Comparisons of Insecticides on Fall Alfalfa Insect Populations, and Resultant Hay Yields and Quality

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Abstract

Three insecticide active ingredients (cyfluthrin, indoxacarb, and zetacypermethrin) were evaluated for their efficacy on several insects found in fall alfalfa in the low desert. Both liquid and wettable formulations were included for both cyfluthrin and zetacypermethrin, and four rates of indoxacarb were applied. Insect pressures were fairly low throughout the study. Pyrethroid chemistries (cyfluthrin, zetacypermethrin) provided excellent control of threecornered alfalfa hoppers for seven days after application while cyfluthrin applications resulted in lowest numbers of pale striped flea beetles during the same time period. All chemistries resulted in excellent control of the South American bean thrips (Caliothrips phaseoli). Indoxacarb treatments resulted in significantly increased levels of spotted alfalfa aphid, thought due to a reduction of big eye bugs noted with usage of this chemistry. Wettable formulations of both cyfluthrin and zetacypermethrin resulted in significant hay yield increases (0.1 tons/acre) when compared with their liquid formulations. An inverse yield trend was noted with indoxacarb rate. Usage of the liquid cyfluthrin chemistry also resulted in an unexplained quality decrease in this experiment.

Introduction

A complex of fall alfalfa insect pests often occurs and peaks in population during the late summer and early fall in low desert production. Members of this fall insect complex include the threecornered alfalfa hopper (*Spissistilus festinus* Say), leafhoppers (*Empoasca* spp.), and to a lesser extent silverleaf whiteflies, flea beetles, and various caterpillars, such as granulate cutworm, beet armyworm and alfalfa caterpillar. Spotted alfalfa aphids (*Therioaphis maculata*) are also beginning to be noted about the same time of year.

The effects of leafhopper feeding results in a diamond shaped yellowing of leaflets. Severe infestations that are not controlled result in symptoms known as hopperburn and/or hopper yellows. The feeding of leafhoppers can also cause alfalfa plants to be stunted in growth, with reduced vigor of the regrowth in the following cutting. Separating and documenting the effects of a single insect on alfalfa production is often difficult to do under field conditions in the low desert because other insect species of the fall complex are usually present.

Limited data are available for fall insect pressures and resultant alfalfa yields and quality in the low desert. Rethwisch (2000) reported a significant increase in hay quality at harvest from insecticidal control of threecornered alfalfa hoppers averaging 9.2/three foot sweep and *Empoasca* spp. leafhoppers averaging 9.4/three foot sweep during the 7 days immediately after application. This application was made 11 days prior to harvest and summer black stem and leaf spot disease (*Cercospora medicaginis*) was present. Yield data were unable to be obtained.

In a 2000 experiment threecornered alfalfa hopper populations averaged 10.9/three foot sweep in the 10 days after application, although leafhopper numbers were much less, averaging only 1.93/three foot sweep over the same period while summer black stem and leaf spot were not present (Rethwisch and Nelson, 2001). Data from this experiment indicated that of six insecticide treatments evaluated, only Baythroid® resulted in an economical yield increase while no

significant differences were noted for quality parameters. It was hypothesized that yield increases noted were due to both insect control coupled with xylene present in carriers of the two highest yielding (Baythroid®, Dimethoate) treatments (Rethwisch and Nelson, 2001).

In the past several years new insecticide chemistries and formulations have become available for alfalfa insect control that have note been evaluated for fall insect control in low desert alfalfa. This experiment was initiated to determine the effects of several of these new chemistries/formulations on fall alfalfa insects as well as resultant effects on alfalfa yield and quality.

Methods and Materials

A second year field of 'Highline' alfalfa grown on beds with 40 inch centers was utilized for this experiment. Treatments were applied with ground application equipment on the morning of 22 September, 2003, with a Melroe 3640 SpraCoupe (James and van Dyke, Blythe, CA) calibrated to deliver 25 gpa with T-Jet 8006 spray tip nozzles on 20" centers and with a boom height of 20 inches. R-11 surfactant (Wilber-Ellis Company) was used at the rate of 0.05% vol/vol. Insects known to be adequately present at time of application for insecticide efficacy studies included threecornered alfalfa hoppers and pale striped flea beetles.

Three insecticide active ingredients were tested (cyfluthrin, indoxacarb, and zetacypermethrin). Four rates (11.3, 9.6. 6.7 and 4.5 oz./acre) of the product containing indoxacarb (Steward®) were included in the experiment. The other two active ingredients were tested twice, comparing the same rates of active ingredient per acre in both liquid and wettable powder or emulsifiable wettable formulations. The formulation comparisons included Baythroid® 2EC and Renounce® 20WP for cyfluthrin, and Mustang MAX™ 0.8 EC and Mustang MAX™ 0.8EW for zetacypermethrin. Treatments were replicated four times in a randomized complete block design. Plots were 26.67 feet wide (8 beds) and were 1,083 feet long. Alfalfa regrowth was 13.5 inches tall at application.

Plots were sampled at 1, 4 , 7, 10, and 15 days post treatment (Sept. 23, 26, 29, Oct. 2, 7). Sampling consisted of ten 90 degree sweeps across a bed of alfalfa with a 15 inch diameter sweep net, with each sweep being about 36-40 inches long. Insects from each plot sample were transferred to containers, frozen, and then later separated, counted, and recorded. Plots were swept mid to late afternoon.

Field was harvested (swathed) on October 13th, and resulting 'rows' were raked together on October 16th. Hay was baled the morning of October 17th. Bale counts and weights (minimum of 4/plot) were obtained from each plot, and yields/acre were calculated. Quality samples were also obtained from 3-4 bales/plot of each treatment. Samples consisted of the cores from ends of 3-4 consecutive bales obtained with a Utah sampler. Samples were analyzed for various quality components by near infrared technology (Stanworth Crop Consultants, Blythe, CA).

All data were analyzed utilizing Statgraphics Plus for Windows (Manugistics, Inc.), and separations of treatment means for the various insects was accomplished using a Fishers least significant difference.

Results

Insect pressures were very light for many species, especially *Empoasca* spp. leafhoppers, during the duration of the experiment, and therefore distinct differences that may have been noted with greater numbers of insects were not always able to be obtained. On the other hand, this study did allow insecticide efficacy data to be collected on the South American bean thrips (*Caliothrips phaseoli*), and is thought to be the first such US insecticide data on this particular insect species.

Threecornered alfalfa hopper

Threecornered alfalfa hoppers were present throughout the study at adequate levels in this experiment to allow excellent data to be collected. All insecticide treatments significantly reduced numbers of threecornered alfalfa hoppers when compared with the untreated check through seven days post treatment (Table 1). Pyrethroid treatments

(Baythroid®, Renounce®, Mustang MAX™) provided excellent (90%+) control in the first seven days of this experiment, with a minimum of 86.8% control (Mustang MAX™ 0.8EC) noted at seven days post treatment. Steward® treatments resulted in about 70% less threecornered alfalfa hoppers than the untreated check during this time period. All treated alfalfa had fewer threecornered alfalfa hoppers than the untreated check from 10-16 days post treatment, although some of the Steward® treatments were not statistically different than the untreated check.

Pale striped flea beetle

Populations of this insect at the beginning of the experiment were about 1/sweep with a populations reduction noted at 10 days post treatment. Pyrethroid treatments provided excellent control at one day post treatment (Table 2), although applications of Steward® also resulted in numerically fewer numerically adult beetles on this sample date. After this sample date numbers of pale striped flea beetles in untreated and Steward® treated alfalfa were very similar.

Differences were noted between the two pyrethroid chemistries for pale striped flea beetle control however at four and seven days post treatment. Fewer flea beetles were swept from foliage treated with cyfluthrin chemistries (Renounce®, Baythroid®) than with Mustang MAX™ formulations at four and especially at seven days after application, as number of flea beetles noted in Mustang MAX™ treated alfalfa was higher than the untreated check at this latter sample date. Numbers of flea beetles of all pyrethroid treated alfalfa were slightly higher than the untreated check at 10 and 16 days post treatment.

Bean Thrips

Numbers of bean thrips were fairly low in this experiment, with populations near 1/sweep during the first four days after application and declining thereafter. All insecticide treatments resulted in significantly fewer bean thrips than untreated alfalfa at one and four days post treatment (Table 3) with no notable differences for control noted between treatments. At 10 days post treatment only the Baythroid® treatment had significantly fewer bean thrips than the untreated check, while at 16 days after application only Baythroid® and the 11.3 oz./acre rate of Steward® had significantly fewer bean thrips than the untreated check.

Silverleaf whiteflies

Silverleaf whiteflies were the most prevalent insect in this study, and were thought to be migrating out of area cotton that had been defoliated and settling into alfalfa. No treatment was significantly different than the untreated check at one day post treatment (Table 3). Liquid formulations of pyrethroid insecticides had numerically fewer whiteflies than their wettable forms, with Renounce® having significantly more (97.0 in 10 sweeps) than Baythroid® (47.75) at one day post treatment. At four days post treatment highest numbers of whiteflies were in the pyrethroid treated plots, especially those treated with Mustang MAX™, with Steward® treated plots similar to slightly less than the untreated check. Treatment means for numbers of whiteflies were not statistically different from the untreated check at 7, 10 or 16 days post treatment.

Spotted alfalfa aphids

Spotted alfalfa aphids were noted at fairly low populations throughout the study, necessitating data expression as numbers per 10 sweeps. The untreated check never reached one/sweep (= 10/10 sweeps) in this study although spotted alfalfa aphids exceeded this level in Steward® treated alfalfa at seven days post treatment (Table 5). There was a trend for more spotted alfalfa aphids as rate of Steward® increased from this point of the experiment. The exact reason for this is unknown, but be may related to the numbers of beneficial insects such as big eye bugs as high rates of Steward® resulted in fewest numbers of this beneficial predatory insect. No significant differences were noted for numbers of spotted alfalfa aphids from pyrethroid insecticide treated alfalfa when compared with the untreated check in this experiment.

Leafhoppers

Populations of *Empoasca* leafhoppers were very, very low (less than 6 per 10 sweeps) during the course of this experiment (Table 7), with higher populations of a complex of other leafhopper species thought to include the clover leafhopper *Aceratagallis sanquinolenta*; *Agallia quadripunctata*, and *Agalliopsis* sp. (species determinations are still awaited) present (Table 8) than *Empoasca* spp. leafhoppers noted.

Because of the low numbers of *Empoasca* spp. leafhoppers present, few treatments resulted in significantly fewer *Empoasca* sp. leafhoppers than the untreated check. Significantly fewer *Empoasca* spp. leafhoppers were noted from alfalfa treated with Renounce® at seven days post treatment than in untreated alfalfa, and at 10 days after application both the low (4.6 oz/acre) rate of Steward® and the Baythroid® treated alfalfa had significantly fewer leafhoppers than untreated alfalfa. It appears that treatments containing cyfluthrin (Baythroid®, Renounce®) had more activity on the *Empoasca* spp. leafhoppers present than did Mustang MAX™ based on leafhopper numbers at seven days post treatment, but too few leafhoppers were present to conclude such without further testing. All treatments resulted in numerically fewer *Empoasca* spp. leafhoppers than untreated alfalfa at both seven and 10 days post treatment.

Almost all treatments resulted in significantly fewer clover leafhopper/complex of similar appearing species than the untreated check throughout the experiment (Table 8) with no leafhoppers from this complex collected from any of the pyrethroid treated alfalfa at one day post treatment. Steward® treatments resulted in a range of 36-73% fewer leafhoppers of this complex than noted from untreated alfalfa at one day post treatment. Pyrethroid treatments resulted in numerically fewer leafhoppers at four and seven days post treatment than most Steward® treatments. Lowest average number of these types of leafhoppers throughout the experiment were noted in the Baythroid® (0.7/10 sweeps) and the high rate (11.3 oz./acre) of Steward® (0.8/10 sweeps).

Lygus Bugs

Data on lygus bugs were separated by different life forms (small nymphs, large nymphs, adults) in this study. Small nymphs were almost non-existent at one day post treatment (Table 9), but reached one/sweep in untreated alfalfa by seven days post treatment. Steward® treatments resulted in significantly fewer small lygus bug nymphs at four and seven days post treatment than the untreated check with the exception of the 9.2 oz/acre rate, which still had 47% fewer small nymphs than the untreated check at seven days post treatment, and the two lower rates of Steward® at four days post treatment. At seven days post treatment the liquid forms of the pyrethroid insecticides resulted in 2-2.5x more small nymphs than their wettable counterpart formulations, and were similar in number to that noted from untreated alfalfa, while wettable formulations of both cyfluthrin and zetacypermethrin had significantly fewer small nymphs than the untreated check. Differences between treatment formulations were statistically significant for Mustang MAX™. The reason for these differences is unknown. No treatments were significantly different for numbers of small lygus bug nymphs from the untreated check at 10 or 16 days post treatment.

Numbers of large lygus bug nymphs were also very low in all plots through seven days post treatment (Table 10) with the exception of the Renounce® treatment which had more large lygus bugs at seven days post treatment (4.5/10 sweeps) than any other treatment. No statistical differences were noted at 10 days post treatment. At 16 days post treatment the Baythroid® and the Mustang MAX™ EW treatments had more large lygus bug nymphs than the untreated check.

Adult lygus bugs were not as prevalent in this study as the nymphal forms, with highest average of 4.75/10 sweeps noted for Baythroid® at 16 days post treatment (Table 11). This was the only treatment and sample date that resulted in significantly more lygus bug adults than the untreated check from 4-16 days post treatment. At one day after application almost all treatments resulted in numerically and often significantly fewer adult lygus bugs than the untreated check with the exception of Baythroid® which had equal numbers of adult lygus bugs as the untreated check.

Several of the Steward® treatments resulted in significantly fewer total lygus bugs than the untreated check at seven days post treatment (Table 12), indicating that this product has activity against lygus bugs. A trend was noted for fewer lygus bugs as rate of Steward® increased as both four and seven days after treatment. Fewest total lygus bugs were noted from alfalfa treated with the 11.3 oz./acre rate of Steward® at 10 days post treatment, but no treatment resulted in a statistical difference of total lygus bugs when compared with the untreated check at 10 or 16 days post treatment although a few treatments had 50% more than collected from untreated alfalfa at the latter sample date.

Big eye bugs

Big eye bugs were fairly numerous throughout the study. All treatments resulted in a significantly fewer big eye bug nymphs (Table 13) and as well as fewer adults (Table 14) at one day post treatment. Nymphal numbers from treated alfalfa continued to be numerically less than the untreated check through 16 days post treatment. Of the insecticide treatment, cyfluthrin chemistries (Baythroid®, Renounce®) and the 4.6 oz./acre rate of Steward® had the most big eye bug nymphs at four and seven days post treatment. Similar results were noted for adults on these sample dates, but numbers

of big eye bug adults tended to be higher in both Mustang MAX™ treatments than in the top three rates of Steward® evaluated (Table 14). When data for both adults and nymph were combined (Table 15) it was noted that from the highest three rates of Steward® had significantly fewer big eye bugs than the 4.6 oz./acre rate and the untreated check at seven days post treatment, and numerically less than the pyrethroid treatments at both seven and 10 days post treatment.

Minute pirate bugs

Numbers of minute pirate bugs were very low throughout this study (Table 16). All treatments significantly reduced minute pirate bugs at one day post treatment when compared with the untreated check, however by seven days post treatment the untreated check was lower than any other treatment. This is thought due to the insecticide treatments having activity on other predacious insects, such as damsel bug and big eyed bugs, that may also feed on the much smaller minute pirate bugs, resulting in lower levels of these predators than in the untreated check.

Damsel bugs

Damsel bugs were not very numerous in this study, but some treatment differences for numbers of damsel bugs were noted. All treatments resulted in fewer damsel bugs than the untreated check at one day post treatment (Table 17). At four days post treatment no damsel bugs were noted from three of the four pyrethroid treatments, although were detected from alfalfa treated with all four rates of Steward®. At four days after application damsel bugs from several of the Steward® treatments were often significantly fewer than the untreated check. Of the treatments evaluated the pyrethroid chemistries appear to be more active against damsel bugs than Steward®.

Predacious insects

Predacious insects included the big eye bugs, damsel bugs, minute pirate bugs and *Collops* sp. beetles. All insecticide treatments resulted in significantly fewer predacious insects than the untreated check at one day post treatment as well as 10 days post treatment (Table 18). At four days post treatment only the Renounce® treatment did not have statistically fewer predacious insects than the check, although the Renounce® treatment had about 40% fewer predators. At seven days after application numbers of predacious insects in the Renounce® treatment and the low (4.6 oz./acre) rate of Steward® were very similar numerically to the untreated check (12.25-13.0/10 sweeps), although all other treatments resulted in significantly lower levels of these predacious insects. Fewest predacious insects were noted in Steward® treatments at 10 days post treatment.

Leafminer flies

Leafminer flies were present and continued in increase in number throughout the study (Table 19). No treatment resulted in significant differences from the untreated check at one day or four days after application, but the average number of adult leafminers/10 sweeps was only 1.0 and 1.25 for the untreated check for these two sample dates respectively. At seven days after application, there were numerically more leafminer flies from alfalfa treated in insecticide than the untreated check. Greatest increase in adult leafminer flies attributed to insecticide application was noted at 16 days post treatment, as all pyrethroid treatments resulted in at least 6 flies/sweep. Fewest flies were noted in the high rate of Steward® on this sample date.

Wasps

The wasps included several parasitic species. Populations of these were fairly low in the first two sample dates. Steward® treatments tended to have more wasps at seven day post treatment than did the untreated check, which had similar numbers as the pyrethroid treated alfalfa (Table 20). Wasps were almost undetectable from samples at 10 days post treatment, and no treatment had numbers of wasps that were significantly different than the untreated check at 16 days after application.

Beet armyworms

Beet armyworms were not prevalent in this study. No statistical differences were noted at one, four, ten or 16 days post treatment (Table 21). Several treatments resulted in significantly fewer beet armyworms than noted from untreated alfalfa at seven days post treatment, including the liquid formulations of both pyrethroid insecticides and three of the four rates of Steward®.

Hay Yields

Alfalfa hay yields in this experiment ranged from 0.87-0.98 tons/acre, with none of the treatments being significantly different than the untreated check (Table 22) which was not entirely surprising as insect pressures were fairly low throughout the experiment. Several things were notable however, one of which included a trend for slightly lower yields as amount of Steward® increased. The reason for this trend is unclear but could be due to insecticide/plant photosynthesis interactions.

The second item of note was that alfalfa hay yields were significantly different between the wettable vs. liquid formulations for both pyrethroid insecticides, with wettable forms having significantly higher yields (0.1 tons/acre) than their liquid counterparts. The pyrethroid insecticide permethrin was documented to decrease photosynthesis of lettuce plants by up to 17.1% for at least eight days after an application, and reduced transpiration rates by 16.1% at one day post treatment and 28.2% at eight days, a much longer and greater reduction than other insecticide classes tested (Sances et al., 1981) The yield reduction noted between the liquid and wettable forms of the two different pyrethroid insecticide active ingredients in light of the lettuce photosynthesis data may indicate that differences could be due to emulsifiers associated with the liquid forms of the insecticides rather than the active ingredient itself. More experimentation is needed to verify if hay yield differences noted between formulations in this experiment are consistent.

Alfalfa Hay Quality

Often an inverse relationship exists for hay yields and hay quality. In this experiment application of Baythroid®, which resulted in the lowest alfalfa yields, also resulted in the lowest alfalfa hay quality when very light insect pressures existed (Table 22). Highest acid detergent fiber, as well as lowest levels of crude protein, total digestible nutrient and relative feed value were all noted from the Baythroid® treatment with many of these quality parameters statistically different than the untreated check. The reason for the quality reduction for the Baythroid® treatment alone is unknown and was unexpected as highest quality usually occurs in lower yielding hay due to less stem material in relation to leaf content. Hay quality in terms of acid detergent fiber and relative feed value did increase as rate/acre of Steward® increased, consistent with the inverse relationship often noted for decreased hay yields and increased quality.

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Table 1. Mean numbers of three cornered alfalfa hoppers/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.0 a	1.25a	2.0a	4.75ab	10.75abc
Renounce® 20WP @ 3.0 oz	0.5a	1.0 a	3.25a	3.25a	6.0ab
Mustang MAX™ 0.8EC @ 4 oz	0.0a	1.0a	4.25ab	5.25abc	5.75ab
Mustang MAX™ 0.8EW @ 4 oz	0.0a	0.5a	3.25a	3.5a	5.5a
Steward® 1.25SC @ 11.3 oz	5.0 b	8.25 b	12.5 d	9.75 de	12.5 bc
Steward® 1.25SC @ 9.2 oz	7.5 b	8.25 b	13.0 d	9.0 cd	16.0 cd
Steward® 1.25SC @ 6.7 oz	6.0 b	7.0 b	7.5 bc	5.0ab	7.5ab
Steward® 1.25SC @ 4.6 oz	4.75 b	5.5ab	7.75 c	8.25 bcd	8.75ab
Untreated check	13.75 c	26.0 c	32.25 e	13.5 e	21.25 d

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 2. Mean numbers of pale striped flea beetles/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	15
Baythroid® 2EC @ 2.4 oz	0.25a	1.5a	6.5a	4.0ab	6.75a
Renounce® 20WP @ 3.0 oz	0.25a	0.75a	3.5a	2.75ab	6.5a
Mustang MAX™ 0.8EC @ 4 oz	0.0a	2.75ab	14.75 d	6.5 b	7.5a
MustangMax 0.8EW @ 4 oz	0.0a	2.25ab	8.75abc	5.5ab	7.25a
Steward® 1.25SC @ 11.3 oz	6.25ab	9.0 c	13.0 cd	6.5 b	5.0a
Steward® 1.25SC @ 9.2 oz	5.25ab	8.75 c	9.5 bcd	4.25ab	5.25a
Steward® 1.25SC @ 6.7 oz	3.75ab	7.25 bc	9.75 bc	3.25ab	5.75a
Steward® 1.25SC @ 4.6 oz	3.25ab	7.25 bc	7.5abc	2.25a	7.75a
Untreated check	9.25 b	8.75 c	8.0abc	4.0ab	4.75a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 3. Mean numbers of bean thrips/10 three foot sweep after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	15
Baythroid® 2EC @ 2.4 oz	0.5a	1.33a	0.0a	1.0a	1.5a
Renounce® 20WP @ 3.0 oz	0.25a	1.0 a	0.25ab	2.0abc	2.5ab
Mustang MAX™ 0.8EC @ 4 oz	1.0a	0.97a	0.75ab	1.34ab	2.5ab
Mustang MAX™ 0.8EW @ 4 oz	0.25a	1.0a	0.0a	3.0abc	1.25a
Steward® 1.25SC @ 11.3 oz	1.75a	0.97a	0.75ab	2.0abc	1.5a
Steward® 1.25SC @ 9.2 oz	2.25a	3.25a	3.5 b	4.0 bc	7.75 c
Steward® 1.25SC @ 6.7 oz	1.5a	0.5a	2.0ab	4.25 c	2.75ab
Steward® 1.25SC @ 4.6 oz	0.25a	0.97a	1.0ab	2.0abc	3.0 ab
Untreated check	7.25 b	12.75 b	2.5ab	4.5 c	6.5 bc

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 4. Mean numbers of adult whiteflies/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	15
Baythroid® 2EC @ 2.4 oz	47.75ab	225.4abc	139.0a	235.75bc	150.25a
Renounce® 20WP @ 3.0 oz	97.0 c	317.75 bc	140.5a	193.0abc	173.25a
Mustang MAX™ 0.8EC @ 4 oz	71.0abc	363.7abc	144.75a	149.75ab	167.5a
Mustang MAX™ 0.8EW@ 4 oz	88.5 bc	327.75 c	224.0a	240.8 bc	160.5a
Steward® 1.25SC @ 11.3 oz	54.5 ab	194.4a	200.25a	139.25a	168.5a
Steward® 1.25SC @ 9.2 oz	60.5abc	217.0ab	264.25a	261.0 c	189.5a
Steward® 1.25SC @ 6.7 oz	60.5abc	207.75a	143.25a	198.0abc	145.0a
Steward® 1.25SC @ 4.6 oz	45.25a	178.7a	174.0a	188.75abc	155.0a
Untreated check	60.0abc	217.0ab	146.0a	169.25abc	100.5a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 5. Mean numbers of spotted alfalfa aphids/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	15
Baythroid® 2EC @ 2.4 oz	0.25a	1.5a	2.5a	5.0ab	6.25a
Renounce® 20WP @ 3.0 oz	1.25ab	1.5a	2.75a	6.25ab	10.5ab
Mustang MAX™ 0.8EC @ 4 oz	0.5a	0.5a	4.0a	2.5a	10.0ab
Mustang MAX™ 0.8EW @ 4 oz	2.25ab	1.75a	2.0a	5.75ab	10.5ab
Steward® 1.25SC @ 11.3 oz	3.5 b	0.5 a	21.25 b	7.75abc	14.0ab
Steward® 1.25SC @ 9.2 oz	3.0ab	0.5 a	19.0 b	12.5 c	17.5 b
Steward® 1.25SC @ 6.7 oz	1.25ab	1.25a	12.0ab	9.5 bc	12.25ab
Steward® 1.25SC @ 4.6 oz	2.0ab	1.75a	14.0ab	3.75a	10.25ab
Untreated check	2.0ab	0.75a	3.5a	7.0abc	5.5a

Means in columns followed by the same letter are not significantly different at the p≤ 0.05 level (Fisher's LSD test).

Table 6. Mean numbers of total leafhoppers (*Empoasca* spp., clover leafhopper complex)/ 10 three foot sweep after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz 0.0a	2.5a	1.5a	1.25a	1.5a	
Renounce® 20WP @ 3.0 oz	0.0	0.25a	3.25a	1.5a	3.5abc
Mustang MAX™ 0.8EC @ 4 oz	0.25a	1.0a	5.25ab	1.75a	2.75ab
Mustang MAX™ 0.8EW @ 4 oz	0.0a	2.75a	4.5ab	2.0a	2.0a
Steward® 1.25SC @11.3 oz	1.5ab	1.0a	3.75ab	2.25a	1.5a
Steward® 1.25SC @ 9.2 oz	2.5 bc	4.0ab	6.75ab	2.5ab	3.0ab
Steward® 1.25SC @ 6.7 oz	1.25ab	1.75a	7.75 b	2.75ab	5.25 bc
Steward® 1.25SC @ 4.6 oz	1.25ab	3.25ab	3.75ab	1.25a	2.75ab
Untreated check	3.25 c	7.5 b	16.5 c	5.5 b	6.25 c

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 7. Mean numbers of *Empoasca* sp. leafhoppers/ 10 three foot sweep after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.0a	1.25abc	1.0ab	0.00a	1.0a
Renounce® 20WP @ 3.0 oz	0.0a	0.25a	0.75a	1.0ab	1.0a
Mustang MAX™ 0.8EC @ 4 oz	0.25a	0.5ab	3.0abc	0.75ab	1.75ab
Mustang MAX™ 0.8EW @ 4 oz	0.0a	2.0 bc	2.5abc	1.75ab	0.75a
Steward® 1.25SC @ 11.3 oz	0.5a	0.5ab	3.0abc	1.25ab	0.75a
Steward® 1.25SC @ 9.2 oz	0.75a	2.25 c	1.5ab	1.75ab	1.75aab
Steward® 1.25SC @ 6.7 oz	0.25a	0.75abc	4.0 bc	1.25ab	3.25 b
Steward® 1.25SC @ 4.6 oz	0.5a	0.75abc	1.0ab	0.25a	1.0a
Untreated check	0.5a	1.75abc	5.25 c	2.25 b	2.25ab

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 8. Mean numbers of clover leafhopper complex species/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.00a	1.25a	0.5a	1.25a	0.5a
Renounce® 20WP @ 3.0 oz	0.0a	0.0a	2.5ab	0.5a	2.5 bc
Mustang MAX™ 0.8EC@ 4 oz	0.0a	0.5a	2.25ab	1.0a	1.0ab
Mustang MAX™ 0.8EW @4 oz	0.0a	0.75a	2.0ab	0.25a	1.25ab
Steward® 1.25SC@ 11.3 oz	1.0ab	0.5a	0.75a	1.0a	0.75ab
Steward® 1.25SC @ 9.2 oz	1.75 bc	1.75a	5.25 b	0.75a	1.25ab
Steward® 1.25SC @ 6.7 oz	1.0ab	1.0a	3.75ab	1.5ab	2.0ab
Steward® 1.25SC @ 4.6 oz	0.75ab	2.5ab	2.75ab	1.0a	1.75ab
Untreated check	2.75 c	5.75 b	11.25 c	3.25 b	4.0 c

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 9. Mean numbers of small lygus bugs/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.0a	0.75ab	8.0 bcd	8.5a	6.25ab
Renounce® 20WP @ 3.0 oz	0.25a	2.25 b	4.5ab	6.5a	7.25ab
Mustang MAX™ 0.8EC @ 4 oz	0.0a	0.75ab	10.25 d	7.0a	8.5ab
Mustang MAX™ 0.8EW@ 4 oz	0.25a	0.5ab	4.5ab	6.5a	6.25ab
Steward® 1.25SC @ 11.3 oz	0.0a	0.25a	2.0a	2.75a	6.25ab
Steward® 1.25SC @ 9.2 oz	0.0a	0.25a	5.25abc	8.25a	11.0 b
Steward® 1.25SC @ 6.7 oz	0.0a	0.75ab	4.5ab	6.5a	4.75a
Steward® 1.25SC @ 4.6 oz	0.0a	2.0ab	4.25ab	5.75a	4.5a
Untreated check	0.0a	2.25 b	10.0 cd	6.5a	6.75ab

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 10. Mean numbers of large lygus bug nymphs/ 10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment amd Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.0a	0.0a	0.0a	8.0a	12.25 bc
Renounce® 20WP @ 3.0 oz	0.0a	0.0a	4.5 b	5.75a	6.75ab
Mustang MAX™ 0.8EC @ 4 oz	0.0a	0.0a	0.0a	5.25a	9.25abc
Mustang MAX™ 0.8EW @ 4 oz	0.0a	0.25a	0.25a	5.5a	13.5 c
Steward® 1.25SC @ 11.3 oz	0.0a	0.25a	0.0a	5.25a	6.25a
Steward® 1.25SC @ 9.2 oz	0.0a	0.0a	0.0a	3.5a	6.0a
Steward® 1.25SC @ 6.7 oz	0.0a	0.0a	1.25a	5.5a	9.5abc
Steward® 1.25SC @ 4.6 oz	0.0a	0.0a	1.75ab	5.75a	6.75ab
Untreated check	0.25 b	0.0a	0.5a	6.0a	5.75a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 11. Mean numbers of adult lygus bugs/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	1.25 c	1.0a	2.25a	1.0a	4.75 b
Renounce® 20WP @ 3.0 oz	0.5ab	1.25a	2.0a	2.75 b	3.5ab
MustangMax 0.8EC @ 4 oz	0.0a	1.0a	3.25a	1.25ab	3.5ab
MustangMax 0.8EW @ 4 oz	1.0 bc	0.75a	2.5a	1.75ab	2.75ab
Steward® 1.25SC @11.3 oz	0.5abc	1.0a	2.0a	1.0a	3.25ab
Steward® 1.25SC @ 9.2 oz	0.25ab	1.5a	0.75a	0.75a	1.25a
Steward® 1.25SC @ 6.7 oz	0.0a	0.5a	0.75a	1.25ab	1.0a
Steward® 1.25SC @ 4.6 oz	0.25ab	1.25a	2.25a	2.0ab	1.5ab
Untreated check	1.25 c	1.0a	1.25a	1.5ab	2.0a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 12. Mean numbers of total lygus bugs/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	1.25 b	1.75ab	10.25 bcd	17.5a	23.25 b
Renounce® 20WP @ 3.0 oz	0.5ab	3.5 b	11.5 cd	15.0a	17.5ab
Mustang MAX™ 0.8EC @ 4 oz	0.0a	1.75ab	13.5 d	13.5a	21.25ab
Mustang MAX™ 0.8EW @ 4 oz	1.25 b	1.5ab	7.25abc	13.75a	22.5 b
Steward® 1.25SC @ 11.3 oz	0.5ab	1.5ab	4.0a	9.0a	15.75ab
Steward® 1.25SC @ 9.2 oz	0.25a	1.75ab	6.0ab	12.5a	18.25ab
Steward® 1.25SC @ 6.7 oz	0.0a	1.25a	6.5ab	13.25a	15.75ab
Steward® 1.25SC @ 4.6 oz	0.25a	3.25ab	8.25abc	13.5a	12.75a
Untreated check	1.25 b	3.25ab	11.75 cd	14.0a	14.5ab

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 13. Mean numbers of big-eye bug nymphs/ 10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.25a	1.75ab	3.0abc	0.25a	0.5ab
Renounce® 20WP @ 3.0 oz	0.25a	3.0ab	3.75abc	0.0a	0.25ab
Mustang MAX™ 0.8EC @ 4 oz	0.0a	2.0ab	2.0ab	0.25a	0.0a
Mustang MAX™ 0.8EW @ 4 oz	0.0a	0.25a	1.75ab	0.5a	0.0a
Steward® 1.25SC @ 11.3 oz	0.0a	0.75a	1.5a	0.25a	0.0a
Steward® 1.25SC @ 9.2 oz	0.25a	1.0a	2.0ab	0.25a	0.25ab
Steward® 1.25SC @ 6.7 oz	0.25a	1.0a	1.5a	0.25a	0.5ab
Steward® 1.25SC @ 4.6 oz	0.0a	1.75ab	4.25 bc	0.0a	0.5ab
Untreated check	2.0 b	4.75 b	5.0 c	1.75 b	1.0 b

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 14. Mean numbers of big eyed bug adults/ 10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.25a	0.75ab	1.75ab	2.75 b	2.5abcd
Renounce® 20WP @ 3.0 oz	0.75a	2.25ab	4.25 bc	4.0 a	4.0 cd
Mustang MAX™ 0.8EC@ 4 oz	0.75a	1.25ab	2.25ab	1.0a	3.25 bcd
Mustang MAX™ 0.8EW @ 4 oz	0.25a	1.5ab	2.75ab	2.75 b	2.0abc
Steward® 1.25SC @ 11.3 oz	0.25a	0.25a	0.25a	0.5a	0.75a
Steward® 1.25SC @ 9.2 oz	0.0a	0.75ab	1.75ab	0.75a	1.25ab
Steward® 1.25SC @ 6.7 oz	0.0a	0.75ab	1.5a	0.5a	0.5a
Steward® 1.25SC @ 4.6 oz	0.0a	0.5a	4.25 bc	0.75a	2.0abc
Untreated check	0.75a	2.75 b	5.25 c	3.5 b	4.75 d

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 15. Mean numbers of total big eyed bugs/ 10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	15
Baythroid® 2EC @ 2.4 oz	0.5a	2.5ab	4.75abc	3.0 bcd	3.0ab
Renounce® 20WP @ 3.0 oz	1.0a	5.25 bc	8.0 bcd	4.0 de	4.25 bc
Mustang MAX™ 0.8EC @ 4 oz	0.75a	3.25ab	4.25ab	1.25abc	3.25abc
Mustang MAX™ 0.8EW@ 4 oz	0.25a	1.75ab	4.5 abc	3.25 cde	2.0ab
Steward® 1.25SC @ 11.3 oz	0.25a	1.0a	1.75a	0.75a	0.75a
Steward® 1.25SC @ 9.2 oz	0.25a	1.75ab	3.75a	1.0ab	1.5a
Steward® 1.25SC @ 6.7 oz	0.25a	1.75ab	3.0a	0.75a	0.75a
Steward® 1.25SC @ 4.6 oz	0.0a	2.25ab	8.5 cd	0.75a	2.5ab
Untreated check	2.75 b	7.5 c	10.25 d	5.25 e	5.75 c

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 16. Mean numbers of minute pirate bugs/ 10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.25a	0.5a	0.5ab	0.25a	1.25a
Renounce® 20WP @ 3.0 oz	0.0a	1.0a	2.25 c	0.25a	0.5a
Mustang MAX™ 0.8EC @ 4 oz	0.0a	1.0a	0.25ab	0.5a	1.25a
Mustang MAX™ 0.8EW @ 4 oz	0.25a	0.5a	0.25ab	0.5a	1.0a
Steward® 1.25SC @ 11.3 oz	0.0a	0.5a	0.5ab	0.25a	1.75a
Steward® 1.25SC @ 9.2 oz	0.0a	0.5a	0.5ab	1.75 b	1.5a
Steward® 1.25SC @ 6.7 oz	0.25a	1.0a	1.25abc	1.0ab	1.25a
Steward® 1.25SC @ 4.6 oz	0.0a	0.5a	1.5 bc	0.0a	0.75a
Untreated check	1.5 b	1.5a	0.0a	0.0a	0.75a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 17. Mean number of damsel bugs/ 10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.0a	0.5ab	0.25ab	0.0a	0.0a
Renounce® 20W @ 3.0 oz	0.0a	0.0a	1.0abc	0.5a	0.25ab
Mustang MAX™ 0.8EC @ 4 oz	0.0a	0.0a	0.25ab	0.0a	0.25ab
Mustang MAX™ 0.8EW @ 4 oz	0.0a	0.0a	0.0a	0.5a	0.25ab
Steward® 1.25SC @ 11.3 oz	0.0a	0.5ab	0.5ab	0.25a	0.25ab
Steward® 1.25SC @ 9.2 oz	0.0a	1.25ab	2.25 c	0.25a	1.0 c
Steward® 1.25SC @ 6.7 oz	0.0a	0.25a	1.5 bc	0.0a	1.0 c
Steward® 1.25SC @ 4.6 oz	0.25b	0.25a	1.25abc	0.5a	0.25ab
Untreated check	1.0 c	2.0 b	2.25 c	2.0 b	0.75 bc

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 18. Mean numbers of total predacious insects/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.75a	4.5a	6.0a	5.0 c	5.25ab
Renounce® 20WP @ 3.0 oz	1.5a	6.75ab	12.5 b	4.5 c	5.0ab
Mustang MAX™ 0.8EC@ 4 oz	1.25a	4.75a	5.25a	3.0abc	6.0ab
Mustang MAX™ 0.8EW @ 4 oz	0.5a	3.5a	5.0a	4.37 bc	3.75a
Steward® 1.25SC @11.3 oz	0.5a	3.0a	3.25a	1.25a	3.75a
Steward® 1.25SC @ 9.2 oz	0.5a	4.5a	7.25a	4.0 bc	5.25ab
Steward® 1.25SC @ 6.7 oz	0.75a	3.25a	6.0a	2.5abc	4.0a
Steward® 1.25SC @ 4.6 oz	0.25a	3.5a	12.25 b	1.75ab	3.75a
Untreated check	6.0 b	11.75 b	13.0 b	8.25 d	7.5

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 19. Mean numbers of adult leafminer flies/10 per three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.0a	1.25a	5.0ab	1.0a	72.25b
Renounce® 20WP @ 3.0 oz	0.75abc	1.0a	5.75ab	2.0ab	67.25 b
Mustang MAX™ 0.8EC @ 4 oz	0.25a	1.5a	5.0ab	2.25abc	70.0 b
Mustang MAX™ 0.8EW @ 4 oz	0.0a	1.25a	7.0ab	2.75abc	62.5 b
Steward® 1.25SC @ 11.3 oz	2.0 c	2.25a	7.75ab	1.25a	38.0a
Steward® 1.25SC @ 9.2 oz	1.5 bc	2.5a	9.0 b	4.5 c	51.5ab
Steward® 1.25SC @ 6.7 oz	1.0abc	1.0a	5.75ab	2.25abc	53.75ab
Steward® 1.25SC @ 4.6 oz	0.75abc	2.0a	6.5ab	3.0abc	48.5ab
Untreated check	1.0abc	1.25a	3.5a	3.75 bc	49.75ab

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 20. Mean numbers of wasps/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.5a	0.5ab	0.5ab	0.5a	5.0ab
Renounce® 20WP @ 3.0 oz	0.0a	0.0a	1.75abc	0.0a	8.0ab
Mustang MAX™ 0.8EC @ 4 oz	0.25a	0.25ab	0.25a	0.0a	8.75 b
Mustang MAX™ 0.8EW @ 4 oz	0.25a	0.75ab	1.5abc	0.25a	3.5ab
Steward® 1.25SC @ 11.3 oz	0.0a	1.0ab	4.75 bcd	0.25a	6.25ab
Steward® 1.25SC @ 9.2 oz	0.25a	1.25 b	6.75 d	0.25a	3.0a
Steward® 1.25SC @ 6.7 oz	0.5a	0.75ab	5.0 cd	0.0a	4.5ab
Steward® 1.25SC @ 4.6 oz	0.5a	0.0a	3.25abcd	0.0a	5.5ab
Untreated check	0.75a	0.25ab	1.25abc	0.0a	4.0ab

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 21. Mean numbers of beet armyworms/10 three foot sweeps after insecticide application on September 22, 2003, Ripley, CA.

	Days after application				
Treatment and Rate/acre	1	4	7	10	16
Baythroid® 2EC @ 2.4 oz	0.25a	0.0a	2.0 bc	0.25a	0.25a
Renounce® 20WP @ 3.0 oz	0.25a	0.0a	0.75ab	0.25a	0.0a
Mustang MAX™ 0.8EC @ 4 oz	0.0a	0.25a	1.25abc	0.0a	0.75a
Mustang MAX™ 0.8EW @4 oz	0.5a	0.25a	0.75ab	0.0a	0.25a
Steward® 1.25SC @ 11.3 oz	0.25a	0.25a	0.0a	0.0a	0.25a
Steward® 1.25SC @ 9.2 oz	0.0a	0.0a	2.0 bc	0.25a	0.0a
Steward® 1.25SC @ 6.7 oz	0.0a	0.0a	0.25ab	0.0a	0.0a
Steward® 1.25SC @ 4.6 oz	0.0a	0.0a	0.0a	0.0a	0.0a
Untreated check	0.0a	0.0a	2.75 c	0.0a	0.75a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).

Table 22. Alfalfa hay yields and quality parameters when cut on October 13 after insecticide application on September 22, 2003, Ripley, CA.

	Tons/	Protein %					
Treatment and Rate/acre	Acre	Crude	Digestible	ADF[1]	NDF[2]	TDN[3]	RFV[4]
Baythroid® 2EC @ 2.4 oz	0.87 b	22.7a	15.45a	33.2 b	43.4 b	51.7 b	135.6 b
Renounce® 20WP @ 3.0 oz	0.96a	23.4a	16.05a	31.8ab	40.7a	52.6ab	146.8a
Mustang MAX™ 0.8EC @ 4 oz	0.87 b	23.3a	15.98a	31.9ab	41.3ab	52.5ab	144.3ab
Mustang MAX™ 0.8EW @ 4 oz	0.98a	23.8a	16.25a	31.7a	40.9a	52.7ab	145.6a
Steward® 1.25SC @ 11.3 oz	0.90ab	23.1a	15.81a	31.6a	40.3a	52.8a	148.7a
Steward® 1.25SC @ 9.2 oz	0.91ab	23.3a	15.92a	32.1ab	40.7a	52.4ab	146.3a
Steward® 1.25SC @ 6.7 oz	0.94ab	23.3a	15.99a	32.4ab	41.1ab	52.2ab	144.1ab
Steward® 1.25SC @ 4.6 oz	0.98a	22.6a	15.52a	32.5ab	41.5ab	52.2ab	142.7ab
Untreated check	0.94ab	23.9a	16.35a	31.5a	40.8a	52.8a	146.9a

Means in columns followed by the same letter are not significantly different at the p< 0.05 level (Fisher's LSD test).
[1] Acid detergent fiber, reported at 90% dry matter
[2] Neutral detergent fiber, reported at 90% dry matter
[3] Total digestable nutrients, reported at 100% dry matter.
[4] Relative feed value