This phenomenon is important in practical crop protection because inefficient application techniques may result in the deposition of sublethal doses of insecticides and, together with environmental factors which reduce pesticide toxicity, may lead to pest population outbreaks rather than control (Chelliah et al. 1980). Carbaryl does not appear to be a stressing agent, but conversely it stimulates reproduction.

Host plant physiological condition may also be instrumental in influencing insect population fluctuations. In addition to affecting insects directly, insecticides have also been shown to affect insects indirectly through alteration of host plant condition. Lobzhanidze (1977) reported that a single application of carbaryl resulted in increased nitrogen and monosaccharides in apple leaves, which caused an increase in fecundity and lifespan of *Tetranychus urticae* Koch and *T. viennensis* Zacher. Similarly, Chaboussow (1966) suggested that the primary reason for population increases of *T. telarius* L. on grapes following applications of carbaryl was due to increases in reducing sugars.

There is no information regarding aphid population increases as affected by insecticide-induced host plant changes, but aphids generally respond positively to increased element concentration, especially nitrogen (Rodriguez 1960). Jansson and Smilowitz (1986) found that the GPA population growth rates increased with the level of nitrogen fertilizer applied, and was positively correlated with the concentration of free amino acids in leaves. GPA fecundity is also positively correlated with levels of leaf nitrogen in brussels sprout (Van Emden and Bashford 1969) and tobacco (Wooldridge and Harrison 1968).

This study was conducted to investigate increases in GPA population densities on potato following carbaryl applications. Specifically, the experiments were designed to determine: 1) whether natural enemy destruction was a factor; 2) whether carbaryl may increase or indirectly stimulate GPA reproduction; and
3) if increased aphid reproduction was due to carbaryl-induced changes in total host plant nitrogen.

**Materials and Methods**

**Field studies.** Field experiments were conducted at the University of Wisconsin Experimental Farm at Arlington, Wisconsin. Certified potato (cv. Katahdin) seed was planted in plots which were two rows wide (0.91-m centers) by 15 m long, in a randomized complete block design with four replications. Planting dates were 15 May 1980 and 6 May 1981. Fertilizer (9-24-24) was banded at planting at a rate of 1120 kg/ha. Standard commercial practices (cultivation, herbicides, fungicides) were followed (Binning et al. 1979). A water-soluble formulation of carbaryl (Sevin® 80S; Rhone-Poulenc, Research Triangle Park, North Carolina) was used in all field and laboratory experiments. Applications were made with a backpack sprayer equipped with a hollow cone nozzle in a water volume of 936 liters/ha in 1980 and 522 liters/ha in 1981. Treatments consisted of a recommended use rate of 1.12 kg (AI)/ha, a 4X rate (4.48 kg [AI]/ha) and an untreated control. Application dates were 8, 15, 22, 29 July, 5 and 12 August in 1980; and 25 June, 1, 9, 16, 25, 31 July and 6 August in 1981. Weekly counts of GPA were made 2-3 d after each application by recording the number of aphids on 30 leaves from the lower one-third of the plant in each plot (Shands et al. 1954). Leaves showing signs of senescence (yellowing or necrosis) were not sampled. As GPA numbers became very high (> 50 aphids/leaf) in 1981 the sample size was reduced to 15 leaves per plot.

The effect of carbaryl on GPA natural enemies was determined by recording the number of parasitized GPA found in leaf counts. Aphid mummies were held at 25°C for adult parasite emergence and identification. Percent parasitized (number parasitized/total aphids X 100) for each sample date and a season average percent parasitization was determined. Adult parasites were sent to the USDA Insect Identification and Beneficial Insect Introduction Institute at Beltsville, Maryland, for identification. Sweep net sampling (25 sweeps with a 38-cm diam sweep net across the two rows in each plot) was used to record predator numbers. The number of adult and immature predators were recorded separately but were combined for analyses. Predators sampled were ladybird beetles (Coleoptera: Coccinellidae), green lacewings (Neuroptera: Chrysopidae) and syrphid flies (Diptera: Syrphidae).

**Field cage studies.** An exclusion cage study was conducted in 1981 to examine the effect of carbaryl applications on GPA in the absence of predators and parasites. Cages consisted of a wooden frame (75 by 90 by 70 cm) with a removable top covered with 40-mesh Lumite® screen (Chicopee Company, Gainesville, Georgia) to exclude predators and parasites. The bottoms of cages were surrounded with a 20-cm band of aluminum flashing which was sunk into the ground. Each cage was placed over a single potato (cv. Katahdin) plant approximately 1 wk after plant emergence. One month after emergence, approximately 50 g of fertilizer (6-24-24) was evenly distributed around each plant. One pitfall trap was placed in each cage to trap predacious ground beetles. Four applications of carbaryl at 1.12 kg (AI)/ha applied at 936 liters/ha were made at 7-d intervals by spraying the plants directly through the screening.
Untreated control cages received no applications. Five single-cage replicates were arranged randomly with 3 m of bare ground separating cages on all sides. Five adult apterous GPA from a laboratory colony (reared on turnips [cv. Purple-Top White Globe] at 24 ± 2°C under constant fluorescent lighting, to prevent alate production) were placed on each of five middle leaves per plant 1 d after the first carbaryl application. GPA populations were monitored by recording the numbers of aphids found on six lower leaves per plant per sample date.

A separate study was conducted to determine the effect of carbaryl applications on total nitrogen in treated plants. Carbaryl at 1.12 kg (Al)/ha in a water volume of 936 liters/ha was applied five times at 7-d intervals to potatoes (cv. Atlantic) in plots measuring two rows (0.91-m spacing) by 8 m long with two replications and compared with untreated control. Total nitrogen was determined for middle and lower leaves (plants divided at five-node intervals from the lowermost node) at early maturity by the micro-Kjeldahl method (McKenzie and Wallace 1954).

Laboratory studies. Laboratory studies were originally conducted at the University of Wisconsin-Madison at the same time as field studies and then repeated and expanded upon later in 1989 and 1990. The 1989 and 1990 studies were conducted at CIBA-GEIGY Ltd. in Basel, Switzerland. A laboratory colony of GPA was maintained on excised leaves of potato cv. Bintje, a common fresh market cultivar in Switzerland, at 24°C with a 16:8 L:D photoperiod. To determine if carbaryl directly influenced GPA fecundity, aphids were placed on excised potato leaves (cv. Bintje), treated with differential concentrations of carbaryl, and the numbers of nymphs produced were recorded. Potato leaves were placed in plexiglass cages measuring 120 by 80 by 30 mm with four ventilation holes (diam = 15 mm) covered with 16-mesh copper screening. The bottoms of rearing cages were equipped with a hole (15 mm diam) to allow the leaf stem to rest in a shallow tray of distilled water. Individual leaves were dipped in carbaryl solutions (in distilled water + Extrawon® [a wetting agent] at 0.05% v:v) at 250, 500 and 1000 ppm, air-dried at room temperature, placed individually in plexiglass rearing cages, and then one apterous GPA (pre-reproductive adult) placed on each leaf. Untreated (0 ppm) leaves were dipped in distilled water + Extrawon® only. Leaves were held at 25 ± 1°C under a 16:8 L:D photoperiod and the number of nymphs produced per day over a 5-d period recorded (leaves were not changed during the 5-d period). For each carbaryl dose, there were four replications of 15 aphids each (n = 60).

A laboratory experiment was conducted to determine the effects of carbaryl on total nitrogen in treated leaves. Potato (cv. Bintje) seed pieces were planted in plastic pots (10 cm diam by 7 cm high) containing a mixture of loamy soil, sand and peat (2:1:1) and grown in a greenhouse at 20 ± 1°C, 60-70% relative humidity, under a 14:10 L:D photoperiod. Plants (six/treatment) were sprayed with carbaryl solutions at 250, 500 and 1000 ppm in distilled water in a water volume of 500 liters/ha at 2, 3, 4 and 5 wk after plant emergence. Untreated plants (0 ppm) were sprayed with distilled water only. All plants received 50 ml of nutrient solution (Greenzit® - 2.0 ml in 1 liter of distilled water) at 1, 2, 4 and 5 wk after emergence. At 6 wk, the lower leaves (from the fourth node down) were harvested for total nitrogen contents using the combustion technique (Sweeney and Rexroad 1987).
Data analyses. Analysis of variance (ANOVA) procedures were performed on insect count data and treatment means separated by LSD at $P < 0.05$ (Steel and Torrie 1980). In total nitrogen tests, ANOVA was performed on data transformed to square root of $(x + 0.5)$, and means separated by $t$-test at $P < 0.01$ (Steel and Torrie 1980).

Results

Field tests. In 1980, aphid population densities in carbaryl treatments did not differ significantly from those in untreated plots throughout July (Fig. 1). Population densities in the untreated plots peaked on 25 July and declined thereafter, while peak densities in both carbaryl treatments occurred 1 wk later, at which time population densities were approximately 25 times higher in carbaryl treatments compared with the control. Numbers declined after 1 August due to heavy rains and a fungal epizootic by the entomopathogen, Conidiobolus thrombiodes Drechsler (Fungi Imperfecti: Entomophthorales) (identified by R. S. Soper, USDA-ARS, Boyce Thompson Institute, Cornell University, Ithaca, New York). There were no significant differences in aphid numbers between the two rates of carbaryl on any count date.

Fig. 1. Influence of carbaryl on green peach aphid population densities on potato (cv. Katahdin), 1980. Arrows indicate date of carbaryl application. Different letters on the same date indicate significant differences among treatments by LSD ($P < 0.05$).
In 1981, GPA population densities in carbaryl-treated plots were much higher than in 1980, while densities in the control were similar to the previous year (Fig. 2). In early July, after three carbaryl applications, aphid population densities increased rapidly in both carbaryl treatments, with a peak in the 4.48 kg (Al)/ha treatment occurring on 19 July (after four applications) and in the 1.12 kg (Al)/ha treatment 1 wk later, after five applications. Peak numbers in the control occurred on 12 July. Populations in the 4.48 kg (Al)/ha treatment were significantly larger than in the 1.12 kg (Al)/ha treatment on two count dates and the untreated on five count dates; densities in the 1.12 kg (Al)/ha treatment were significantly higher than in the untreated on three count dates. As in 1980, aphid population densities in both carbaryl treatments decreased drastically after attaining peak densities, due to a fungal epizootic by Conidiobolus thromboides.

In 1980, few coccinellids were found in either carbaryl treatment throughout July, while in the untreated plot they began to appear by 18 July (Fig. 3). The most common species was Hippodamia convergens Guerin-Meneville (Coleoptera: Coccinellidae) while the only other species found with any frequency was Coleomegilla maculata (De Geer). Coccinellids attained their highest numbers in all plots on 1 August: 3.75 per 25 sweeps in the untreated

![Graph showing influence of carbaryl on green peach aphid population densities on potato (cv. Katahdin), 1981. Arrows indicate date of carbaryl application. Different letters on the same date indicate significant differences among treatments by LSD (P < 0.05).](image-url)
versus 1.0 and 0.75 per 25 sweeps in the 1.12 and 4.48 kg (Al)/ha carbaryl treatments, respectively. The largest numbers of coccinellids were found in August as aphid population densities declined. The seasonal population trend for the other common predator encountered, the common green lacewing, *Chrysopa carnea* Stephens (Neuroptera: Chrysopidae), was similar to that of the coccinellids, with few found throughout July when aphid population densities started to increase in all plots, and the largest numbers found as aphid populations declined. Larger numbers of green lacewings were found in the 1.12 kg (Al)/ha carbaryl treatment compared with the control on all count dates, except 18 July. In addition, lacewing population densities in the 4.48 kg (Al)/ha carbaryl treatment were lower compared with the 1.12 kg (Al)/ha rate or the untreated control. Very few syrphid larvae were found at any time in any plot so their numbers were not included in Fig. 3.

In 1981, coccinellids were found consistently throughout the season in all treatments, although in lower numbers compared with 1980, with the largest numbers found as aphid population densities peaked and then declined (Fig. 4). As in 1980, the most common species was *H. convergens*. The chrysopid *Chrysopa carnea* was most numerous after mid-July, with the largest numbers occurring on 19 July, when aphid population densities peaked. On that date, the largest number was found in the 4.48 kg (Al)/ha carbaryl treatment, with 7.0 per
25 sweeps, versus 3.75 and 2.75 per 25 sweeps in the 1.12 kg (AI)/ha carbaryl treatment and untreated, respectively. As in 1980, syrphid larvae were rarely found, thus their numbers were not included in Fig. 4.

In 1980, no parasitized GPA were encountered until the third count date (25 July), at which time aphid population densities were at their highest levels in the untreated control and increasing in the carbaryl treatments. The season average percent parasitization was highest in the untreated (2.7%), followed by carbaryl at 1.12 kg (AI)/ha (2.0%) and 4.48 kg (AI)/ha (0.75%). The most common parasite found was *Aphidius nigripes* Ashmead (Hymenoptera: Aphidiidae). In 1981, numbers of parasitized aphids in the untreated control were much lower than in 1980. The largest populations were detected in the carbaryl treatments in mid-July when aphid population densities were extremely high, and thus, resulting percent parasitization very low. The scarcity of parasites was reflected in the low seasonal percent parasitization; 0.51% in the untreated and 0.05% in both carbaryl treatments. As in 1980, *Aphidius nigripes* was the most common parasite found. Other parasites encountered in both years were *Praon occidentale* Baker and *Asaphes lucens* (Provencher). Several hyperparasitic *Dendrocerus* spp. were recovered from parasitized aphids.

![Graph](image_url)

**Fig. 4.** Effects of carbaryl on coccinellid and chrysopid predators of green peach aphids in field plots, 1981.
In the exclusion cage experiment, the first aphid counts were made on 24 July, after the third carbaryl application and 17 d after aphid introduction. At this time aphid population densities on carbaryl-treated plants were more than three times greater than those on untreated plants (Fig. 5). The sharp decline thereafter was due to a fungal epizootic by Conidiobolus thrombiodes, as occurred in other field experiments. No predacious ground beetles were found in the pitfall traps.

In the field experiment to determine the effect of carbaryl on total nitrogen in potato (cv. Atlantic) foliage, samples were taken after the fifth application (at early maturity). In middle leaves, a 17% increase in total nitrogen occurred in carbaryl-treated plants (4.15% total nitrogen versus 3.55% in untreated plants), while in lower leaves an increase of 11.0% occurred with carbaryl treatment (3.13% total nitrogen versus 2.82% in the untreated).

Laboratory studies. In the laboratory study to determine if carbaryl influenced GPA fecundity directly by exposure to residues, aphids exposed to 500 and 1000 ppm carbaryl produced significantly more nymphs per day over a 5-d period than those exposed to 250 and 0 ppm (Table 1). The number of nymphs produced at 250 and 0 ppm was similar. With a label rate of 1.12-2.24 kg (AI)/ha (Rhone-Poulenc 1990) applied in a typical ground application water volume of 468-935 liters/ha, a spray solution of 1200-4800 ppm occurs.

In laboratory tests conducted to examine the effects of carbaryl on total nitrogen, 500 ppm carbaryl resulted in significantly higher total nitrogen in...
Table 1. Effect of carbaryl on percent total nitrogen content in lower leaves and average numbers of nymphs produced/day over a 5-d period by green peach aphids on carbaryl-treated potato (cv. Bintje) leaves in laboratory tests, 1989-1990.a

<table>
<thead>
<tr>
<th>Carbaryl rate (ppm)</th>
<th>Mean percent total N (± SEM)b</th>
<th>Mean number nymphs/day (± SEM)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.88 (0.07) a</td>
<td>4.63 (0.52) a</td>
</tr>
<tr>
<td>250</td>
<td>3.70 (0.13) a</td>
<td>4.11 (0.39) a</td>
</tr>
<tr>
<td>500</td>
<td>4.31 (0.09) b</td>
<td>5.68 (0.28) b</td>
</tr>
<tr>
<td>1000</td>
<td>3.83 (0.28) a</td>
<td>5.50 (0.31) b</td>
</tr>
</tbody>
</table>

a Total nitrogen determination by combustion technique (Sweeney and Rexroad 1987).
b Means in column followed by the same letter do not differ significantly by LSD (P > 0.05).

lower levels of potato (cv. Bintje) than at either 250 or 1000 ppm, which were similar to the 0 ppm treatment (Table 1).

Discussion

In both years of the field experiments, carbaryl applications resulted in significantly larger GPA populations than in untreated plots, with effects most notable after three or four weekly applications, producing peak aphid population densities that were more than ten times greater than those in untreated plots. In 1980 both rates of carbaryl resulted in similar aphid numbers, while in 1981 the high rate (4.48 kg [AI]/ha) resulted in significantly higher numbers. In all carbaryl plots in both years, as aphid populations attained their highest densities, fungal epizootics occurred that resulted in rapid population declines. Although additional carbaryl applications were made during the epizootics, aphid populations did not resurge. Such drastic effects of fungal epizootics were not seen in untreated plots, probably due to lower aphid densities, which may be unfavorable for epizootics by entomopathogenic fungi (Hughes 1963, Hodek et al. 1965).

In general, the largest numbers of coccinellids and chrysopids were found as aphid populations declined, both in carbaryl-treated and untreated plots. In a study of the impact of predators on GPA populations on sugarbeets, Tamaki and Weeks (1973) reported that coccinellid predators were more numerous after aphid populations peaked and started to decline. Hagen and Van den Bosch (1968) also reported that natural enemy action became important and significant only when aphid populations had been declining for some time. In the present study, carbaryl only slightly delayed and reduced the seasonal population trends of coccinellids, while on the other hand, chrysopid numbers were similar in both treated and untreated plots.
Parasites appeared to have had little or no influence on GPA populations. Season percent parasitization in untreated plots was very low (2.7% in 1980 and 0.5% in 1981). In both years carbaryl treatment resulted in lower seasonal percent parasitization than in the untreated. In a 12-yr study by Shands et al. (1965), the average seasonal rate of parasitization of *Myzus persicae* on potatoes was 0.14%, with a high of 0.63%. The most common parasite in that study was *Aphidius nigripes*, which was also most common in our study. Shands et al. (1965) concluded that parasites had no appreciable adverse effect on aphid populations on potatoes, which the present data supports. Additionally, parasite larvae are protected from insecticides by the mummified shell of the aphid host (Godfrey and Root 1968, Shean and Cranshaw 1991). Thus, carbaryl, with relatively short residual activity, would affect only adult parasites that came into contact with residues.

Increases in population density due to carbaryl were less in exclusion cage studies (> 3X control) compared to field studies (> 10X control). While this suggests that predator reductions have some role in population increases, the exclusion cage experiment supported the field trial results that carbaryl applications clearly resulted in large GPA population buildups on potatoes. This further supports the hypothesis that natural enemy reduction is not the primary cause of aphid increases in carbaryl-treated plots.

Laboratory experiments clearly demonstrated that carbaryl directly stimulated reproduction in GPA’s, with the maximum effect occurring at 500 ppm in these experiments. Given the label rate for carbaryl on potato of 1.12-2.24 kg (AI)/ha (Rhone-Poulenc 1990), if applied in a typical ground application water volume of 468-935 liters/ha, which would result in a spray solution of 1200-4800 ppm, it is likely that aphids would encounter spray deposits of > 500 ppm, even on lower leaves. The use of lower water volumes would result in higher spray deposits. This stimulatory effect of carbaryl on GPA’s is consistent with the hormoligosis concept of Luckey (1968). Bartlett (1968) stated that carbaryl tends to promote aphid and mite populations in most countries where it is applied, regardless of the species involved or the host plant. The present study indicates that hormoligosis may be the driving factor.

In the 1980 field tests there were no significant differences between carbaryl at 1.12 kg (AI)/ha and 4.48 kg (AI)/ha, whereas in 1981 aphid numbers in the 4.48 kg (AI)/ha plots were significantly higher on two count dates. Based on the results of the laboratory experiments in which the degree of stimulation was similar at 500 and 1000 ppm, it could be concluded that the 4X rate would not result in four times the stimulation and, thus, the results at 4.48 kg (AI)/ha seen in 1981 are inexplicable. Southwood (1975) stated that relatively modest changes in both birth rate and survival rates, or in generation time, lead to changes in the rate of population increase. Carbaryl caused a significant change in birth rate in this study, however, generation time and survival rates were not examined.

The effects of carbaryl on nitrogen content of potato leaves were less conclusive. A complicating factor in the present study was that different cultivars and fertilization schedules were used in the field and laboratory tests. In a non-replicated field test there was an increase of 11% in total nitrogen in lower leaves of carbaryl-treated plants versus untreated. In the replicated
laboratory experiment, a significant increase (11%) in total nitrogen in lower leaves of potato occurred only at 500 ppm while the amounts at 250 and 1000 ppm were not significantly different from the untreated leaves (0 ppm). Green peach aphid population growth has been shown to increase with the level of nitrogen fertilizer applied and is positively correlated with the concentration of free amino acids in leaves (Jansson and Smilowitz 1986). White (1984) states that any agent which disturbs the nitrogen metabolism of a plant or plant part will favor increased survival and abundance of herbivores feeding on those tissues. Thus, even small changes in nitrogen content of potato leaves, as occurred with carbaryl, may play a role in GPA population buildups on potatoes following carbaryl applications, however, further research is needed to examine the interaction between carbaryl application, fertilization, and the resultant effect on plant nitrogen content.

In summary, large GPA population buildups on potatoes following repeated carbaryl applications was clearly demonstrated. The results of the exclusion cage and laboratory experiments indicate that the major factor driving this phenomenon is the direct stimulation of reproduction by carbaryl, which is consistent with the hormoligosis concept of Luckey (1968). Reduction of natural enemies appears to be of minor importance in this agroecosystem. Increased total nitrogen content due to carbaryl application may provide a more suitable host plant condition for GPA’s. Additional research on the effect of carbaryl on host plant condition, such as partitioning of nitrogen within plants (i.e. soluble protein and free amino acid concentration), changes in free amino acid composition and effects of carbaryl on defensive chemicals within potatoes will be required to fully elucidate this phenomenon.

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References Cited


