

Population Growth of Lettuce Aphid, *Nasonovia ribisnigris*, on Resistant Butter and Head Lettuce Cultivars

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Abstract

Studies to examine lettuce aphid population growth on resistant head and butter lettuce cultivars were conducted in small field plots at the Yuma Agricultural Center. By artificially infesting plants on several lettuce plantings during the spring, the influence of the resistant lettuce plants were evaluated for their capability of preventing lettuce aphid populations from colonizing plants. Results of five field trials showed that several varieties of head and butter lettuce have been developed that almost completely prevent lettuce aphids from surviving and reproducing on plants during the spring. Although the cultivars tested did not possess marketable characteristics for harvests, they do provide germplasm for breeding new varieties suited for desert production. In addition, these studies also support conclusions drawn from the past several seasons that suggest lettuce aphid population growth is greatest when ambient temperatures average between 65-70 °F.

Introduction

A new aphid species, the currant-lettuce aphid, *Nasonovia ribisnigri* (Mosley), has been creating problems for lettuce growers throughout the western United States. Commonly referred to as the lettuce aphid, the pest was found in Salinas in 1998 causing economic losses to summer head and leaf lettuce crops. Infestations of this species were also reported on lettuce in the Imperial Valley, central Arizona, and Baja California, Mexico in early 1999. They have consistently appeared throughout lettuce growing areas of California and Arizona during the past two years, particularly in organically produced lettuce. Aphid populations in the Yuma area have occurred at very low levels in most commercial fields where Admire® applied on an areawide basis appears to have prevented large-scale outbreaks.

There is much uncertainty surrounding this new species, and its ability to thrive within our desert growing conditions. Furthermore, new methods of control that do not rely heavily on insecticides are needed. In Europe, lettuce cultivars have been developed that are highly resistant to lettuce aphids. Although these cultivars are not adapted to desert growing conditions, they do provide opportunities for plant breeders to develop resistant varieties that are suitable for western lettuce production. We were recently able to gain access to several experimental cultivars that have shown resistance to lettuce aphids and conducted field trials to compare the population growth of lettuce aphids on resistant varieties under various field conditions.

Methods and Materials

Studies to examine aphid population growth on resistant and susceptible lettuce plants were conducted in small plot trials at the Yuma Agricultural Center, Yuma, Arizona. Three separate plots of head and butter lettuce were planted on Dec 15th, 2000, and Jan 8th and Feb 4th, 2001 (see Table 1 below). On each planting date, the lettuce cultivars were direct seeded into double row beds on 42 inch centers. Each planting was subdivided into plots consisted of 2

beds, 40 feet long. Plots were arranged in a randomized complete block design with four replications. Comparisons between resistant and susceptible head lettuce included an equal number of replicates of susceptible plants that were treated with either imidacloprid (Admire 2F) at 20 oz / acre at planting or thiamthoxam (Platinum 2SC) at 11 oz as a side dress application. The Admire was applied to plots during the bed-shaping operation by injecting the chemical 1.5" below the seed. Plots were furrow irrigated to a stand. Platinum was applied post-planting at a rate of 9 oz/acre as a side dress application to ½ of each untreated plots (2 beds * 80 ft) on 20 Feb. Side dress applications were made by placing the product near the bed shoulder at approximately 3-4" below the soil. Plots were irrigated 2 days following side dress on Feb 22. No other insecticide applications were made during the study. Resistant cultivars used in this trial included the following lines: head lettuce; IC9005 (SunSeeds, Inc, Morgan Hill, CA) and 'Fortunas' (Rijk Zwaan, DeLier, Holland) and for butter lettuce; BG 9007 and BG9109 SunSeeds, Inc, Morgan Hill, CA). Susceptible standard cultivars included for head lettuce 'Diamond' (Coastal Seeds Inc, Salinas, CA), 'Beacon' (Paragon Seeds, Salinas, CA) and IC 9007 (SunSeeds, Inc, Morgan Hill, CA) and for butter lettuce, BG 9101 (SunSeeds, Inc, Morgan Hill, CA).

Five separate studies were established by infesting individual plants with either reproductive mature or immature apterae lettuce aphids. Aphids used in this study were reared in the field. An infestation of lettuce aphid was discovered in another test in December 2000, and from this, a lettuce aphid nursery was established in a romaine field located about 1 mile to the south of the experimental area. Specimens of this population were verified as *Nasonovia ribisnigri* (Mosley), by Dr. John Sorensen, CDFA, Sacramento, CA. In the first trial, 3 reproductive mature apterous aphids were placed onto the terminal of 4-leaf head lettuce plants using a camel hair brush. A total of 4-5 plants in each resistant and susceptible cultivar per replicate were infested (16-20 plants per treatment) and marked on Jan 29. Aphid population were left unmolested for 35 days, after which each marked (artificially infested) plant was individually removed from the field and brought into the laboratory for examination. All foliage on each plant was visually examined for alatae, and immature and reproductive apterous lettuce aphids. Numbers of aphids per plant were recorded for each plant and averaged for each treatment. In the remaining four trials, 5 immature apterous aphids were infested on the same number of plants and population numbers were sampled similarly to trial 1. In trials 2 (Dec 15th planting) and 3 (Jan 8th planting), lettuce aphids were also artificially infested in Platinum-treated plots. Trials 4 and 5 were conducted in the Feb 4th lettuce planting and evaluated similarly. Details for infestation periods and temperature (AZMET station, Yuma Valley; <http://ag.arizona.edu/azmet/>) are shown in Table 3. In addition, in each trial, five unmarked (not artificially infested) plants from each plot were randomly sampled as above to determine the natural lettuce aphid infestation occurring in the experimental plots. This was done to measure the incidence of naturally-occurring aphids migrating onto artificially infested plants. Mean differences in aphid numbers among treatments following infestation periods were determined using a one-way ANOVA and a protected LSD, or with paired t-tests ($p < 0.05$).

Results and Discussion

Lettuce aphid population growth for each trial is shown in Tables 2-6. In Trial 1, the mean number of aphids per plant differed significantly among the resistant and susceptible cultivars in the artificially-infested plants. Aphids failed to colonize both the butter and head lettuce resistant cultivars (Table 2). Both of the susceptible cultivars, 'Diamond' and BG 9101, had extremely high numbers of aphids following the 35 day infestation period. The Admire treated head lettuce contained fewer aphids than the untreated susceptible, but had significantly higher numbers than the IC9005. Although temperatures were sub-optimal for lettuce aphid population growth (Table 1), the resulting densities were not surprising because 3 reproductive apterous were placed on each plant allowing for immediate reproduction. We would not expect to see this under commercial situations, as suggested by the low aphid numbers found in the naturally infested plants, and where differences among susceptible and resistant cultivars were only observed in the butter lettuce cultivars (Table 2).

Population growth on treated and untreated plants was much lower when plants were infested with 5 immature apterous lettuce aphids in the February infestations. In Trial 2 in head lettuce, both Admire and Platinum plots had significantly fewer aphids than the untreated check when artificially infested (Table 3). Additionally both of these treatments were similar to the resistant cultivar IC9005, which did not allow the development of mature aphids (Table 3). Surprisingly, susceptible plants in the natural infestation were actually more heavily infested with lettuce aphids than the artificially infested trial, which may be a reflection of how this aphid tends to become highly

aggregated upon migration into fields. Both the Platinum and IC9005 prevented aphid colonization. Similarly, both resistant butter varieties, BG 9007 and BG 9109, prevented lettuce aphids from establishing colonies on plants following the 28 d infestation period. In Trial 3 on artificially infested plants, lettuce aphid numbers were significantly lower in the insecticide treatments, where Admire and Platinum reduced aphid numbers by 91 and 71% respectively. However, more impressive was the lack of any aphid colonization at all in the resistant cultivars 'Fortunas' and IC 9005 (Table 4). Similarly, aphid colonization was negligible in the resistant butter cultivar BG 9107 where aphid populations exceeded 900 per plant in the susceptible cultivar. In the naturally infested plants, differences between cultivars were not observed in either the head or butter lettuces due to the light population levels.

In trial 4, we were unable to evaluate our artificially infested plants due to a heavy rainfall event 2 days following infestation and accidental destruction of several plants during cultivation. Naturally occurring lettuce aphid populations were light in the head lettuce and did not result in significant difference in population growth among the resistant and susceptible cultivars (Table 5). Aphid pressure was somewhat greater in the butter types and similar to the previous tests, the resistant butter cultivar BG 9107 almost completely prevented any aphids from colonizing plants. In trial 5, following a 32 d infestation period under optimal temperatures, both resistant head lettuce cultivars, 'Fortunas' and IC 9005 prevented colonization on both artificially and naturally infested plants (Table 6). Surprisingly, the susceptible variety IC 9007, contained significantly higher numbers of aphids than 'Beacon'. Again the resistant butter type BG 9107 provided excellent aphid control.

These trails clearly demonstrate that lettuce germplasm is available that can completely control lettuce aphids under spring growing conditions. Both head and butter lettuce cultivars were capable of preventing both immigrant and artificially infested aphid populations from surviving and reproducing on resistant plants. This is quite significant considering the high infestation levels that were observed in susceptible lettuce types. Based on reports from Europe, resistance of lettuce aphid in lettuce varieties is due to a chemical or mechanical difference in the phloem between resistant and susceptible plants. Feeding studies have shown that lettuce aphids probe the phloem tissue of resistant plants with their stylet, but do not ingest phloem sap. We speculate that a similar mechanism was responsible for the resistance measured in these studies because of the lack of apparent feeding observed in surviving individuals on resistant plants. Survivors often looked pale and starved, suggesting that they were unable to ingest phloem sap. Unfortunately, the resistant cultivars evaluated in this study do not possess the desired marketable qualities and characteristics suited for desert production. However, they do provide cultivars for plant breeders to use in the development of resistant varieties that are suitable for western lettuce production. Efforts to use breed resistant cultivars for coastal lettuce types are presently being conducted by Dr. Ed Ryder, USDA-ARS, Salinas, CA.

The results of these studies also suggest that in the absence of resistant varieties, Admire and Platinum have a significant influence on lettuce aphid population growth. Depending on residual, significant control can result from the application of these compounds. For instance, infestation initiated at 28 d following planting initially resulted in minimal population growth, but later allowed aphids to reproduce at high numbers. In both cases, Admire provided about 90% control of the lettuce aphid population. Under natural conditions, control wasn't quite as good, and probably reflects the aggregating behavior of this aphid species. However, aphid infestations occurring at later periods of plant residual almost always resulted in higher population development. Finally, these studies also support conclusions drawn from the pest several seasons that suggested that population growth was greatest when temperatures averaged between 65-70 °F. Although, population growth for aphids was high in the first trial when temperature averaged 56 °F, the presence of reproductive immatures was probably a greater influence. The highest aphid growth rates coincided with average ambient temperatures of 66°F (Table 3). Previous studies in the laboratory (Bill Chaney, Univ. Calif., personal communication), and in the fields suggest that this is the optimal developmental range. However, other factors such as variety, planting date, plant growth stage, infestation pressure and natural enemies will also certainly affect the rate at which lettuce aphids develop in lettuce.

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Trial (Planting Date)	Infestation period (days)	Average ambient temperatures (°F)	
		Max-Min	Mean
1 <i>(Dec 15)</i>	Jan 29- Mar 4 <i>(35 d)</i>	69-43	56
2 <i>(Dec 15)</i>	Feb 20- Mar 20 <i>(28 d)</i>	76-50	63
3 <i>(Jan 8)</i>	Feb 20- Mar 20 <i>(28 d)</i>	76-50	63
4 <i>(Feb 4)</i>	Mar 4-Mar 21 <i>(17 d)</i>	82-49	66
5 <i>(Feb 4)</i>	Mar 4-April 5 <i>(32 d)</i>	83-51	67

Table 1. Planting dates, infestation periods and temperatures for each lettuce aphid trial, Yuma Agricultural Center , spring 2001.

Table 2. Infestation (infested Jan 29) of *Nosanovia* on susceptible and resistant lettuce cultivars (evaluated 35 days following infestation on March 4).

Trial 1	Artificial Infestation ^{a/} (Mean aphids/plant)				Natural Infestation ^{b/} (Mean aphids/plant)			
	Apterae				Apterae			
	Alatae	Immature	Mature	Total	Alatae	Immature	Mature	Total
<i>Head</i>								
'Diamond' - Untreated	7.6 a	348.7 a	57.0 a	405.7 a	0.3 a	5.2 a	2.1 a	7.3 a
'Diamond' - Admire	0.3 b	80.7 b	8.8 b	89.5 b	0.3 a	1.0 a	0.0 a	1.0 a
IC 9005	0.0 b	1.0 c	0.7 c	1.7 c	0.0a	0.2 a	0.1 a	0.3 a
<i>Butter</i>								
BG 9101	6.7 a	695.3 a	108.3 a	803.7 a	0.4 a	78.6 a	11.8 a	90.4 a
BG 9007	0.2 b	1.6 b	0.3 b	2.0 b	0.0 a	0.7 b	0.3 a	1.0 b
BG 9109	0.4 b	2.4 b	0.7 b	3.1 b	0.4a	1.5 b	0.7 a	2.2 b

a/ 3 mature apterous lettuce aphids placed on each of 9 plants on Jan 29, 2001 and evaluated on 4 March, 2001. Upon close inspection prior to artificial infestation, lettuce aphids were not found on plants.

b/ Lettuce aphids were not placed on these plants. Aphids found on plants occurred from outside of the field

Table 3. Infestation (infested Feb 20) of *Nosanovia* on susceptible and resistant lettuce cultivars (evaluated 28 days following infestation on March 20)

Trial 2	Artificial Infestation ^{a/} (Mean aphids/plant)				Natural Infestation ^{b/} (Mean aphids/plant)			
	Apterae				Apterae			
	Alatae	Immature	Mature	Total	Alatae	Immature	Mature	Total
<i>Head</i>								
'Diamond' - Untreated	0.1 a	34.6 a	2.7 a	37.3 a	1.9 a	58.5 a	-	58.5 a
'Diamond' - Admire	0.1 a	7.9 b	1.3 a	9.2 b	0.3 b	69.9 a	-	69.9 a
'Diamond' - Platinum ^{c/}	0.2 a	5.0 b	0.6 a	5.6 b	0.3 b	6.5 b	-	6.5 b
IC 9005	0.0 a	2.0 b	0.0 a	2.0 b	0.0 b	2.0 b	-	2.0 b
<i>Butter</i>								
BG 9101	16.2 a	572.8 a	-	572.8 b	4.6 a	233.3 a	-	233.3 a
BG 9007	0.4 b	2.6 b	-	2.6 b	0.2 b	3.7 b	-	3.7 b
BG 9109	0.0 b	0.8 b	-	0.8 b	0.0 b	0.6 b	-	0.6 b

^{a/} 5 immature apterous lettuce aphids placed on each of 20 plants on 20 Feb, 2001 and evaluated on 20 Mar, 2001. See Table 1 for natural infestation levels on plants at the time of infestation

^{b/} Lettuce aphids were not placed on these plants. Aphids found on plants occurred from outside of the field.

^{c/} Platinum side dressed at 11 oz/acre on Feb 20, irrigated on Feb 22.

** syrphid fly and ladybeetle larvae were very active on infested plants (mean=7.8 SF larvae/plant; 1.3 LB larvae / plant).

Table 4. Infestation (infested Feb 20) of *Nosanovia* on susceptible and resistant lettuce cultivars (evaluated 28 days following infestation on March 20)

Trial 3	Artificial Infestation ^{a/}				Natural Infestation ^{b/}			
	(Mean aphids/plant)				(Mean aphids/plant)			
	Apterae				Apterae			
	Alatae	Immature	Mature	Total	Alatae	Immature	Mature	Total
<i>Head</i>								
'Diamond' - Untreated	0.4 a	103.7 a	7.3 a	111.0 a	0.3 a	7.2 a	0.7 a	7.9 a
'Diamond' - Admire	0.4 a	9.3 c	1.2 b	10.5 c	0.3 a	0.9 a	0.3 a	1.2 a
'Diamond' - Platinum ^{c/}	0.8 a	28.9 b	2.0 b	30.9 b	0.6 a	1.1 a	0.2 a	1.3 a
'Fortunas'	0.0 a	0.0 d	0.0 a	0.0 d	0.1 a	0.0 a	0.0 a	0.0 a
IC9005	0.0 a	0.0 d	0.0 a	0.0 d	0.3 a	0.0 a	0.0 a	0.0 a
<i>Butter</i>								
BG 9101	2.8 a	832.9 a	76.5 a	908.5 a	0.1 a	2.3 a	0.0 a	2.3 a
BG 9107	0.3 b	0.0 b	0.5 b	0.5 b	0.3 a	0.3 a	0.0 a	0.3 a

^{a/} 5 immature apterous lettuce aphids placed on each of 20 plants on 20 Feb, 2001 and evaluated on 22o Mar, 2001. See Table 1 for natural infestation levels on plants at the time of infestation

^{b/} Lettuce aphids were not placed on these plants. Aphids found on plants occurred from outside of the field.

^{c/} Platinum side dressed at 11 oz/acre on Feb 20, irrigated on Feb 22.

Table 5. Infestation (infested Mar 4) of *Nasonovia* on susceptible and resistant lettuce cultivars (evaluated 17 days following infestation on March 21)

Trial 4	Artificial Infestation ^{a/} (Mean aphids/plant)				Natural Infestation ^{b/} (Mean aphids/plant)			
	Apterae				Apterae			
	Alatae	Immature	Mature	Total	Alatae	Immature	Mature	Total
<i>Head</i>								
'Beacon' - Untreated	-	-	-	-	0.8 a	2.2 a	0 a	2.2 a
'Beacon' - Admire	-	-	-	-	0.3 a	2.2 a	0 a	2.2 a
IC 9007	-	-	-	-	0.8 a	13.5 a	1.0 a	14.5 a
'Fortunas'	-	-	-	-	0.2 a	0.3 a	0.0 a	0.3 a
IC 9005	-	-	-	-	0.2 a	0.0 a	0.0 a	0.0 a
<i>Butter</i>								
BG 9101	-	-	-	-	2.0 a	60.3 a	9.2 a	69.5 a
BG 9107	-	-	-	-	0.7 a	0.2 b	0.0 b	0.2 b

^{a/} 5 immature apterous lettuce aphids placed on each of 16 plants on 4 Mar, 2001 and evaluated on 21 Mar, 2001. See Table 1 for natural infestation levels on plants at the time of infestation

^{b/} Lettuce aphids were not placed on these plants. Aphids found on plants occurred from outside of the field.

Table 6. Infestation (infested Mar 4) of *Nosanovia* on susceptible and resistant lettuce cultivars (evaluated 32 days following infestation on April 5).

Trial 5	Artificial Infestation ^{a/} (Mean aphids/plant)				Natural Infestation ^{b/} (Mean aphids/plant)			
	Apterae				Apterae			
	Alatae	Immature	Mature	Total	Alatae	Immature	Mature	Total
<i>Head</i>								
‘Beacon’ - Untreated	2.2 a	280.9 b	46.9 a	327.9 b	1.1 a	82.8 b	13.3 a	96.1 b
‘Beacon’ - Admire	0.5 b	34.5 c	5.9 b	40.4 c	0.9 a	21.7 bc	3.0 b	24.7 bc
IC 9007	5.0 a	615.0 a	82.0 a	697.0 a	2.0 a	373.5 a	35.3 a	408.8 a
‘Fortunas’	0 b	0 d	1.0 b	1.0 d	0 a	0.5 c	0 b	0.5 c
IC 9005	0.3 b	0.5 d	0.3 b	0.8 d	0 a	0.3 c	0 b	0.3 c
<i>Butter</i>								
BG 9101	3.0 a	643.8 a	146.0 a	789.6 a	0 a	518.5 a	118.5 a	637.0 a
BG 9107	0.3 b	4.3 b	3.5 b	7.8 b	0 a	0 b	0.5 b	0.5 b

^{a/} 5 immature apterous lettuce aphids placed on each of 16 plants on 4 Mar, 2001 and evaluated on 5 Apr, 2001. See Table 1 for natural infestation levels on plants at the time of infestation

^{b/} Lettuce aphids were not placed on these plants. Aphids found on plants occurred from outside of the field.