The Effects of Spray Adjuvants on the Insecticidal Activity of Success® (spinosad) on Lettuce and Melons

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Abstract

Studies were conducted in the field and laboratory to investigate how the addition of spray adjuvants to Success affected its insecticidal activity against leafminers, thrips and lepidopterous larvae. Studies were also designed to evaluate the knockdown and residual mortality of Success against worms when applied with a buffer to produce an acidic spray solution. Results indicated that Success applied without an adjuvant appeared to provide the most consistent adult mortality of Liriomyza leafminers. In contrast, the addition of a penetrating surfactant (crop oil concentrate) resulted in significantly greater larval mortality consistent with the leafminer feeding behavior. Efficacy of Success against lepidopterous larvae and western flower thrips was not improved using a spray surfactant. However, addition of buffering agents to Success spray solutions significantly affected efficacy against beet armyworm and cabbage looper. Lab bioassays and field studies showed that knockdown mortality was not affected, but residual efficacy was significantly reduced when Success was applied in an acidic (pH 4.2) spray environment.

Introduction

Success® (spinosad) has become a standard insecticide in pest management programs for the production of desert vegetables and melons. Success is a fermentation metabolite of the actinomycete *Saccharopolyspora spinosa*, a soil-inhabiting microorganism, and has a novel mode of action that provides excellent crop protection with a relatively low toxicity to non-target organisms, including many beneficial insects. It has both contact and stomach activity against lepidopteran larvae, leaf miners, and thrips with relatively long residual activity (Palumbo 1999, Palumbo and Reyes 1998, Palumbo et al. 2000). Although foliar applications of spinosad are not highly systemic in plants, translaminar movement in leaf tissue has been demonstrated. Consequently, this route of activity is one of the reasons why Success is felt to be highly efficacious against selected leaf feeding insect pests. It has been suggested that the addition of certain penetrating surfactants may increases translaminar movement and insecticidal activity on pests that mine within leaves and feed on lower leaf surfaces (Larson, 1997). However, other anecdotal reports have suggested that the performance of Success ® (spinosad) can be negatively impacted when buffered with adjuvants to create acidic spray conditions. Unfortunately, little information is available concerning the influence of spray adjuvants on the activity of Success on leafy vegetables and melons under dessert growing conditions. Because numerous surfactants are commonly used with insecticide applications, several studies were designed to evaluate the effects of surfactants on the activity of Success against several insect pests on melons and lettuce.

Methods and Materials

Spray Adjuvants on Fall Melons The purpose of this study was to determine whether the addition of spray adjuvants improve the activity of Success against *Liriomyza* leafminers. Cantaloupe plots were established on September 12, 2000

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('Topmark') and August 16, 2001 (American Takii - W1060') and managed similarly to local growing practices. Plots consisted of two 42-inch beds, 75 ft long with a 2 bed untreated buffer between each plot. The study was designed as a randomized complete block design (4 rep/treatment) with the program treatments applied to melons as shown in Table 1.

Table 1. Success and Spray Adjuvant combinations used in studies.

Insecticide	Adjuvant	Type
1. Success (6 oz)	None	
2. Success (6 oz)	Agridex (0.125 % v/v)	Crop oil concentrate
3. Success (6 oz)	DyneAmic (0.125 % v/v)	Crop oil + Organosilicone
4. Success (6 oz)	Kinetic (0.125 % v/v)	Organosilicone
5. Agrimek (8 oz)	Agridex (0.125 % v/v)	Crop oil concentrate
6. Untreated Check		

Foliar applications were made with a backpack, CO_2 sprayer delivering 18 GPA at 50 psi through 2 nozzles (TX18 ConeJet) per bed. Sprays were applied on Oct 10, 17, 2000 and Sep 9 and 16, 2001. The plant size at the 1st application was 3-4 leaf stage and 6-8 leaves at the 2nd application. All adjuvants were applied at equal rates (0.125% volume to volume) as indicated above. The impact of each treatment on leafminer adult mortality was estimated by counting the number of dead adults on leaf surfaces at 1-4 days following each spray application. Larval mortality was estimated by counting the number of live, dead, and parasitized larvae, and empty and total mines per leaf. A total of 10 leaves per plot were collected and examined in the laboratory for presence of mines and larvae on each sample date. In addition, population efficacy was determined by counts of the total number of pupae emerging from 10 randomly selected leaves in each replicate. These leaves were taken into the laboratory and placed in emergence containers to allow for pupation and emergence of *Liriomyza* and parasitoid adults. The total number of pupae, leafminer (*Liriomyza sativa* and *L. trifolii*) and parasitoid adults, and dead pupae which did not yield adults were counted. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Spray Adjuvants on Spring Lettuce-Thrips. The objective of the study was to compare the efficacy of Success and adjuvant combinations against western flower thrips on head lettuce. Lettuce was direct seeded on Dec 12, 2001 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 50 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Success and adjuvant combinations are shown in Table 1. All adjuvants were applied at equal rates (0.125% volume to volume) as indicated above. Foliar applications were made with a CO_2 operated boom sprayer operated at 50 psi and 26.5 GPA. A directed spray (~75% band, with rate adjusted for band) was delivered through 3 nozzles (TX-18) per bed. Sprays were applied on 7 and 19 February, and 5 March. Numbers of thrips (adults and larvae) from 8 plants per replicate were recorded on each sample date. Relative thrips numbers were measured by removing plants and beating them vigorously against a screened pan for a predetermined time. A 6 in. by 6 in. sticky trap was placed inside of the pan to catch the dislodged thrips. Sticky traps were then taken to the laboratory where adult and larvae were counted. WFT counts were transformed ($\log_{10}$ n+1) before analysis of variance to stabilize variances that were found to be heterogeneous. Untransformed means are presented in tables. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Spray Adjuvants on Fall Lettuce – Worms: Field efficacy trials and laboratory bioassays were conducted in three trials at the Yuma Ag Center to investigate the influence of adjuvants on the efficacy of Success against beet armyworm and cabbage looper in head lettuce. Lettuce, 'Diplomat' was direct seeded into double-row beds on Aug 26, 1999 at the Yuma Valley Agricultural Center, Yuma, AZ. Each plot consisted of four, 30 ft long beds spaced 42 inches apart and bordered on each side by 2 untreated beds. Plots were replicated 4 times in a RCBD. The following adjuvants used with Success (6 oz/acre) were tested during the study: Latron CS-7 (0.125 % v/v), Silwet (0.05 % v/v), LI700 (0.125%), and Coax (0.625%). Foliar applications were made with a tractor drawn, hydraulic sprayer that delivered 30 GPA at 50 psi. A directed spray was applied to each bed by 3 nozzles/bed.

Field Efficacy: The various insecticide*adjuvant combinations were investigated by sampling 10 plants / replicate in the center 2 rows of each replicate. Samples were taken 1 day before treatments were applied (precount), and at 6 d after treatment (DAT). The number of small BAW (>10mm), large BAW (>10 mm in length) , small CL (<5 mm) and large CL (> 10 mm) that were alive were counted and recorded.

Laboratory bioassay: Individual leaves (3 / rep) were collected from sprayed plants at 4 hr after treatment and brought into the laboratory. The leaves were taken from the middle of the plant that were partially covered by upper leaves. A leaf disks (70mm diam) was then removed from each leaf and placed into petri dishes. Five 2nd instar beet armyworm and five 2nd instar cabbage loopers were placed within each petri dish. Larvae were obtained from a laboratory colony at the USDA/ARS Western Cotton Research Lab in Phoenix. The dishes were placed at room temperature for 5 days (78-80 F), after which the number of dead and alive larvae were recorded for each dish.

Spray Buffers on Success Efficacy in Lettuce.

2001 Bioassay Two separate field applications were made; one on romaine and one on head lettuce to investigate the influence of a spray buffer to acidify spray pH on the residual efficacy of Success against beet armyworm and cabbage. Lettuce, 'Van Mor ' head lettuce, and ' PIC' romaine were direct seeded into double-row beds on Dec 2 at the Yuma Valley Agricultural Center, Yuma, AZ. Each plot consisted of two 30 ft long beds spaced 42 inches apart and bordered on each side by 2 untreated beds. Plots were replicated 4 times in a RCBD. Using data from the previous tests five treatments were applied to the plots: 1). Success applied at 6.0 oz/acre with no buffering agent added (pH 7.9); 2). Success applied at 3.0 oz/acre with no buffering agent added; (pH 7.9); 3). Success applied at 6.0 oz/acre with Buffer Trend 0-8-0 added (0.5 % v/v; pH 4.2); 4). Success applied at 3.0 oz/acre with Buffer Trend 0-8-0 added (0.5 % v/v; pH 4.2); and 5). an untreated control. A single foliar application was made to romaine lettuce on March 27th and head lettuce on April 6th with a CO2 operated boom sprayer that delivered 30 GPA at 50 psi. A directed spray was applied to each bed by 3 nozzles/bed. To measure knockdown mortality, individual leaves (3 / rep) were collected from sprayed plants at 6-hrs after treatment and brought into the laboratory. To measure residual mortality, leaves were collected 5 days following the spray application. The leaves were removed from the upper portions of the plant that had received adequate spray deposition. Once in the lab, a leaf disk (70mm diam) was removed from each leaf and placed into petri dishes. On head lettuce leaves, five 2nd –3rd instar beet armyworm were placed within each petri dish,; for romaine leaves, five 3nd instar cabbage loopers were placed within each petri dish. Larvae were obtained from a laboratory colony at the USDA/ARS Western Cotton Research Lab in Phoenix. The dishes were placed at room temperature for a 5 d duration of infestation (78-80 F). Mortality was scored on each day to calculate cumulative mortality. Foliage consumption was estimated for each leaf with a dish at day 5 and % leaf consumption over was calculated for each treatment. All means were analyzed using a two-way ANOVA and mean differences were estimated using a protected LSD ($p<0.05$).

2002 Field Validation. The objective of the study was to validate the effects of spray buffers on pH of spray solution and Success efficacy in lettuce against cabbage looper and beet armyworm. Head lettuce was direct seeded on 5 Sep at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were four beds wide by 50 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. The following treatments were evaluated: 1. Success applied at 5.0 oz/acre with no buffering agent added (pH 7.8); 2. Success applied at 5.0 oz/acre with Buffer Trend 0-8-0 added (0.5 % v/v ; pH 4.0) ; 3. Proclaim applied at 2.8 oz/acre with no buffering agent added (pH 7.8); 4 Proclaim applied at 5.0 oz/acre with Buffer Trend 0-8-0 added (0.5 % v/v; pH 4.0); and 5. an untreated control. Foliar applications were made with a CO_2 operated boom sprayer operated at 50 psi and 26.5 GPA. A directed spray (~75% band, with rate adjusted for band) was delivered through 3 nozzles (TX-18) per bed. Sprays were applied on 1 Oct. Evaluation of lepidopterous larvae control was based on the number of live larvae per plant sampled from the center 2 rows of each replicate. The plots were sampled at 3, 6, and 9 days after the treatments were applied (DAT). Ten plants per plot were destructively sampled on each sample date. The sample unit consisted of examination of whole plants for presence of small and large BAW and CL larvae. For BAW, larvae were considered small if <5 mm in length, large >5mm. For CL, larvae were considered small if <10 mm, large if > 10 mm. Treatment means were analyzed using a 1-way ANOVA and means separated by a protected LSD $_{(P<0.05)}$.

Results and Discussion

Spray Adjuvants on Fall Melons. In both years, leafminer activity on seedling melons plants was considered moderate. Results from the fall tests in 2000 and 2001 were very similar. The influence of spray adjuvants on Success

activity against adult leafminers is shown in Tables 1 and 2. Following each application, Success applied without an adjuvant appeared to provide the most consistent adult mortality. The adjuvants which contained crop oil concentrates (DynAmic and AgriDex) appeared to provide less adult activity, particularly at longer periods following sprays (4 DAT). Only Success without adjuvant provided significant residual adult mortality. Agrimek, the industry standard for leafminers in melons and lettuce, does not appear to have significant activity on adult leafminer flies.

In contrast, spray adjuvants that provided penetration into leaves, did have a significant influence on larval mortality, and protected leaves from damage caused by leaf mines. Following the first application in both years, all spray treatments had fewer total mines than the untreated check (Table 3 and 4). However, only the Success+adjuvant treatments provided protection from mines similar to AgriMek, where mines where almost negligible. A similar trend was observed following the second application. The Success treatment applied without adjuvant had significantly more mines and feeding damage than any of the Success treatments where adjuvant was used. Pupal counts showed no differences among Success treatments in total pupae, but a significantly greater number of adult *L. sativa* were recovered from the Success treatment that contained no adjuvant (Tables 3and 5).

The results of this study are consistent with the translaminar activity of Success and the feeding behavior of leafminers. First, leafminer adults walk on the surface of leaves, and feed through ovipositional stipules in the leaf surface made by females flies. The more active ingredient remaining on the leaf surface, the more adult mortality can be expected. The addition of adjuvants, particularly those with crop oil, will help the compound penetrate the leaf surface and move into the leaf. Thus, it is not surprising that Success applied alone killed more adults, but was less effective against larvae which feed within the middle layers of leaf tissue. The addition of crop oil to Success provided larval control comparable to Agrimek, which is known to effectively penetrate the leaf where larvae feed. Because mining by larvae is an indication of damage, prevention of larval feeding is probably more important than adult oviposition and feeding (which is minor in most cases). Thus, for specifically controlling leafminers in melons with Success, it is recommended that a crop oil type of adjuvant be added.

Spray Adjuvants on Spring Lettuce-Thrips. Thrips pressure was moderate during the study, initially starting a very low densities and increasing to higher densities at harvest (>80 / plant in the check). As per University of Arizona guidelines, the first application was initiated at low thrips numbers (Figure 1). Significant differences in thrips adults and larvae were not observed among the Success/Adjuvant combinations. Similarly, all the success treatments provided efficacy comparable to the Lannate + Mustang standard. The results of this study are consistent with previous studies that have shown that adjuvants do not improve Success efficacy against western flower thrips. This is not surprising considering that thrips tend to feed on both upper and lower leaf surfaces. What appears to be more important in thrips control is spray timing. Our experience has been that initiating spray treatments before populations become established allows insecticides to effectively prevent thrips population from significantly increasing to damaging levels.

Adjuvants on Fall Lettuce – Worms. During thinning stage, the field efficacy trial showed that all adjuvant/ insecticide combinations provided similar control of BAW at 2 DAT. Unfortunately, data collected at 5 DAT was not usable due to heavy rainfall Four inches of rain was associated with the storm. Consequently, BAW numbers dropped to less than 0.1 / plant in all treatments including the untreated control. A lab bioassay conducted with treated leaves collected 4 hrs after treatment was conducted to measure adjuvants on BAW and CL mortality (Table 6). Success appeared to be negatively affected by the addition of Coax. None of the other adjuvants effected mortality.

At early heading stage, the 4 hr after treatment bioassay showed no differences in CL or BAW morality between Success and any of the adjuvant treatments (Table 7). Field efficacy measured at early heading showed Success provided excellent control of CL and *Heliothis* at 6 DAT regardless of which adjuvant was used (Table 8). This is not surprising considering the excellent activity of Success at 6 oz and the fact that worms tend to contact or ingest the compound quite readily on head lettuce leaves.

Buffers on pH of Spray solution and Success Efficacy in Lettuce. The results of this study clearly showed that acidic spray solutions had a negative impact on the residual efficacy of Success against beet armyworm and cabbage looper in lettuce. Bioassays on romaine lettuce leaves showed that initial knockdown mortality was not affected by Success rate or the pH of the spray solution. As expected, the 90% mortality was observed after 2 days of exposure in the bioassay dishes (Figure 2). However, acidic pH conditions had a significant impact on the residual mortality of larvae in the 3.0 oz/acre Success treatment, where we observed about a 40% reduction in efficacy. Residual efficacy in the higher Success rate was not apparently affected by lower pH. A significant increase in foliage consumption was also observed (Figure 2). Beet armyworm on treated head lettuce responded similarly, but affects of pH on residual mortality

were seen at both high and low rates (Figure 3). Consequently mortality did not differ significantly between the untreated check and the two Success rates sprayed in acidic solutions. Larvae exposed to acidic spray solutions fed significantly more than those feeding on leaves treated with non-acidic sprays. As we had expected, our field data corroborated our laboratory bioassays. Residual efficacy of Success sprayed in an acidic environment against beet armyworm was significantly reduced at 9 DAT and did not differ from the untreated check. We did not observe this phenomena with Proclaim, a microbial-based insecticide derived from fermentation. Similarly, efficacy against cabbage looper was affected at 6 and 9 DAT. Success applied in the absence of a spray buffer (pH=7.8) provided excellent efficacy against both worm species at 9 DAT.

These data corroborate the anecdotal reports of poor Success residual performance when applied in acidic spray solutions. The reasons for this breakdown in residual apparently is related to the Success formulation. Success is formulated as a suspension concentrate made up of suspended granules, each granule containing many spinosad monomers. When Success is mixed in spray solutions at a pH above 6, the Success granules remain intact, thus protecting it from UV degradation However, when in a acidic environment (pH < 6), the granules break, exposing the spinosad monomers to rapid degradation. Thus, knockdown mortality is not immediately affected, but residual mortality becomes reduced as the sprayed product is exposed to UV light for a length of time. In this study 5-9 days of exposure in both spring and fall weather was enough to significantly reduce residual mortality. Under normal conditions in Yuma using Colorado River water, buffers or acidifying agents should be avoided. The product should not be mixed in acid spray solutions if possible. This can be particularly important for growers and PCAs who use the product in tank-mixes with phosphorus-based foliar nutrient sprays like (0-8-0). When used as a foliar fertilizer, recommended rates range from 1-2 qts / 30-50 gal (0.5-1.0 % v/v) by ground and 1 qt / 10-15 gal (1.7-2.5%) by air. All of these concentrations can result in highly acidic water conditions in our study. Furthermore, tank mixing with other pesticides like MSR, dimethoate or Aliette could result in problems if pH is not adjusted. Finally, we recommend that pH levels of all spray mixes should be measured before these types of products are used.

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Table 1. Influence of spray adjuvants on Success efficacy against leafminer adults on treated plants, Fall 2000.

	Mean Dead Leafminer Adults / 20 plants			
	Application # 1		Application # 2	
Treatment	**2 DAT**	**4 DAT**	**2 DAT**	**4 DAT**
Success	1.0 a	0.5 a	7.1 a	2.7 a
Success+Agridex	0.3 b	0 a	4.5 ab	1.0 b
Success+Kinetic	0.5 b	0 a	3.5 bc	1.0 b
Success+DyneAmic	0.3 b	0 a	2.5 bcd	0.8 b
Agrimek	0 b	0 a	0 d	0 c
Untreated	0 b	0 a	0 d	0 c

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

Table 2. Influence of spray adjuvants on Success efficacy against leafminer adults on treated plants, Fall 2001.

	Mean Dead Leafminer Adults / 20 plants					
	Application # 1				Application # 2	
Treatment	**1 DAT**	**2 DAT**	**3 DAT**	**4 DAT**	**2 DAT**	**4 DAT**
Success	5.7 a	4.5 a	3.8 a	1.8 a	2.2 a	0.4 a
Success+Agridex	2.8 bc	1.9 b	1.0 b	1.8 a	0 b	0 a
Success+Kinetic	4.2 ab	1.7 c	1.3 b	0.5 b	0 b	0.1 a
Success+DyneAmic	2.1 bc	1.9 b	1.5 b	1.0 ab	0 b	0 a
Agrimek	0.5 c	0.1 d	1.0 b	0.3 b	0 b	0 a
Untreated	0 c	0 d	0 b	0.2 b	0 b	0 a

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

Table 3. Influence of spray adjuvants on Success efficacy on leafminers pupae collected from infested leaves, YAC Fall 2000.

	Mean per leaf				
Treatment	**Total pupae**	**Dead pupae**	***L. sativae* adults**	***L. trifoilii* adults**	**Parasitoid adults**
October 11					
Success	8.3 b	1.7 a	5.0 b	0	1.7 b
Success+Agridex	0 c	0 b	0 c	0	0 c
Success+Kinetic	1.0 c	0 b	1.0 c	0	0 c
Success+DyneAmic	0 c	0 b	0 c	0	0 c
Agrimek	0 c	0 b	0 c	0	0 c
Untreated	25.0 a	2.3 a	19.4 a	0	3.3 a
October 15					
Success	17.7 b	4.0 b	13.0 b	0 b	0.7 b
Success+Agridex	7.5 cd	1.7 c	4.3 cd	0.8 a	0.7 b
Success+Kinetic	10.3 c	1.7 c	8.0 bc	0 b	0.7 b
Success+DyneAmic	3.3 cd	1.0 c	2.3 d	0 b	0 b
Agrimek	0.3 d	0.3 c	0 d	0 b	0 b
Untreated	30.0 a	6.0 a	20.0 a	0 b	4.0 a
October 23					
Success	8.3 b	1.7 bc	7.7 b	0	2.0 b
Success+Agridex	1.0 c	0.3 cd	0.7 c	0	0 c
Success+Kinetic	2.0 c	0.3 cd	1.7 c	0	0 c
Success+DyneAmic	0 c	0 d	0 c	0	0 c
Agrimek	0 c	0 d	0 c	0	0 c
Untreated	22.7 a	4.3 a	9.7 a	0	8.7 a

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

Table 4. Influence of spray adjuvants on Success efficacy against leafminer larvae in infested leaves, Fall 2001

	Mean per leaf				
Treatment	**Total mines**	**Empty mines**	**Live larvae**	**Dead larvae**	**Parasitized larvae**
September 16					
Success	9.0 b	3.3 b	1.0 bc	4.1 b	0.7 b
Success+Agridex	4.1 cd	0.3 c	1.0 bc	2.7 b	0 c
Success+Kinetic	5.5 c	0.5 c	1.9 ab	2.9 b	0.2 bc
Success+DyneAmic	2.6 de	0 c	0.3 bc	2.3 b	0 c
Agrimek	0.2 e	0 c	0.1 c	0.1 b	0 c
Untreated	17.7 a	5.9 a	3.4 a	6.4 a	2.0 a
September 23					
Success	7.2 b	2.4 a	0.2 a	3.1 b	1.5 ab
Success+Agridex	3.4 c	0.5 b	0 a	2.5 b	0.4 b
Success+Kinetic	7.0 b	0.2 b	0.1 a	6.0 a	0.7 b
Success+DyneAmic	2.4 c	0 b	0 a	2.2 b	0.2 b
Agrimek	0.3 d	0 b	0 a	0.3 c	0 b
Untreated	14.2 a	2.8 a	0.2 a	8.1 a	3.3 a

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

Table 5. Influence of spray adjuvants on Success efficacy on leafminers pupae collected from infested leaves, YAC Fall 2001.

	Mean per leaf				
Treatment	**Total pupae**	**Dead pupae**	***L. sativae* adults**	***L. trifoilii* adults**	**Parasitoid adults**
September 16					
Success	1.2 b	0.1 a	1.2 a	0 a	0.4 b
Success+Agridex	0.8 b	0.1 a	0.5 bc	0 a	0.2 b
Success+Kinetic	1.1 b	0.2 a	0.5 bc	0 a	0.4 b
Success+DyneAmic	0.3 b	0 a	0.2 bc	0 a	0.1 b
Agrimek	0.1 b	0 a	0.1 c	0 a	0 b
Untreated	5.1 a	0.3 a	3.1 a	0.5 a	1.2 a
September 23					
Success	0.4 b	0.1 a	0.1 b	0 a	0.2 ab
Success+Agridex	0 b	0 a	0 b	0 a	0 b
Success+Kinetic	0.1 b	0 a	0 b	0 a	0.1 b
Success+DyneAmic	0 b	0 a	0 b	0 a	0 b
Agrimek	0 b	0 a	0 b	0 a	0 b
Untreated	0.8 a	0 a	0.4 b	0 a	0.4 a

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

Table 6. Influence of adjuvants on larval mortality on lettuce leaves collected 4 hr after treatment with Confirm and Success in a laboratory bioassay. Thinning stage (4-5 leaves/ plant) (Sept 22 application)

				Larval mortality (%)			
				Cabbage looper		Beet armyworm	
Treatment	Rate (oz)	Adjuvant	Rate (v/v, %)	2 DAT	5 DAT	2 DAT	5 DAT
Success	6	—	—	95 a	100 a	98 a	100 a
Success	6	Latron	0.125	98 a	100 a	100 a	100 a
Success	6	Silwet	0.05	95 a	100 a	95 a	100 a
Success	6	LI 700	0.125	98 a	100 a	96 a	100 a
Success	6	Coax	0.625	20 b	66 b	29 b	40 b
Untreated	—	—	—	2 c	5 c	0 c	5 c

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

Table 7. Influence of adjuvants on larval mortality on lettuce leaves collected 4 hr after treatment with Success in a laboratory bioassay, - Early heading stage (12-14 leaves/plant) - YAC 1997

				Larval mortality (%)			
				Cabbage looper		Beet armyworm	
Treatment	Rate (oz)	Adjuvant	Rate (v/v, %)	2 DAT	5 DAT	2 DAT	5 DAT
Success	6	—	—	80 a	100 a	48 b	98 a
Success	6	Latron	0.125	78 a	100 a	68 a	100 a
Success	6	Silwet	0.05	83 a	100 a	52 b	100 a
Success	6	LI 700	0.125	61 b	97 a	55 ab	95 a
Untreated	—	—	—	0 c	0 b	0 c	0 b

Means followed by the same letter are not significantly different, ANOVA; LSD $_{(p<0.05)}$

TABLE 8. Influence of adjuvants on larval populations sampled on lettuce plants 6 days after treatment with Confirm and Success in small fields plots, YAC, Fall 1997 (10/14/97).

		Mean no. larvae / 5 plants at 6 DAT						
		Beet armyworm	Cabbage looper			*Heliothis*		
Treatment	Adjuvant	All stages	Small	Large	Pupae	Small	Medium	Total larvae
Pre-count[a]		*0.2*	*1.6*	*5.4*	*0.8*	*1.0*	*3.4*	*12.4*
Success	—	0 b	0 b	0 a	0 b	0 a	0 c	0 b
Success	Latron	0 b	0 b	0 a	0.3 b	0 a	0 c	0.3 b
Success	Silwet	0 b	0 b	0 a	0 b	0 a	0 c	0 b
Success	LI 700	0 b	0 b	0 a	0 b	0 a	0 c	0 b
Confirm	—	0 b	1.7 a	0.3 a	0 b	0.7 a	1.0 abc	3.7 b
Confirm	Latron	0 b	1.3 a	0 a	0.7 ab	0.3 a	0.7 bc	3.0 b
Untreated	—	0.3 a	1.7 a	7.6 b	1.0 a	0 a	2.3 a	12.9 a

a / No significant differences among treatments in the number of BAW, CL, and Hel larva. Pre-count numbers reflect the average of larvae across all plots sampled 1-day prior to treatment.

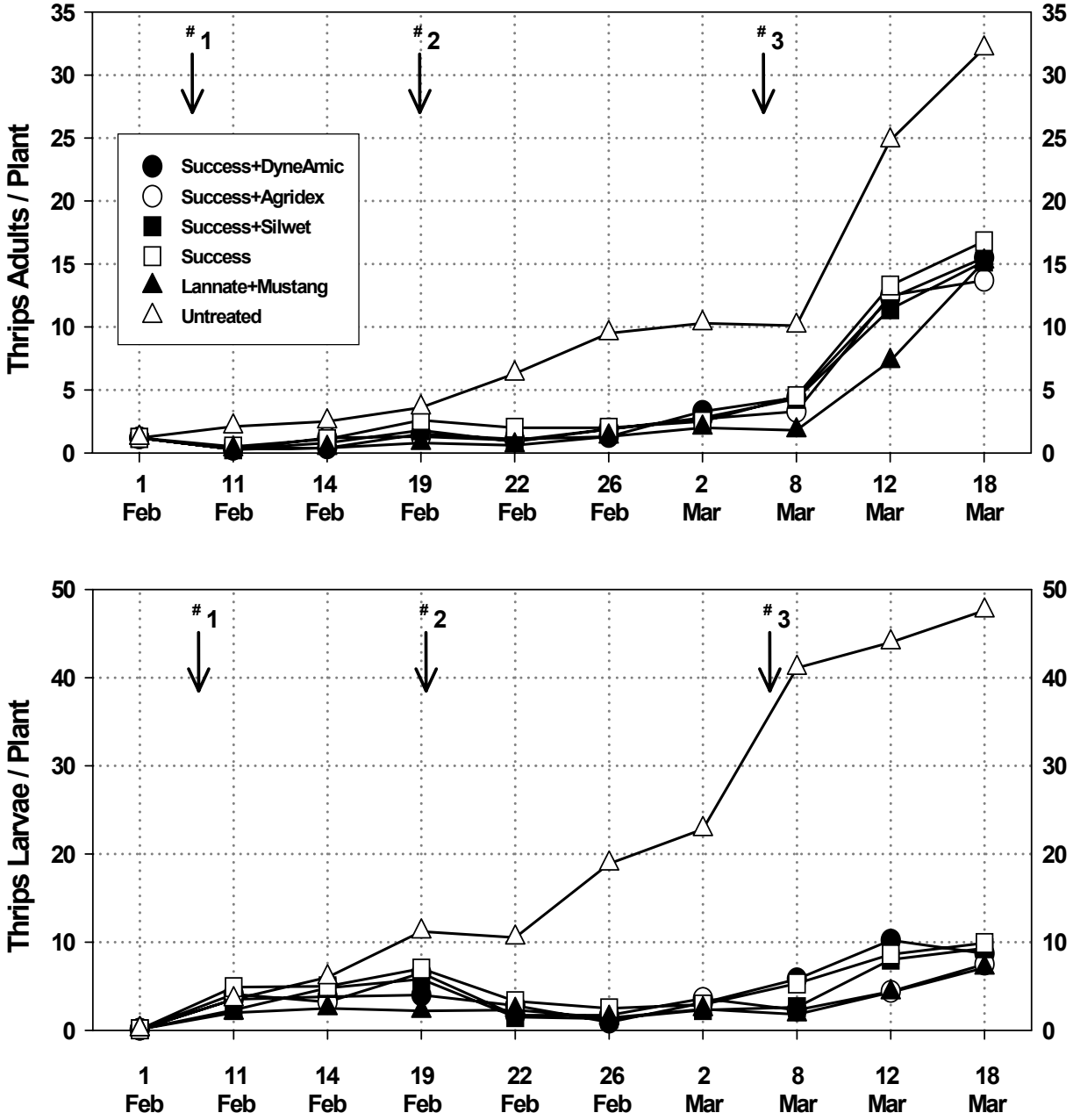
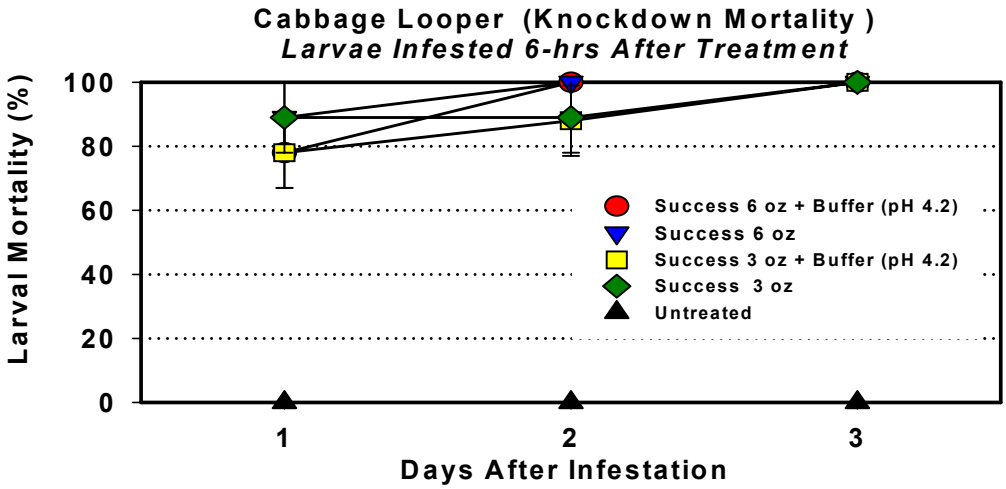
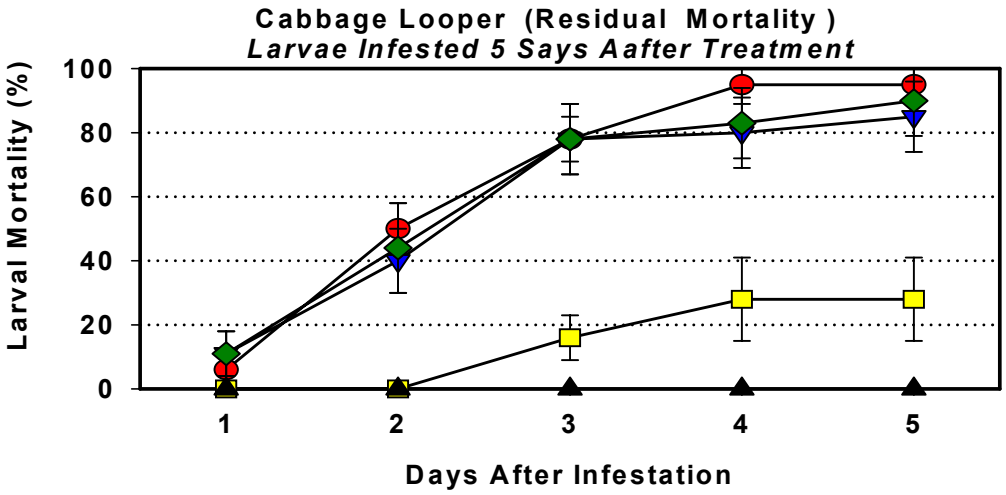


Figure 1. **Efficacy of Success and adjuvants against western flower thrips in head lettuce, YAC, spring 2002; A, Adults; B, Larvae; Arrows indicate spray applications.**





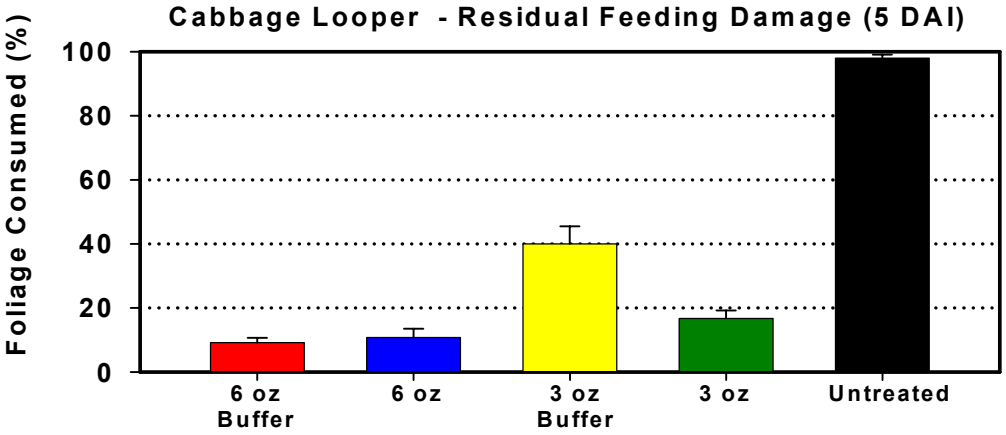


Fig. 2 Influence of Buffer and acidic spray solution on field efficacy of Success in head lettuce, YAC, 2001

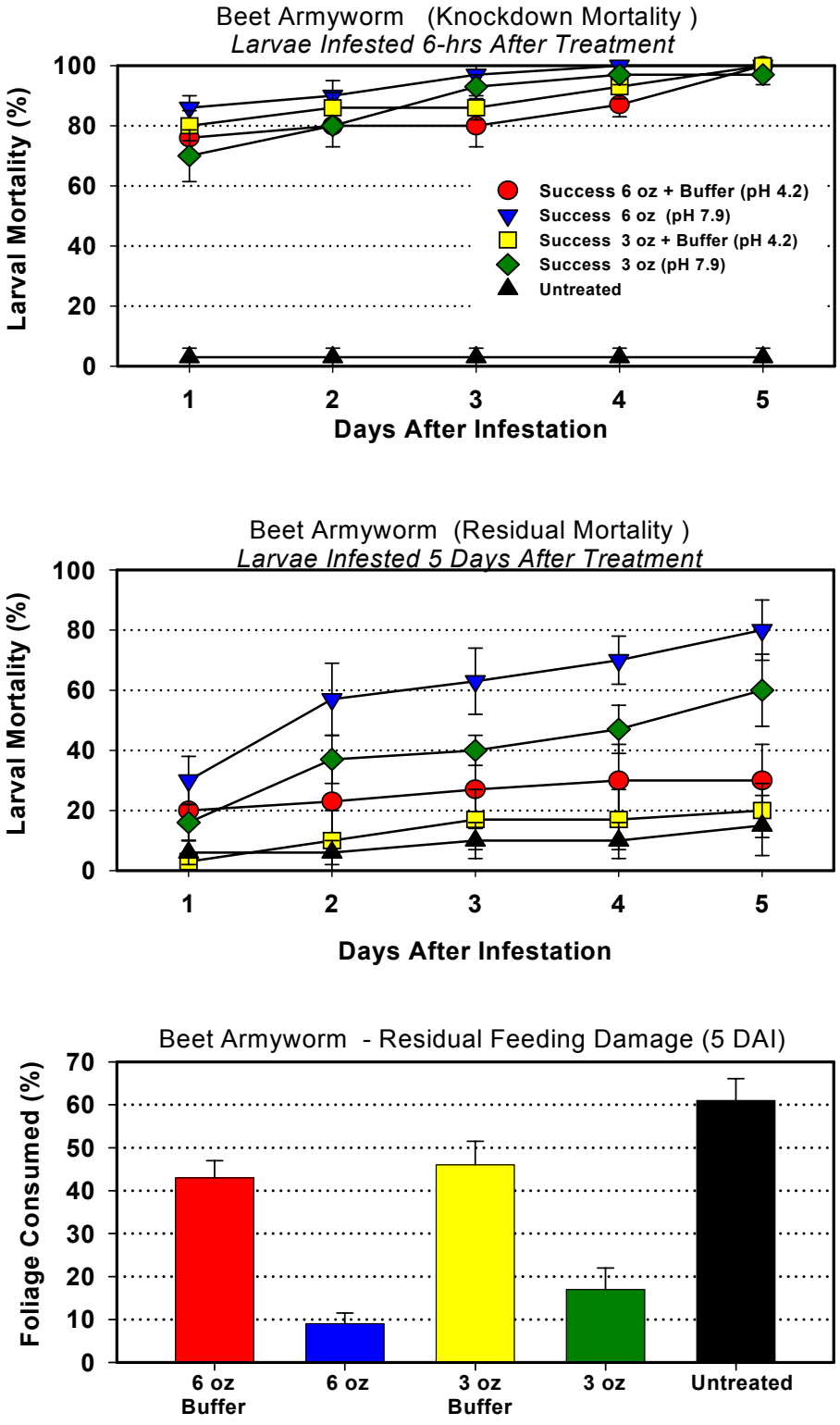


Fig. 3 Influence of Buffer and acidic spray solution on field efficacy of Success in head lettuce, YAC, 2001

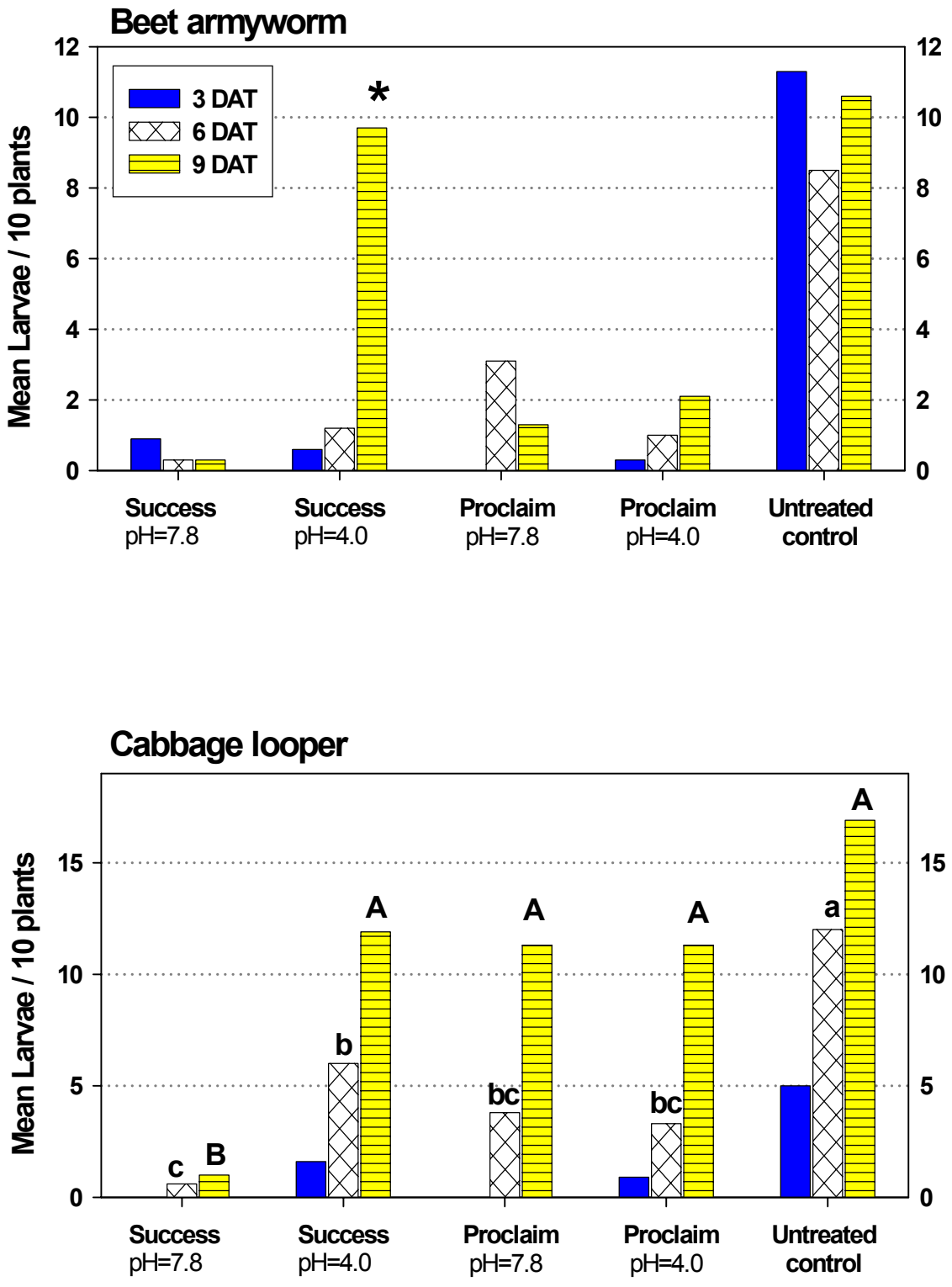


Fig. 4 **Influence of Buffer and acidic spray solution on field efficacy of Success in head lettuce. *, indicates no difference *(p<0.05)* from checkin upper graph. Means followed by the same letter are not significantly different, ANOVA; LSD *(p<0.05)***