Alfalfa Yield and Quality Responses to Applications of Three Types of Plant Growth Regulators

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Abstract

Three plant growth regulators (two for growth enhancement, one for growth inhibition) were applied to several consecutive cuttings of alfalfa during the period of May-August in the Blythe, CA, area. All treatments resulted in reduced tonnage compared to the untreated check, although application of prohexadione calcium (active ingredient in the growth inhibition plant growth regulator) did result in increase in alfalfa quality when applied in May. Subsequent applications during the summer of this material did not result in a quality class increase for alfalfa hay production. Treatments of growth enhancement chemistries did result in less tonnage, however, data indicate that this reduction may be due to nutritional needs of alfalfa not being supplied during periods of increased growth. Supplemental nutrition along with the growth enhancement chemistries has not been tested to determine resulting alfalfa yields.

Introduction

Several plant growth regulators have recently been introduced into the agricultural market for various crops. These products include Messenger® (active ingredient = harpin protein Ea, Eden Biosciences), AuxiGro® (a product from Auxein Corporation (now Emerald BioAgriculture) whose active ingredients are gamma aminobutyric acid (GABA) and L-glutamic acid, and Apogee® (BASF Corp., active ingredient = prohexadione calcium). Messenger® and AuxiGro® are labeled on other crops for both growth promotion and related pest suppression but no data were available for these products on alfalfa.

Messenger® applications activate the jasmonic, salacytic acid and plant growth system pathways leading to increased growth and photosynthesis, while applications of AuxiGro® have been documented to increase potassium uptake (Kinnersley, 2000). The active ingredient in Apogee® (prohexadione calcium) is a gibberellic acid inhibitor registered for usage on apples and does not increase growth but instead limits internode expansion, resulting in increased alfalfa leafiness (Rethwisch, 2001).

Testing of prohexadione calcium (active ingredient in Apogee®) had previously been conducted on alfalfa in small plots under low desert conditions (Rethwisch and Kruse 2002; Rethwisch et al., 2002), but testing under commercial large scale field conditions to gather actual yields and quality data had not been attempted. This project was initiated to determine the effects of plant growth regulator chemistries on late spring and summer alfalfa yields and quality, and to gather additional data so that best usage of these products on alfalfa could be ascertained.

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Methods and Materials

A second year alfalfa field grown utilizing bedded production practices was chosen for this experiment due to its availability. The alfalfa variety was WL525HQ, a variety with a fall dormancy of 8.2. Previous research that had been completed in the area on alfalfa varieties indicated that production of some alfalfa varieties that had less than a class 9 dormancy were less well suited for summer production under normal to high temperature conditions in the low desert (Rethwisch et al., 1998) than those alfalfa varieties with fall dormancy ratings of 9 or higher.

May cutting

Materials were first applied to gather data for the late May harvest, a seasonal period when area alfalfa quality becomes variable and often decreases in quality due to increased warmer temperatures (100+°F) and longer days. This application was made the morning of May 8, 2001, with a 3640 SpraCoupe calibrated to apply 20 gpa at 56 psi using T-Jet 8006 nozzles on 20 inch spacings. Plant height at time of application was slightly under 8 inches (7.87, range of 4-11 inches), representing about 6 inches of regrowth.

All plots were 0.75 acres in size (1,229 ft long x eight 40" beds wide), with all treatments replicated four times in randomized complete block design. Five treatments were included in the experiment, consisting of AuxiGro® WP at 1.5 oz/acre, Messenger® at both 2.25 oz/acre and 4.37 oz/acre, and Apogee at 0.25 and 0.314 lbs. active ingredient/acre (0.91 and 1.14 lbs of product/acre). Rates of Apogee® active ingredient used in this experiment were much higher than rates previously noted as potential best fits for alfalfa (0.1-0.125 lbs active ingredient/acre) from previous small plot research (Rethwisch and Kruse 2002; Rethwisch et al., 2002) due to a miscalculation. As the experiment had been initiated, future application rates of Apogee® during this experiment continued at this level to gather data on high rate effects of this product on alfalfa (both single cuttings and multiple cutting applications). All treatments had the non-ionic surfactant BreakThru (Western Farm Services) added at a rate of 5 fl oz/100 gal of solution.

Plots were swathed on May 25, 2001 (17 days post treatment) and baled on May 29th. Immediately after swathing, 60-140 stems per plot were collected and examined for presence/absence of bud/flowering. Any purple/lavender coloring that was evident was considered positive, although fully formed flowers may or may not have been present. Floral numbers were not counted.

Swaths were raked together to form windrows on May 27 and 28, with two replicates being completed each day. Windrow ends were then marked with red spray paint to later determine exact amounts for each plot after baling. Plots were baled with a Heston 4790 baler the morning of May 29.

Bales in each plot were then counted and partial bales for each plot ascertained. Several bales were then weighed to determine average bale weight for each plot so that yields could be calculated. Quality samples were also obtained from four bales in each plot with a Utah sampler. Near infrared (NIR) analyses were conducted by Stanworth Crop Consultants in Blythe, CA, a 2001 certified facility for NIR testing by the National Forage Testing Association.

June cutting/July harvest

Second application was made on the afternoon of Monday, June 4, 2001, using the same methods as previously described. Treatments were applied to the same plots as in the May cutting to help ascertain effects of multiple applications. Top rate of Messenger® was somewhat altered (instead of 4.37 oz./acre was 4.32 oz. product/acre). Alfalfa regrowth was not as uniform or vigorous in comparison with the first application, and application was delayed several days until some regrowth was present, although very little was noted in bed centers which may have affected results. Regrowth was higher on the sides of the beds, but regrowth in bed centers was much reduced in comparison. Plots were swathed on June 30 and represented a longer time period from application to harvest than the first application (26 days vs. 17 days).

Immediately after swathing, a sample was taken from each plot, placed in a plastic ziplock bag, and refrigerated. Twenty stems per bag were then removed and measured for internode lengths, numbers of trifoliate leaves and colored floral structures (buds and open flowers) at each node were counted and recorded, and stem diameters were obtained using a calipers (recorded to nearest 0.001 in of diameter) at four cm above cutting and additional 5 cm increments thereafter as stem allowed. Three weight samples (fresh flowers, stems and leaves) for the 20 stem sample were then collected and recorded. Samples were then placed in paper bags and dried to determine dry weights of materials.

Swathes were raked together and baled on Tuesday July 3, 2001. As the rakes accidentally mixed swathes from two treatments together in one of the replicates, only three replicates were utilized for yield and quality data. These data were collected using the same methodology as the first harvest.

July cutting

Third application of materials was made the morning of July 10, 2001 (beginning about 9:30). Plant height at time of this application was 9.6 inches, representing approximately 7.5 inches of regrowth (assuming about a 2 inch height at previous cutting), which was slightly taller than that of previous applications. A different sprayer and nozzles were used for this application (SpraCoupe 3630 with T-Jet 8004 nozzles), although gallonage per acre remained the same. The high rate of Messenger® was 4.37 oz./acre, as in the first application. Plots were cut on July 30 and baled on Aug.1.

August-September harvest

Fourth application was made the morning of August 13, 2001. Plant heights exhibited a range of values, with plants on the west end of the field (closest to the irrigation canal and therefore receiving more water) being taller and more robust than plants on the east side. Two rates of Messenger® were applied, but Apogee® and AuxiGro® WP treatments were discontinued at this time. A 3630 SpraCoupe was used for this application. One accidental alteration to the previously described protocol was that less surfactant was used (5 oz/160 gallons) than in other applications.

Plots were cut on Sept. 7, 2001 (24 days after treatment), and baled on September 11. Weights and quality samples were obtained as previously discussed. Two of the plots in the southern replicate were baled with too high of pressure (untreated and low rate of Messenger®) and quality samples were fuzzy from fungal growth (high moisture) in the plastic bags prior to delivering for quality analyses.

Results

Yields

Alfalfa yields in this experiment were much below those expected. This may have been due to several factors, including a vary hot summer combined with a low (8.2) fall dormancy alfalfa variety (WL525HQ) as well as stress from previous spider mite infestations. Copius amounts of nutsedge were also present in the furrows, which may have also altered yields expecially in lower yielding plots were less alfalfa was available to compete with this weed.

Alfalfa hay yields were consistantly highest in the untreated check from all four harvests (Tables 1, 2). The next highest yielding treatment after the check was generally the 2.25 oz/acre rate of Messenger® (three of four harvests), with similar, although lesser mean yields, from the higher rate of Messenger® evaluated. It should be noted however, that almost invariably a gradient was noted across the plots (south = poor to north = good), and that the northern-most plot of the 4.35 oz/acre rate of Messenger® had the highest yields in each of the first two harvests, followed by the 2.25 oz./acre rate in both the first two harvests (May 25 and June 30 cuttings). These yields were 0.05-0.1 tons greater than the check in this replicate. This may indicate that yield responses to Messenger® will only be elicited when adequate fertility and production is available, but that this product can not overcome additional stress associated with poor production soils or practices. Similar results have been noted with AuxiGro® WP on cotton, where usage of this product by itself resulted in less yield than the untreated check, but when combined with foliar fertizliers resulted in increased yields and value/acre.

Alfalfa plants in the Apogee® treated plots were noticably shorter than those in other plots, which was not unexpected. Plant heights were not obtained, however. One aspect of harvest thought related to this observation was that more alfalfa remained behind in the windrows in the Apogee® treated plots than other treatments after baling. This is thought to be partially related to the shorter alfalfa as well as cultural field condition (beds). Shorter alfalfa stems are thought to be more likely to fall down into the furrows between beds than longer stemmed alfalfa, hence more is left behind during this field operation. This would probably not occur on alfalfa that is grown on level ground however.

Floral structures at May harvest

A trend was noticed for increased floral development in plots treated with plant growth regulators, especially the Apogee® plots (Table 1) at time of swathing on May 25. These numbers represent the percentage of stems with colored floral structures, although no attempt was made to further quantify floral numbers for this harvest. Differences noted were not statistically different than the untreated check, which had the least percentage of stems with colored reproductive structures among the treatments. Floral presence in Messenger® treatments was similar to that of the untreated check.

Quality

May harvest - Significant yield reductions were noted for Apogee® treatments (Tables 1,2), however, these treatments also resulted in significantly higher quality hay (premium classification based on 100% dry matter acid detergent fiber) than untreated and other treated alfalfa, which was only good quality in the late May harvest.

June Cut/July Harvest - All treatments applied to alfalfa were found to be detrimental when compared with data from the untreated check (Table 3). The untreated check had significantly lower acid detergent fiber (ADF) than both the AuxiGro® WP and high rate of Messenger®, and numerically lower ADF than all other treatments. The untreated check also had the numerically highest levels of protein, relative feed value, and NDF, with a signficantly higher percentage of both digestible and crude protein, and significantly higher relative feed value than AuxiGro® WP and both Messenger® treatments. Temperatures were also very high during this period, and may have added additional stress to treated plants.

These data were from three replicates only, as one replicate had treatment plots mixed together via raking. Data were somewhat inconsistant from replicate to replicate, perhaps indicative of the long time between harvests (about 7-10 days longer than normal cutting cycle) which allowed more floral structures, as well as the varying amounts of regrowth present at time of treatment application. Although differences noted were significant at the 0.05 level of signficance, no statistical differences were noted at the 0.01 level of probability.

July harvest - Quality data were very similar for all treatments in this harvest (Table 4). High rates of both Messenger® and Apogee® had lowest amounts of acid detergent fiber (ADF) and were below the 29% level, which would place both treatments as premium alfalfa hay and increase their value. This was not true for every replicate for these treatments however. Lowest quality was noted in the low rate of Messenger® (mean %ADF = 29.875)

September harvest - Quality data were not statistically different by treatment in this harvest (Table 5). The 4.35 oz/acre rate of Messenger® had lower levels of protein than did the 2.25 oz./acre rate of Messenger® or the untreated check, but the 4.35 oz./acre treatment also had the numerically lowest acid detergent fiber (ADF) and resultant highest overall quality based on relative feed value (RFV) and neutral detergent fiber (NDF).

Plant measurements from June 30 cutting

Leaves

Greatest number of trifoliate leaves was noted in the untreated check, which averaged almost 7 trifoliate leaves/stem more than treated alfalfa. Means of treatments were very similar. This data conflicts with previous reported data for the active ingredient in Apogee® on alfalfa however (Rethwisch and Kruse 2002; Rethwisch et al., 2002), and may be indicative that other factors, such as the very higher rates of Apogee® used in this experiment than in previous experiments, high temperatures during the June 2001 period combined with a lower dormancy alfalfa and as well as field conditions (based on yields) may have been causing high levels on stress upon the plants. Additional stress from treatments may have exacerbated these stress conditions.

Blooms

Data obtained at cutting following the June application again indicated more blooms on stems of Apogee® than other treatments or the untreated check up through node 11. Differences in floral numbers were also noted for treatment rates, with the higher rates of both Messenger® and Apogee® having more blooms than the lower rates of these products tested. When entire stems were investigated, the untreated check had the most bloom, with fewest floral structures noted from the AuxiGro® WP treatment. Stems were not evaluated prior to this sample date, and previous bloom distribution may not have mirrored these findings.

Stem Height

Tallest plants were noted in the untreated check, with shortest plants noted in the low rate of Apogee® which reflected hay yields. AuxiGro® WP and Messenger® treated plant heights were similar. Internode lengths in the untreated check were longer than in the treated alfalfa from nodes 9 to stem terminals.

Stem Diameters

Average stem diameters were wider in the untreated check at all points measured than alfalfa that had been treated. Higher rates of Messenger® had wider diameters than lower rates of Messenger® below the point of 20 cm of regrowth.

Leaf presence/senescence

Although almost all treatments had leaves at nodes 4 and 5 above regrowth, this was not true for nodes 1-3. At node 2, 35% of the Messenger® treated alfalfa stems no longer had vegetative material, which was about 10% higher than other treatments (25% of stems with no vegetative material at this node). This may indicate that more plant carbohydrates had been used by the plants as Messenger® applications had been visually noted to cause rapid elongation of stems and branch/leaf materials at lower nodes, and thereby may have resulted in overall lower growth due to carbohydrate depletion. These data indicate that Messenger® applications may be better for plant growth closer to harvest when plant carbohydrate reserves will have been adequately replaced via photosynthesis of regrowth, or need supplemental foliar fertilization.

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Table 1. Means of stems with colored reproductive structures, alfalfa hay yields, and quality classification from a late May harvest after treatment on May 8, 2001, Blythe, CA.

Treatment	Rate	% of stems with floral color	Hay yield (tons/acre)	Quality Class	Value $/acre
Apogee®	0.909 lbs	32.2a	0.768 b	Premium	80.64
Apogee®	1.13 lbs	31.0a	0.768 b	Premium	80.64
AuxiGro® WP	1.5 oz	27.7a	0.887a	Good	79.83
Messenger®	2.25 oz	22.4a	0.934a	Good	84.06
Messenger®	4.37 oz	22.1a	0.904a	Good	81.36
Untreated check		20.9a	0.939a	Good	84.51

Means in columns followed by the same letter are not statistically different at the $p \leq 0.05$ level (Fishers LSD test)

Table 2. Yields (tons/acre) of alfalfa hay by cutting date following applications of various plant growth regulators.

		Cutting date				Accumulative yields		
Treatment	Rate	May 25	June 30	July 30	Sept. 7	May-June	May-July	May-Sept.
Apogee®	0.909 lbs	0.768 b	1.125 b	0.804 b	-----	1.893	2.697	
Apogee®	1.13 lbs	0.768 b	1.123 b	0.813 b	-----	1.891	2.704	
AuxiGro®WP	1.5 oz	0.887a	1.217ab	0.945a	-----	2.104	3.049	
Messenger®	2.25 oz	0.934a	1.262ab	0.902ab	0.566a	2.196	3.098	3.664
Messenger®	4.37 oz	0.904a	1.154 b	0.916ab	0.547a	2.158	3.074	3.621
Untreated check		0.939a	1.310a	0.974a	0.674a	2.249	3.223	3.897

Means in columns followed by the same letter are not statistically different at the p≤0.05 level (Fishers LSD test)

Table 3. Quality data from alfalfa cut May 25 following plant growth regulator application on May 8, Blythe, CA.

		Percent Protein						
Treatment	Rate/acre	Crude[1]	Digestable[1]	ADF[1]	TDN[2]	NDF[1]	MCF[1]	RFV
Apogee®	0.909 lbs	23.75a	16.45a	28.45a	54.9a	37.5a	22.0 a	165.6a
Apogee®	1.13 lbs	23.28ab	16.15ab	29.0 ab	54.5ab	37.9a	22.15ab	162.85ab
AuxiGro® WP	1.5 oz	22.6 b	15.75ab	30.4 ab	53.55b	39.1ab	23.1ab	155.35abc
Messenger®	2.25 oz	22.45b	15.55 b	31.03 b	53.2 b	40.0 b	23.5 b	150.7 c
Messenger®	4.37 oz	22.78ab	15.78ab	30.28ab	53.7 b	38.8ab	23.0ab	156.6abc
Untreated check		22.50b	15.63 b	30.75 b	53.35b	39.9 b	23.3ab	152.05bc

Means in columns followed by the same letter are not statistically different at the p≤0.05 level (Fishers LSD test)

[1] Reported using 100% dry matter basis

[2] Reported using 90% dry matter basis

Table 4. Mean quality data from alfalfa cut June 30 following plant growth chemistry application on June 4, 2001, Blythe, CA.

Treatment	Rate/acre	Percent Protein Crude[1]	Percent Protein Digestible	ADF[1]	TDN[2]	RFV
Apogee®	0.91 lbs	21.0abc	14.7abc	30.0ab	53.9ab	157.9abc
Apogee®	1.13 lbs	21.6 bc	15.2 bc	29.0a	54.5 b	164.0ab
AuxiGro® WP	1.5 oz	19.8a	14.0a	31.8 b	52.6a	144.6a
Messenger®	2.25 oz	20.3ab	14.2ab	31.1ab	53.1ab	149.3a
Messenger®	4.35 oz	19.8a	13.9a	31.9 b	52.6a	144.4a
Untreated check	-----	21.8 c	15.3 c	28.7a	54.7 b	171.0 c

Means in columns followed by the same letter are not statistically different at the p≤0.05 level (Fishers LSD test)

[1] Reported using 100% dry matter basis

[2] Reported using 90% dry matter basis

Table 5. Mean quality data from alfalfa cut July 30 following plant growth chemistry application on July 10, 2001, Blythe, CA.

Treatment	Rate/acre	% Crude Protein[1]	ADF[1]	TDN[2]	RFV
Apogee®	0.909 lbs	19.72 b	29.3 abc	54.35abc	165.6 bcd
Apogee®	1.13 lbs	20.42a	28.78a	54.7 a	170.9 a
AuxiGro® WP	1.5 oz	18.8 c	29.5 bc	54.18 bc	165.3 cd
Messenger®	2.25 oz	18.92 c	29.88 c	53.93 c	161.7 d
Messenger®	4.37 oz	19.35 bc	28.7 a	54.7 a	170.55ab
Untreated check		19.15 bc	29.05ab	54.53ab	168.95abc

Means in columns followed by the same letter are not statistically different at the p≤0.05 level (Fishers LSD test)

[1] Reported using 100% dry matter basis

[2] Reported using 90% dry matter basis

Table 6. Mean quality data from alfalfa cut September 7th following plant growth chemistry application on August 13, 2001, Blythe, CA.

Treatment	Rate/acre	Percent Protein Crude[1]	Percent Protein Digestible	ADF[1]	TDN[2]	RFV
Messenger®	2.25 oz	22.05a	15.1a	30.4a	55.05a	155.7a
Messenger®	4.35 oz	20.7a	14.4a	29.8a	54.00a	160.0a
Untreated check		21.1a	14.5a	30.8a	53.3a	151.7a

Means in columns followed by the same letter are not statistically different at the p≤0.05 level (Fishers LSD test)

[1] Reported using 100% dry matter basis

[2] Reported using 90% dry matter basis