Cranshaw

1988

ANNUAL PROJECT REPORT

Prepared for
San Luis Valley Research Center Advisory Committee

TITLE: Potato Insect Pest Management Studies

PROJECT JUSTIFICATION: Primary emphasis has been to develop information related to the spread of potato leafroll virus by aphid vectors. Basic studies have involved investigation of overwintering aphid habits and monitoring of aphid movements, particularly as it relates to the time when disease spread occurs by winged aphids. This information has been used to better target overwintering aphids for control, to improve aphid monitoring systems, and to determine optimal timing of insecticide treatments for controlling aphid-vectored virus disease in potatoes.

Impacts of cultural practices on the colonization of potatoes by aphids have been ongoing, to assist in the development of cultural controls of aphid vectored potato diseases. These include investigations of how crop spacing, use of fungicides, and crop background manipulations affect aphid landing on the crop.

Ongoing also have been attempts to evaluate aphid chemical control treatments. This has been done to identify superior treatments, to assist development of new products that may be of benefit to San Luis Valley potato growers, and to develop alternative treatments in anticipation of insecticide use changes resulting from registration restrictions or insecticide resistance.

The potato psyllid has also been a subject of project studies, although not supported by San Luis Valley grower funding. Evaluation of chemical controls, improvement of detection capabilities, and investigation of host plant resistance are primary areas of interest.

PROJECT STATUS: Some financial support from the San Luis Valley potato growers has assisted this project for the past four years. Although the need for various insect management studies is ongoing, considerable progress has been made in this time. The following research areas are proposed as greatest need at present:

Determination of the time of leafroll spread into crops by winged aphids;

Determination of the time of leafroll spread, within crops, among the different potato cultivars commonly grown in the San Luis Valley;

Determination of the role that potato aphid, and other aphids such as the hop aphid, may have in potato leafroll spread;

Development of monitoring systems to identify insecticide resistance development in green peach aphid;

Development of alternative insecticide controls for aphids.

SIGNIFICANT ACCOMPLISHMENTS, 1987

The bulk of the requested 1987 funding went to the purchase, establishment, and maintenance of an aphid suction trap. This was done in conjunction (at project cost) with Bob Hammon, employed by Agro-Engineering during the season. Similar suction traps are widely employed in potato production areas of Europe and the northwestern U.S.

Comparison of the suction trap to the standard yellow pan trap **did not** indicate any significant improvement in potato-infesting aphid sampling efficiency. The trap did have apparent advantages for detection of aphids that are not strongly attracted to yellow, such as the grain aphids. A continuation of this trap evaluation is planned for 1988, in conjunction with the San Luis Valley Russian wheat aphid project. However, based on the 1987 research, substitution of the suction trap for the existing system of yellow pan traps is not recommended for potato aphid sampling.

Two insecticide field trial evaluations, at Center and Ft. Collins, were initially established. However, reports of erratic efficacy against potato psyllid prompted two additional studies. In these latter studies, a delay of 2-3 days following treatment was observed in the time required to reduce psyllid numbers on plants, similar to reported field observations. Insecticide studies are attached.

Late season reports also indicated problems with poor performance of Asana/Pydrin on green peach aphid. This was not evident in the Center field trial. However, aphids were collected from treated grower fields and were compared for insecticide susceptibility to aphids collected from untreated caged plots off-station. Insecticide susceptibility was evaluated using standard insecticide treated vial test techniques. Time and resources were too limited to conduct a large enough test for statistical validation. However, the trend was that the caged aphids were more susceptible to Pydrin (fenvalerate) than were the aphids collected from grower fields, indicating possible resistance development. However, all San Luis Valley aphids appeared to be more susceptible to fenvalerate than a strain of Minnesota green peach aphid.

The response of five potato cultivars to potato psyllid injury was assessed. All five cultivars sustained serious yield losses. However, yield loss was not related to numbers of psyllids on the plants. For example, TC 582-1 was extremely susceptible to psyllid injury but was not among the cultivars that had the most psyllids on the plants. Conversely, WC 230-14 had large numbers of psyllids on the plants but sustained the least injury. This indicates that susceptibility to psyllid injury can be more related to the tolerance of the plant to the psyllid toxin than to the suitability of the cultivar to the insect.

OBJECTIVES FOR 1988

Because of competing demands and diminished resources, a reduced program in the San Luis Valley in 1988 is anticipated. Insecticide efficacy evaluations will be continued off-station. Evaluation of suction traps will be continued, in cooperation with the San Luis Valley entomologist assigned to the Russian wheat aphid project. A continuation study of psyllid susceptibility among different cultivars is planned. Grower funding assistance will not be requested.

FUNDING REQUEST FOR 1988

None

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POTATO: Solanum tuberosum 'Russet Burbank'

Green peach aphid: Myzus persicae (Sulzer)
Potato psyllid: Paratrioza cockerelli (Sulc)
A leafhopper: Empoasca abrupta Delong

POTATO INSECT CONTROL WITH SOIL SYSTEMIC INSECTICIDES, LARIMER COUNTY, CO, 1987: 'Russet Burbank' potatoes were planted May 15 at the Colorado State University Department of Horticulture Research Farm north of Ft. Collins, CO. Plots were 3-row, 28-ft in length, at 34-in row spacing. Experimental design involved a randomized complete block with 4 replications. Planting time treatments were hand applied over the seed price and lightly incorporated immediately after planting. Sidedressed Temik was applied Jun 8. Evaluations of insect populations were made by examining middle and lower 35-leaves per plot.

Temik gave superior, season-long control of green peach aphid in both planting-time and sidedress applications. Aphid control with Thimet was effective through mid-summer but aphid control declined in late season. Thimet gave excellent control of potato psyllid and leafhoppers.

Treatment and lb (AI/acre		Application date	Insects/140 leaves Jul 7	Jul 27	Aug 10	Aug 27
		Green peach aphid				
Temik 15 G	3.0	May 15	0	0	0	3
Temik 15 G	3.0	Jun 8	0	0	0	2
Thimet 20 G	3.0	May 15	0	0	25	66
Untreated control			5	15	31	127
		Potato psyllid				
Temik 15 G	3.0	May 15	0	7	18	20
Temik 15 G	3.0	Jun 8	0	2	7	12
Thimet 20 G	3.0	May 15	0	0	1	3
Untreated control			1	22	64	38
		Leafhoppers				
Temik 15 G	3.0	May 15	0	1	5	22
Temik 15 G	3.0	Jun 8	0	1	4	19
Thimet 20 G	3.0	May 15	0	0	0	3
Untreated control			0	5	28	48

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POTATO: Solanum tuberosum 'Russet Burbank'

Potato psyllid: Paratrioza cockerelli (Sulc)
Green peach aphid: Myzus persicae (Sulzer)

CONTROL OF POTATO INSECTS WITH FOLIAR INSECTICIDES, LARIMER COUNTY, COLORADO, 1987. 'Russet Burbank' potatoes, planted May 19 at the Colorado State University Department of Horticulture Field Research Station north of Ft. Collins, Colorado were used in the study. Plots were single-row, 30-ft in length, at 34-in row spacing surrounded by untreated borders. Plot design was a rondomized complete block with four replications. Treatments were applied Jul 25 and August 14 using a CO_2 compressed air sprayer delivering 68 gal water/A. Plots were evaluated by randomly selecting 35 leaves/plot.

All of the treatments effectively controlled potato psyllid although some delay in these effects appeared during the first evaluation, five days after treatment. Following the second application, Baythroid caused a temporary increase in aphid populations. None of the treatments were phytotoxic.

		Insects/140 leaves*							
		Potato psyllid				Green peach aphid			
Insecticide and Rate	(lbs. AI)/A	Jul 30	Aug 13	Aug 21	Aug 25	Jul 30	Aug 13	Aug 21	Aug 25
Asana 1.9E	0.025	8a	1a	0a	0a	1a	2a	21a	9a
Pydrin 2.4E	0.1	4a	6a	7a	0a	2a	1a	24a	6a
Baythroid 2.4E	0.04	7a	2a	4a	0a	1a	7ab	92b	19a
Untreated check		11a	30b	72b	44b	1a	20ab	33a	8a

* Treatments applied Jul 25, Aug 14. Numbers not followed by the same letter are significantly different (P=0.05) by Duncan's MRT.

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POTATO: *Solanum tuberosum* 'Russet Burbank'

Potato psyllid: *Paratrioza cockerelli* (Sulc)

Green peach aphid: *Myzus persicae* (Sulzer)

Potato aphid: *Macrosiphum euphorbiae* (Harris)

A leafhopper: *Empoasca* sp.

CONTROL OF POTATO INSECTS WITH VARYING PERMETHRIN RATES, LARIMER COUNTY, CO, 1987. Plots were located at the Colorado State University Department of Horticulture Field Research Station north of Fort Collins, CO. 'Russet Burbank' potatoes planted May 19 at 34-in row spacing were used in the study. Plots were 2-row, 30-ft in length, surrounded by untreated rows. Experimental design was a randomized complete block with four replications. Treatments were applied Sep 1 using a CO_2 compressed air sprayer delivering 33 gal water/A. Evaluations were made by randomly selecting 35 middle and lower leaves per plot.

Preliminary evaluation two days after treatment indicated a poor level of insect control. However, during second evaluations a week later all treatments appeared to give acceptable psyllid and leafhopper control. Aphid control was more erratic although high-end rates acceptably suppressed both green peach aphid and potato aphid. None of the treatments were phytotoxic.

nsecticide and rate (A.I.)/A		Insects/140 leaves*						
		Potato psyllid		Green peach aphid		Potato aphid	Empoasca	
		Sep 3	Sep 10	Sep 3	Sep 10	Sep 10	Sep 3	Sep 1
ounce 3.2E	0.05	51a	4a	18a	4a	11a	4a	1a
ounce 3.2E	0.1	37a	4a	15a	18ab	5a	5a	0a
ounce 3.2E	0.2	34a	1a	30a	3a	1a	0a	0a
ntreated check		59a	45b	25a	31b	69b	7a	25

*Treatment date Sep 1. Total of 4 replications. Numbers followed by same letter not significantly different (P=0.05) by DMRT.

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POTATO: Solanum tuberosum 'Russet Burbank'

Green peach aphid: Myzus persicae (Sulzer)
Potato psyllid: Paratrioza cockerelli (Sulc)

POTATO INSECT CONTROL, CENTER, CO, 1986: 'Russet Burbank' potatoes were planted May 8 in a furrow-irrigated plot 1/2-mile east of the San Luis Valley Experiment Station, Center, CO. Plots were 4-row, 25-ft in length at a 34-in row spacing. Experimental design was a randomized complete block with 4 replications. Temik was applied as a sidedress treatment Jun 5, lightly incorporated. Foliar applications were made Jul 6, when aphids were first detected, and Aug 9 using a CO_2 compressed-air sprayer delivering 48 gal/A. Evaluations were made by examining 35 middle and lower leaves per plot.

Insect populations were highly variable across plot, preventing significance in statistical analysis. All of the synthetic pyrethroids, Monitor, and Temik appeared to give highly effective green peach aphid control. Parathion was ineffective against aphids. All treatments, except Temik, gave acceptable control of potato psyllid. Yields were not taken but Asana and untreated control plots were dug to examine tubers for growth irregularities. Growth of Asana treated tubers was normal; untreated potatoes showed substantial psyllid-related injuries.

	Insects/140 leaves			
Treatment and lb (AI)/acre	Jul 15	Jul 22	Aug 12	Aug 19
	Green peach aphid			
Temik 15G 2.0 (sidedress)	1	0	2	4
Asana 1.9E 0.025	0	0	0	1
Pydrin 2.4E 0.1	0	0	0	2
Capture 2E 0.04	0	0	0	2
Capture 2E 0.08	0	0	0	0
Parathion 8E 0.5	0	2	102	139
Monitor 4WM 0.75	0	0	0	0
DiSyston 8E 0.75	3	1	6	18
Cygon 400 0.375	0	2	11	19
Untreated control	0	8	95	67
	Potato psyllid			
Temik 15G 2.0 (sidedress)	1	2	41	17
Asana 1.9E 0.025	1	0	0	0
Pydrin 2.4E 0.1	0	0	0	0
Capture 2E 0.04	0	0	0	0
Capture 2E 0.08	0	0	0	0
Parathion 8E 0.5	1	0	16	0
Monitor 4WM 0.75	0	0	0	0
DiSyston 8E 0.75	2	0	0	0
Cygon 400 0.375	0	0	8	0
Untreated control	0	0	98	17

EFFECTS OF POTATO PSYLLID INJURY TO DIFFERENT POTATO CULTIVARS

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Abstract

The response of 5 potato cultivars to potato psyllid (Paratrioza cockerelli) infestation and injury was examined. A two-fold range in the insect populations on plants existed during the trial with Sangre being the least preferred cultivar to the insect. Yield reductions from psyllid injury among cultivars were not related to the intensity of infestations. In particular, WC 230-14 supported highest insect populations but showed the least response to psyllid control, indicating a high level of tolerance to psyllid injuries. Conversely, TC 582-1 was highly susceptible to the effects of psyllid toxin. Treatment thresholds developed for potato psyllid will have to reflect cultivar susceptibility to injury and to vary with cultivar.

Introduction

The potato/tomato psyllid (Paratrioza cockerelli) is a sporadic but potentially devastating insect pest of potatoes in the Southwest and southern Rocky Mountain potato growing regions of the United States. Damage is induced by injection of a toxic saliva during feeding ( )that can profoundly disrupt the normal growth of affect potatoes. Foliar symptoms have been termed "psyllid yellows" because of the associated color changes ( ). Normal tuber development can also be greatly affected by potato psyllid damage resulting in sharply reduced yields and quality defects, including premature sprouting.

A number of factors have been associated with intensity of psyllid injury including intensity and timing of the infestation ( ), plant vigor ( ), and environmental conditions ( ). Arslan et al. (1) also made observations regarding cultivar differences in response to psyllid injury. Casual observations in Colorado have indicated that cultivar responses to psyllid injury may range substantially and that at least one cultivar, WC 230-14 has appeared resistant to injury in an infested winter test plot of seed potatoes (Ken Knutson, Colorado State University, personal communication). Studies were initiated to further identify the range in psyllid resistance among potato cultivars.

Methods and Materials

Plots were located at the Colorado State University Department of Horticulture Field Research Farm just north of Ft. Collins, CO. Plantings were made June 8, 1987. Plantings were made about one month later than normal to increase the severity of potato psyllid infestation, which typically occurs later in the season but then declines on more mature plants. Individual plots consisted of 6 plants, spaced at 30-cm, in a single row. Plots of individual varieties were arranged in a split block design so that each plot was replicated in pairs with a 1.5-m in-row separation spacing. Within each replication, one plot of each cultivar was treated with the insecticide esfenvalerate (Asana 1.9E) to achieve psyllid control. The paired plot was not treated with insecticide and natural populations of the insects readily colonized these plots. Experimental design involved a randomized complete block with 6 replications.

Whole plant counts, involving a 6-minute survey of a plot, were made on 3 dates to measure psyllid populations. This survey allowed a thorough survey of insect infestations present on plants. Vines were allowed to die naturally from freezing temperatures and were harvested October 20.

Results and Discussion

Psyllid populations were observed to remain low through July, increasing during August so that peak populations coincided with the peak bloom of most varieties (Table 1). Esfenvalerate effected a high level of control through most of the season on treated plots. All cultivars were infested with psyllid, with approximately a 2-fold range in the total populations found on the most infested cultivar (WC 230-14) and the least infested cultivar (Russet Burbank). Seasonal changes in susceptibility were indicated, particularly with Sangre which showed sharply reduced late season susceptibility to infestation. Seasonal changes in psyllid suitability have also been demonstrated with tomato (author, unpublished).

The response of the cultivars to psyllid injury varied widely and was not correlated to seasonal psyllid infestation levels (Table 2). WC 230-14 showed the least response to psyllid control although it supported the highest psyllid populations. Greatest psyllid injury effects were observed on TC 582-1 which supported the lowest psyllid populations during the peak period of infestation (August 21).

These data show that a substantial range in susceptibility to potato psyllid injury exists among currently grown cultivars. The nature of this susceptibility is not due to effects on psyllid infestation levels but rather due to plant response to psyllid toxin. This will have to be reflected in economic threshold decision-making for this insect since cultivars appear to be at higher (e.g., TC 582-1) or lower (e.g., WC 230-14) risk of being injured by the insect.

The relative immunity of WC 230-14 to potato psyllid injury and the relative immunity of Centennial to potato psyllid infestation and injury are encouraging as potential sources of psyllid resistance that could be included in breeding programs where psyllid control is desirable. It also demonstrates another unusual pest response from WC 230-14 which has also shown a high level of resistance expression to both potato ringrot and potato leafroll virus infection.

Literature Cited

1. Arslan, A. P. M. Bessey, K. Matsuda, and N. F. Oebker. 1985. Physiological effects of psyllid (Paratrioza cockerelli) on potato. Am. Potato J. 62: 9-22.

3. Richards, B. L. 1928. A new and destructive disease of the potato and its relation to the potato psylla. (Abs.) Phytopathology 18 (1): 140-41.

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Table 1. Potato psyllid populations on five potato cultivars planted June 8, 1987. Ft. Collins, CO.

		Psyllids/plot		
Cultivar	Insecticide treatment	July 31	August 31	Sept 10
TC 582-1	None	5.3	22.5	7.0
	esfenvalerate	---	3.0	0.0
WC 230-14	None	6.5	45.8	5.2
	esfenvalerate	---	8.3	0.0
Russet Burbank	None	3.7	24.2	3.5
	esfenvalerate	---	3.5	0.2
Centennial	None	3.7	26.3	3.7
	esfenvalerate	---	3.2	0.0
Sangre	None	4.2	34.3	2.2
	esfenvalerate	---	5.7	0.0

Table 2. Potato yields of five cultivars and their response to potato psyllid control, Ft. Collins, CO, 1987.

Cultivar	Insecticide treatment	Total yield gr/plant (% reduction)	Tubers/plant
WC 230-14	esfenvalerate	873	12.0
WC 230-14	none	569 (-35)	9.6
Centennial	esfenvalerate	532	6.4
Centennial	none	320 (-40)	4.8
Sangre	esfenvalerate	1063	10.4
Sangre	none	583 (-45)	8.8
Russet Burbank	esfenvalerate	1227	10.8
Russet Burbank	none	607 (-51)	10.7
TC 582-1	esfenvalerate	820	8.3
TC 582-1	none	226 (-62)	4.5

EFFECT OF CROP BACKGROUND MANIPULATIONS ON CAPTURE OF ALATE APHIDS

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Abstract

Alate aphid landing over various crop backgrounds was tested during 1985-1987. In comparison of different background colors, greatest numbers of aphids were trapped in yellow pan traps placed over dark backgrounds of soil or black burlap. Fewest aphids were trapped in pan traps placed over light colored backgrounds of white burlap and wheat straw. In comparison of aphid captures over different patterns of green carpeting, simulating cropping patterns, greater captures occurred over row patterns than over uniform green or small circle patterns. These data suggest that an optimal amount of heterogeneity is important in aphid alighting. Manipulations of background color and pattern have important implications in how aphid pan traps whould be located for optimal efficiency. Background manipulations may also be useful in reducing aphid landing rates on crops that are affected by aphids or aphid-vectored virus diseases.

Introduction

Yellow pan traps have been widely adopted for use in aphid sampling since the pioneering work by Moericke (1950). Efficiency of alate aphid trapping in pan traps can by affected by many factors including trap size (Costa and Lewis 1967) and trap height (Evans and Medler 1966, and Landis 1972). Trap background, a frequently neglected factor in sampling programs, has also had demonstrated effects on trapping alate aphids. For example, Moericke (1955) had higher alate captures in yellow pan traps placed over bare soil compared with traps over vegetation. Aluminum foil mulch backgrounds have also been shown to reduce alate aphid captures in yellow pan traps (Kring 1964), presumably because of differences in reflected longwave radiation used in the alighting response of aphids (Kring 1972).

The importance of crop background manipulations on aphid populations has also been demonstrated in cropping systems. Straw mulch has been shown to be useful in limiting spread of non-persistently aphid-transmitted viruses in peppers (Kemp 1978), presumably by affecting crop landing by alate aphid vectors. More recently, Burton et al. (1987) demonstrated sharply decreased rates of sorghum colonization by greenbug (*Schizaphis graminum*) in reduced tillage production systems that left increased stubble from the previous crop.

Alighting response of aphids may also be affected by crop backgrounds affected by planting densities. Smith (1976) found significantly more aphids in suction traps and yellow pan traps over brussels sprouts with bare soil than with weeds. Similarly, Horn (1981) reported higher densities of aphids in weedless collards versus weedy collards. Different perception of the crop by the colonizing insects, and changes in microclimate were among the factors proposed by Theunissen and DenOuden (1980) to explain differences in insect populations of insects in monocropped brussels sprouts. Both of these factors are altered by cropping densities.

The importance of manipulating crop backgrounds for insect control can be particularly valuable in the management of insect vectored plant diseases. Typically these disease problems are poorly managed by the use of insecticides directed at the aphid vectors (Swensen 1967, Nawrocka et al.). Consequently better control of these diseases may be achieved by cultural controls that limit landing of the vectors on the crop. Although some techniques to alter crop backgrounds may be labor and/or material intensive (e.g. use of reflective mulches), others may be relatively easily achieved by changes in cropping practice (e.g. planting density, reduced tillage). These studies are also directed toward identifying cropping patterns that may reduce aphid landing on a crop.

Materials and Methods

Pan Trap Background Color Trials. Experiments evaluating the effects of background color on the alighting response of alate aphids to yellow pan traps were located at a Colorado State University research farm (Bay Farm) located in Fort Collins, CO, during late summer 1985. Experimental design was a 6 x 6 Latin square. Treatments included bare soil (control), black, green, yellow, and white burlap, and wheat straw mulch each having an area of 1.83 x 1.83 m. Burlap treatments were stapled to 2.54 x 5.08 cm boards 2.44 m in length on opposite sides of the burlap squares. Each treatment was separated by a 4.57 m space and the entire experimental area was maintained weed-free during the trials. Experimental design was a 6 x 6 Latin Square.

Aphid landing rates were sampled using plastic yellow dishpan traps (29.2 cm x 33.0 cm) placed in the center of each treatment. Immediately prior to each trial traps were cleaned and refilled with water. Alate aphids subsequently captured were removed from the pan traps, placed into a vial of 70% ethyl alcohol, and brought back to the laboratory and counted. Dates on which pan traps were checked and the sampling interval, in parentheses, were: August 28 (1 d), 30 (2 d), September 4 (3 d), and 10 (3 d).

Over the course of the study observable fading occurred among the burlap treatments. Some soiling of the lighter backgrounds was also apparent on the later trial dates.

Pattern trials. Experiments evaluating the effect of background patterns on aphid alighting response were conducted in 1986 and 1987. Both experiments used plastic green grass-carpet for the different background pattern treatments. To eliminate the attraction to yellow pan traps, water-filled clear plastic saucers (30.5 diam x 3.5 cm) were placed in the center of each treatment and were used to sample alate aphids. Both experiments were kept weed-free by hand hoeing.

In 1986, experiments were again located at the Bay Farm. Treatments included: an area of bare soil 1.83 x 1.83 m (control); one circle of grass carpet 30.5 cm in diam placed in the center of a 1.83 x 1.83 m area; three rows of grass carpet, 0.37 x 1.83 m each, with a .37 m space between the rows; and a square of grass carpet 1.83 x 1.83 m. All treatments were separated by 4.57 m space in each direction. Experimental design was a 4 x 4 Latin Square. Six consecutive trials were conducted between September 2 and 18 September with sampling periods ranging from 1-5 days.

In 1987, treatments were similar to the 1986 study except nine 30.5 cm diameter grass carpet circles arranged as three rows by three columns with 30.5 cm between each circle was used instead of one circle of grass carpet. The initial 2 trials, conducted between August 12-16 for two day sampling intervals, were again located at the Bay Farm. An uncontrollable development of weeds in the study vicinity prompted movement of the third trial to the Colorado State University Horticultural Field Research Station, northeast of Ft. Collins, CO. At this site a x day trapping sample was initiated September ?. A randomized block experimental design was used at both locations. Blocking of the individual treatment and overall experimental area were square. As in the prior trials, a 4.57 m space of bare soil was maintained between all treatments.

A preliminary analysis of the data for all studies revealed a relationship between the means and their variances. A square root transformation resolved the problem (Steel and Torrie 1980). For the 1985 and 1986 studies a three-way analysis of variance (ANOVA) and orthogonal contrasts were carried out with MSTAT (1986). Orthogonal contrasts for the 1985 background color trial compared bare soil to the other five treatments; black burlap to green, yellow, and white burlap and straw mulch; green burlap to yellow and white burlap and straw mulch; white burlap to yellow burlap and straw mulch; and yellow burlap to straw mulch. Orthogonal contrasts for the 1986 pattern trial compared bare soil to the three grass-carpet treatments; one circle of grass carpet to the three rows and square of grass-carpet; and three rows of grass-carpet to the square of grass-carpet. For the 1987 pattern trial a two-way ANOVA and orthogonal contrasts were carried out with MSTAT (1986). Orthogonal contrasts for the 1987 study compared bare soil to the three grass-carpet treatments; the square-grass carpet to the three rows and nine circles of grass-carpet; and the three rows of grass-carpet to the nine circles of grass-carpet (Append. x). If the ANOVA P-value was less than or equal to 0.05 Student-Newman-Kuels (SNK) test was used to compare means with P=.05. On August 12 and 14, 1987, one plastic saucer was tipped over and unusable. The procedure described by Steel and Torrie (1980) was used to estimate the missing values.

Results

Pan Trap Background Color Study, 1985. Highly significant differences in yellow pan trap captures of alate aphids occurred with different colored backgrounds (Table 1). With captures of total aphids, the SNK test showed yellow pan traps on bare soil caught the most aphids, pan traps on the black burlap caught the second most aphids, pan traps on the green and yellow burlap caught the third most aphids, and pan traps on the white burlap and straw mulch caught the fewest aphids. Orthogonal contrast comparisons on the total aphid captures showed that pan traps on bare soil caught more aphids than the other treatments (P=.001); pan traps on black burlap caught more aphids than pan traps on green, yellow, and white burlap and straw mulch (P=.001); pan traps on green burlap caught more aphids than yellow and white burlap and straw mulch (P=.05); pan traps on white burlap caught fewer aphids than traps on yellow burlap and straw mulch (P=.02); and pan traps on yellow burlap caught more aphids than traps on straw mulch (P=.03).

Pattern Study, 1986. There were highly significant differences in alate aphids captures over different patterns of green grass carpet (Table 2). For the season total aphid captures all three orthogonal contrasts were significant.

Saucers on bare soil caught the fewest aphids when compared to the other treatments (P=.001); saucers on one circle of grass-carpet caught fewer aphids than three rows or a square of grass carpet (P=.01); and saucers on the square grass-carpet caught fewer aphids than the three rows of grass carpet (P=.005). For the total number of aphids the SNK test showed that saucers over the three rows of grass-carpet caught the most alate aphids. On 18 September, the SNK test showed that saucers over the three rows of grass-carpet caught the most aphids, one circle and the square of grass-carpet caught the second most, and bare soil caught the least.

Pattern Study, 1987. As in 1986, saucers over the three rows of grass-carpet caught the most aphids (Table 3). Orthogonal contrast comparisons of alate aphid captures in saucers were highly significant: saucers on bare soil caught the fewest aphids (P=.001); saucers on the square grass-carpet caught fewer aphids than saucers on the nine circles or three rows of grass-carpet (P=.002); and saucers on the nine circles caught fewer aphids than saucers on the three rows of grass-carpet (P=.02). The SNK test for total aphids was significant as well: saucers placed on bare soil caught the fewest aphids, the square and nine circles of grass-carpet were intermediate, and saucers on three rows of grass-carpet caught the most aphids. Orthogonal contrast comparisons of individual trials showed that on both 14 August and 23 September there were highly significant differences between the bare soil treatment and the three grass-carpet treatments (P=.004 and P=.002, respectively).

Discussion

Throughout the background color experiment, yellow pan traps on dark backgrounds (bare soil and black burlap) caught the most alate aphids. These results are similar to those reported by Moericke (1955). Increased amounts of longwave radiation reflected by the soil (Kring 1972) or the increased contrast between the yellow pan traps and the soil are possible explanations for this effect. These data strongly support that the use of yellow pan traps for sampling be maintained over dark surface backgrounds to maintain optimal trapping efficiency. Attempts to quantitatively compare yellow pan trap alate aphid captures located over different colored backgrounds will be confounded by the background effects.

In this study, generally similar numbers of aphids were caught in traps placed over the green and yellow burlap backbgounds. Differences between these treatments may have been obscured by burlap fading effects since initially the darker green burlap showed trends of higher aphid capture. Yellow pan traps on white burlap and straw mulch caught the fewest alate aphids.

That fewest alate aphids were been caught over the lighter colored burlap treatments and the straw mulch treatment may be due to the "large trap size" effect noted by Costa and Lewis (1967); the yellow and straw background were similar in color to that of the yellow pan trap. An alternative explanation is that white burlap and straw mulch interfere with the longwave radiation/ shortwave radiation involved in the alighting response of alate aphids (Kring 1972). These data further support the observations that use of straw mulches or similar crop backgrounds, such as produced during reduced tillage, may help reduce alate aphid colonization of crops (Kemp 1987, Burton and Krenzer 1985, Burton et al. 1987, and Harvey et al. 1982) including reduction of non-persistently aphid vectored viruses.

In both the 1986 and 1987 pattern experiments, most alate aphids were caught in the clear plastic saucers over three rows of grass carpet (Tables 2, 3). An optimum amount of heterogenity seems to involved in aphid alighting responses since greatest numbers of alate aphids responded by landing over three rows of grass carpet than other backgrounds. It is interesting to note that aphids also were rarely observed to land on bare soil, previously observed by Kring (1972).

These data indicate that one might expect lower colonization by alate aphids of low density crops (green circle treatments) than higher density crops (three rows). Studies by A'brook (1968 and 1973) and Halbert and Irwin (1981) support this idea. However, lower aphid captures also occurred over uniform green surfaces than over row patterned crop backgrounds. This suggests that plantings of uniform appearance, such as could be established by very high planting densities or by use of living mulches, may be an alternative way to reduce aphid colonization of a crop. Studies which have shown an inverse relationship between crop density and percentage infection by aphid vectored virus diseases (   ) may be due to a reduction in aphid landing within the crop area as well as a "dilution" effect related to the increased number of plants available to infection by the infective aphids intercepting the crop.

Table 1. Aphid captures in yellow pan traps placed over various colored backgrounds, Ft. Collins, CO, 1986.

	Average aphid capture/trap*			
Trap background treatment	Aug 28	Aug 30	Sept 4	Sept 10
Bare soil	123.3a	94.2a	73.3a	51.0a
Black burlap	43.0 b	69.2a	59.3 b	35.0 b
Green burlap	29.3 bc	23.4 b	25.9 cd	17.0 cd
Yellow burlap	12.3 bc	12.8 b	32.3 c	22.2 c
White burlap	11.7 bc	6.2 b	19.0 d	11.5 d
Wheat straw	8.2 c	6.7 b	19.7 d	13.0 d

* Average of 6 traps. Original data; data transformed for analaysis. Numbers followed by the same letter are not significantly different (P=0.05) by DMRT.

Table 2. Aphids captured in water-filled clear plastic saucers placed over various background patterns of green carpeting, Ft. Collins, CO 1986.

	Average aphid capture/trap*					
Trap background	Sept 2	Sept 5	Sept 9	Sept 11	Sept 14	Sept 18
Three rows	1.5	5.0	17.0	8.0	15.8	27.3
Uniform green	0.8	3.0	10.5	6.8	11.8	14.3
Single circle	1.8	1.0	11.0	3.8	8.5	17.0
Bare soil	0.8	2.0	10.0	2.5	9.0	12.8

* Average of 4 traps. Original data; data transformed for analysis.

Table 3. Aphids captured in water-filled clear plastic saucers placed over various background patterns of green carpeting, Ft. Collins, CO 1987.

	Average aphid capture/trap*			
Trap background	Aug 12	Aug 14	Sept 23	Total
Three rows	0.7	2.3	8.7	11.7
Nine circles, in three rows	0.5	1.3	5.8	7.5
Uniform green	0.5	1.0	3.5	5.0
Bare soil	0.3	0.0	1.8	2.0

* Average of 4 traps.

EFFECTS OF SYSTEMIC INSECTICIDES ON POTATO GROWTH

AND THEIR INTERACTION WITH METRIBUZIN

Whitney S. Cranshaw and Michael K. Thornton

Abstract

Effects of the soil systemic insecticides aldicarb, phorate, and disulfoton on potato growth were measured from 1984-1986 on the cultivars 'Russet Burbank' and 'Centennial'. In all seasons, aldicarb was observed to cause a significant promotion of flowering and in one season also caused increased haulm growth. Phorate caused a reduction in these growth parameters in one season. Temporary effects on early season yields were observed from aldicarb treatment in one year but final yields were never significantly affected by insecticide use alone.

During 1985-1986 additional treatments were investigated involving insecticide combinations with the herbicide metribuzin to determine possible insecticide-herbicide interactions. Phorate-metribuzin combinations caused synergistic metribuzin injury symptoms, decreased haulm growth and yield in 1986. Metribuzin also decreased yields of aldiciarb treated potatoes in 1986 and disulfoton treated potatoes in 1985. Disulfoton-metribuzin combinations decreased flowering in 1985. These data suggest that soil systemic insecticides can have direct effects on potato growth, independent of effects on pest suppression, and that they may interact with other crop protection chemicals.

Introduction

Several researchers have reported direct effects of insecticides promoting potato growth independent of insect control effects. This has included DDT (3), azinphosmethyl (7), aldicarb (1), and phorate (9). Phorate has also been reported to be phytotoxic under some conditions (6). On other crops (notably soybean, <u>Glycine max)</u> several of these insecticides have also been demonstrated to have synergistic effects when used with the potato herbicide metribuzin (4, 5, 8).

Soil applied systemic insecticides are currently widely used in potato production to control a variety of insect and nematode pests. Insecticides are also used routinely as crop protection tools in most potato field research studies. Because of their potential for effect on potato physiology, a better understanding is needed of how insecticides may affect potato growth and interact with other crop protection chemicals.

Materials and Methods

Plots were located at the San Luis Valley Experiment Station southwest

of Center, CO from 1984-1986. Soil type was a Norte gravelly sandy loam (pH 7.9) with 0.7% organic matter. Plots were sprinkler irrigated. Initial studies (1984) were designed to detect effects of phorate and aldicarb insecticides, applied at planting, on the growth and tuber development of 'Russet Burbank'
potatoes. This was a parallel study to one reported earlier in Minnesota (2). Subsequent studies primarily involved interactions of insecticide with the herbicide metribuzin on the cultivar 'Centennial', a known metribuzin sensitive cultivar in the San Luis Valley growing region.

1984 Studies. Russet Burbank potatoes were planted May 17 in six row plots, 7.6 m in length at 0.9 m row spacing. Experimental design was a randomized complete block with 4 replications. Systemic insecticides were banded beneath the seed piece at planting. A single aerial application of disulfoton was applied July 22. Tuber development was assessed by a regular sampling of 6 hills per plot from the exterior rows. Final yields were taken by harvest of the center two rows on September 19. Extenst of flowering was determined by counting all flowers on the center two rows at periodic intervals from June 29-August 23. Haulm vigor was visually rated July 29 based on a 1 (least vigorous) to 5 (most vigorous) graduated scale.

1985 Studies. Centennial potatoes were planted May 3 in two row plots, 3 m in length at 0.9 m row spacing. Experimental design was a randomized complete block with 4 replications. Insecticides were banded over the row May 7 and immediately incorporated. Metribuzin (Sencor 4) applications were made June 13, at which time the plants were approximately 25 cm in height. No other insecticides were applied during the season. Assessment of herbicide injury was made July 3 using a graduated damage rating scale of 0 (no injury) to 5 (maximum injury, severe leaf burning and chlorosis). Flowering was quantified by counting all flowers on the plots. Haulm vigor ratings were made July 17 and August 8 using the same scale as in the previous season. Plots were killed August 28 and hand harvested September 9.

1986 Studies. Centennial potatoes were planted May 2 in four row plots, 6.1 m in length at 0.9 m row spacing. Experimental design was a randomized complete block with 4 replications. Insecticides were incorporated as a band over the seed piece on May 19. Metribuzin treatments were applied at the maximum label rates after plant establishment (June 27). Plots were aerially sprayed with disulfoton (July 16, July 30) and fenvalerate (July 10). Assessment of metribuzin injury (July 14, August 8) and haulm vigor (July 21, August 8) were made using the previously described rating scales. Flower counts were made on the center two rows July 21. Plots were killed August 15 and hand harvested September 17.

Data were analyzed used analysis of variance. Where differences exceeded a significance level of 0.05 a Duncan's Multiple Range Test was used to separate means.

Results and Discussion

During the course of the study significant insect populations were never observed to develop on the plots. Maximum infestations of 1 potato aphid/25 leaves were noted in 1984. Insect pests that directly affect potato growth at low populations, notably the potato psyllid (Paratrioza cockerelli (Cockerelli)), and those that affect flowering, (Lygus spp.), were absent.

Strong promotion of flowering by the soil systemic insecticide aldicarb (Temik 15G) was noted in every trial (Tables 1-3). Trends of rate response
occurred in 1984, the only season during which multiple aldicarb rates were used. Conversely, phorate (Thimet 20G) and disulfoton (DiSyston 15G) showed variable effects on flowering, with a significant depression from both treatments observed in the 1986 trials.

Consistent trends of reduced haulm vigor from phorate treatment existed in every season and was significant in 1984. Aldicarb significantly increased haulm growth in 1984 but not in subsequent seasons and, at the high rate, caused a temporary reduction in early season yield. None of the systemic insecticides significantly affected final yields when used without metribuzin.

Greatest metribuzin injury was observed in phorate treated plots in 1986 when herbicide injury was more severe. Metribuzin combinations with aldicarb and disulfoton did not significantly increase visible haulm growth injury. Metribuzin-disulfoton combinations were observed to reduce flowering in 1985 but no other metribuzin related effects on flowering occurred. Metribuzin-insecticide combinations that significantly decreased yield occurred with phorate in 1986, aldicarb in 1986, and disulfoton in 1985.

Synergistic effects from all three insecticides used in this study have been reported with metribuzin use in soybean (4, 5, 8). On soybean these effects have been variable by location and year but some severe yield reductions have been recorded. Synergistic effects of metribuzin-systemic insecticide combinations on potato also appear to vary seasonally, generally at a lower order than reported on soybean. However, the potential of insecticides and herbicides to directly affect potato growth and to interact on the crop should be considered by potato researchers.

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ADDITIONAL KEY WORDS: aldicarb, disulfoton, phorate

Table 1. Yield haulm growth and flowering of potatoes (cv. 'Russet Burbank') as affected by soil systemic insecticides, Center, CO, 1984.

	Rate	Flowers/61 Row-m**			Haulm growth vigor	Tuber wgt (kg)/24 plants ****					Final yield (mT/ha)*****	
Treatment*	[kg(AI)/ha]	Jul 12	Jul 26	Aug 9	rating***	Jun 29	Jul 12	Jul 26	Aug 9	Aug 23	U.S. #1	Total
Phorate	3.4	25a	49a	3a	2.0b	0.3a	2.4ab	9.6a	16.9a	14.1ab	19.0a	37.1a
Aldicarb	2.3	63b	253b	31b	4.5a	0.4a	3.5c	13.2a	17.7	12.7ab	17.3a	33.8a
Aldicarb	3.4	59b	301b	30b	4.5a	0.5a	2.0a	11.3a	19.2a	14.9b	17.9a	35.0a
Untreated		17a	16a	3a	3.8ab	0.3a	3.0bc	11.8a	19.7a	11.9a	17.6a	35.7a

*Phorate applied as Thimet 20G; aldicarb applied as Temik 15G. Numbers within columns followed by same letter not significantly different (P=0.05) by DMRT.

**Total of center rows of four replications.

***Haulm growth vigor rated Jul 26 on a graduated 1 (least vigorous) to 5 (most vigorous) scale.

****Total tuber weight from 6 plants collected from each of 4 plots.

*****Center two rows harvested Sep 18.

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Table 2. Effects on potato (c.v. 'Centennial') haulm growth, flowering, and h from various systemic insecticide/metribuzin combinations, Center, CO, 1985.

Treatment*	Metribuzin injury rating**	Flowers/ 24.4 m-row Jul 17	Flowers/ 24.4 m-row Aug 8	Haulm growth vigor rating *** Jul 17	Haulm growth vigor rating *** Aug 8
Phorate (Thimet 20G)	0.0a	317bc	4a	3.7a	2.6b
Disulfoton (Disyston 15G)	0.0a	517b	0a	4.0a	2.8b
Aldicarb (Temik 15G)	0.0a	926a	0a	4.3a	3.4ab
Untreated check	0.0a	398bc	0a	4.6a	3.7a
Phorate - metribuzin	2.4b	281bc	48a	3.6a	3.5a
Disulfoton - metribuzin	2.8b	190c	0a	3.5a	2.8a
Aldicarb - metribuzin	1.7b	758a	34a	4.3a	4.0a
Metribuzin (Sencor 4)	2.3b	336bc	39a	4.0a	3.7a

*All treatments applied at the rate of 3.4 kg (AI)/ha. Formulations were Thimet 20 DiSyston 15G (disulfoton), and Temik 15G (aldicarb). Numbers within columns follow not significantly different by DMRT.

**Metribuzin applied as Sencor 4 at rate of 6.55 kg (AI)/ha. Damage rating on grad (0-no injury, 5-maximum injury on plots involving severe leaf burning).

***Haulm growth rated on a graduated 1-5 scale where 1=least vigorous haulm growth; haulm growth.

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Table 3. Effects on potato (c.v. 'Centennial') haulm growth, flowering, and herbicide injury from various systemic insecticide/metribuzin combinations, Center, CO, 1986.

Treatment*	Flowers/ 48.8 m-row	Metribuzin injury rating**		Haulm growth vigor rating ***		Total Yield (t/ha)
		Jul 14	Aug 8	Jul 21	Aug 8	
Phorate	937c	0.0a	0.0a	2.6a	2.9a	28.9a
Disulfoton	1226bc	0.0a	0.0a	3.1a	3.2a	28.8a
Aldicarb	2198a	0.0a	0.0a	3.3a	3.2a	28.5a
Untreated check	1809ab	0.0a	0.0a	2.5a	2.8a	26.0ab
Phorate - metribuzin	744c	4.4c	3.4c	2.4a	2.1a	19.5c
Disulfoton - metribuzin	1118bc	1.8b	2.1bc	3.1a	3.3a	26.2ab
Aldicarb - metribuzin	2307a	3.2bc	2.1bc	3.3a	3.4a	22.5bc
Metribuzin	1905ab	2.0b	1.5b	3.6a	3.9a	28.0a

*All treatments applied at the rate of 3.4 kg (AI)/ha. Formulations were Thimet 20G (phorate), DiSyston 15G (disulfoton), and Temik 15G (aldicarb). Numbers within columns followed by same letter are not significantly different by DMRT.

**Metribuzin applied as Sencor 4 at rate of 6.55 kg (AI)/ha. Damage rating on graduated 0-5 scale (0-no injury, 5-maximum injury on plots involving severe leaf burning).

***Haulm growth rated on a graduated 1-5 scale where 1=least vigorous haulm growth; 5 most vigorous haulm growth.

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