Evaluation of Plant Growth Regulator Formulations in Arizona Cotton Production Systems

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Abstract

A single experiment was conducted in 2005 at the University of Arizona Safford Agricultural Center in an effort to continue to evaluate several different formulations of the plant growth regulator (PGR) mepiquat chloride. Plots were established with the cultivar Deltapine DP 655BR on 19 April 2005. Four treatments were imposed on 18 July 2005 of 16 oz./acre applications of Mepex, Pix Ultra, and Pentia, plus a control plot. Plots were four 36" rows wide and extended the length of the irrigation run of 220 feet. Plots were arranged in a randomized complete block design with four replications. Plots were monitored with respect to plant growth and development through collecting plant measurement data over the course of the season. Yield results were obtained by harvesting the center two rows of each plot and weighing the resultant seedcotton. Fiber quality was determined from a sub-sample collected from each plot at harvest. Plant growth and development trends indicated strong fruit retention levels all season with strong early season vigor. Each of the PGR applications had significant impact on plant height effectively reducing internode elongation. Lint yield results indicated increased yields for all PGR applications over the control with Pentia producing a statistically significant higher yield. Fiber quality was also impacted by PGR application. All PGR treatments had trends toward higher staple length, fiber strength, and fiber uniformity. These results are consistent with previous results indicating that PGR applications have the potential to increase yields under situations were high vigor is present.

Introduction

Cotton grown in the deserts of the southwestern cotton belt are intensively managed crops with high levels of input and high yields. Among those inputs are both water and fertilizer nitrogen (N) which are two of the most well recognized growth stimulants for any crop. With high levels of both water and N, maintaining a proper balance between the reproductive and vegetative components of the crop is sometimes difficult to accomplish. Increased production of vegetative components (stems and leaves) at the expense of the reproductive component (squares, flowers, and bolls) can lead to decreased yield. Maintenance of a proper vegetative to reproductive ratio is often difficult due to the dynamic nature of the cotton plant. The tendency of the cotton plant to abort fruiting forms in response to environmental cues may result in the disruption of a vegetative/reproductive balance that is favorable to high yields. The loss of carbohydrate sinks (fruiting forms) results in rapid proliferation of the mainstem (Mauney, 1986) and other vegetative components of the crop. However, the cotton plant also has the ability to compensate for that loss under favorable environmental conditions through rapid initiation and retention of new fruiting forms. This ability of the cotton plant to shed fruit and then also to compensate based upon environmental cues necessitates crop monitoring to properly manage the vegetative/reproductive ratio of the crop.

Indices have been developed and validated that can help to track crop progression and the vegetative reproductive balance over the course of the growing season. Baseline levels for both height (inches) to node ratios (HNR) and fruit retention (FR) levels have been developed for cotton grown in Arizona (Silvertooth et. al., 1993; Silvertooth, 1994; Silvertooth et. al., 1996; Silvertooth and Norton, 1998). These baselines have been developed from over 14 years of data collected from around the state of Arizona and provide a good indication of what is 'normal' for a crop produced in this region. All indices are developed as a function of heat units accumulated after planting (HUAP) which provides a measure of time that is very well correlated to crop growth and development.

There are several tools that can be used to aid in maintaining proper vegetative/reproductive balance in the crop. Optimum planting date will aid in maintaining a proper balance. Research has indicated that delayed planting will result in increased vegetative growth and decreased yields (Silvertooth and Norton, 2000). Proper management of water and fertilizer N will also have an influence on the vegetative/reproductive balance (Silvertooth et. al., 2001). Plant growth regulators such as mepiquat chloride (Pix – manufactured by BASF) have been used in cotton production for many years as a tool for controlling vegetative growth in cotton thus helping to maintain a proper ratio of reproductive to vegetative growth. Mepiquat chloride suppresses the production of the plant hormone gibberellic acid (GA) which is a growth stimulant that induces cell elongation. Suppression of GA production results in decreased cell elongation and overall decrease in the vertical and horizontal elongation of stems and branches (York, 1983; Kerby, 1985).

The PGR Pix was first introduced by BASF in 1980 and was the first product that significantly controlled plant height without inducing crop stress. Since the introduction of Pix (active ingredient mepiquat chloride) in the early 80's several new formulations have been developed by BASF in an attempt to improve the effectiveness and to increase yields. Pix Plus is the second generation product from BASF that contained the original mepiquat chloride plus the addition of bacillus cereus. The third generation of Pix introduced contained mepiquat chloride plus boron. The fourth and most recent formulation released is a new product called Pentia. Pentia contains mepiquat with the chloride ion being replaced with the boron ion resulting in mepiquat pentaborate.

Since the patent expired on mepiquat chloride several new formulations of PGRs have been developed over the years. Each formulation is slightly different with the goal of enhancing the effectiveness and the PGR and increasing lint yields. A product developed by DuPont was introduced several years ago as an alternative to Pix. Mepex is a generic form of mepiquat chloride which is designed to perform the same function as Pix. A newer product recently developed by DuPont, Mepex Gin Out is a blend of mepiquat chloride and kinetin, a cell division hormone, designed to control vegetative growth and enhance growth of fruiting forms through increased cell division.

There has been a considerable amount of research conducted throughout the state of Arizona on the effects of PGR applications on crop growth, development, and yield. A summary of over ten years (31 site-years) of these projects indicated that increases in lint yields with the application of Pix was most commonly observed when crop growth trends indicated an increasing vegetative state of the crop. Using a feedback approach involving crop monitoring of HNR trends and FR levels for scheduling PGR applications demonstrated the highest potential for increased lint yield (Norton and Silvertooth, 2000).

A study similar to the present work was conducted on a grower-cooperator field in 2004 designed to evaluate these same products (Norton et. al., 2005). Results from this project indicated that the Mepex Ginout treatment produced statistically higher yields than the other two mepiquat treatments (Pentia and Pix Ultra) but was not significantly higher than the control. The control was also not significantly different than the Pentia or Pix Ultra treatments. The Mepex Ginout treatment produced significantly higher lint turnout than the other two mepiquat treatments but not significantly different than the control.

The objectives of the current study was to add to the current data on evaluations of the various mepiquat chloride based PGRs available for growers.

Materials and Methods

This project was planted to the cultivar Deltapine DP655BR on 19 April 2005 into moisture at a rate of 25 lbs./acre. Plots were arranged in a randomized complete block design with four replications. Plot size was 4, 36" rows wide and extended the full length of the irrigation run of 200 feet. Treatments included a control and a one-time application of 16 fl. oz./acre of each of the three mepiquat formulations including Mepex, Pentia, and Pix Ultra (Table 1). Treatments were imposed on 18 July 2005 utilizing a John Deere 6000 high cycle with a carrier rate of 19 gallons/acre at 35 psi.

Plots were otherwise managed in an optimum fashion with respect to fertility receiving a total of 158 lbs. N/acre. One insecticide application was made in-season for control of lygus bugs. Final irrigation was applied on 13

September and plots were defoliated 19 October 2005. The center two rows of each four row plot was harvested and weighed to determine treatment yields on 9 November 2005. Subsamples were collected from each plot and submitted to the USDA classing office for fiber quality analysis. Fiber quality data was utilized to determine potential premiums/discounts for fiber quality using the USDA 2005 loan marketing schedule. These premiums/discounts were applied to a base price of $0.52 per pound of lint and multiplied by the total lint yield to determine a total value for each treatment.

In an effort to track the effects of PGR applications on plant growth and development a series of plant measurements were collected over the course of the season. The measurements included, plant height (cm), number of total mainstem nodes, number of the first fruiting branch, total number of aborted and missing fruiting sites on the first two positions of each fruiting branch, and the number of nodes above the top, first position fresh bloom. This data was used to calculate height to node ratios, fruit retention levels, and progression towards cut-out.

All data was analyzed using statistical techniques as outlined in Steele and Torrie (1980) utilizing GLM procedures in SAS (2002). Means separation utilizing a protected Fisher's least significant differences was performed on all yield and fiber quality data. Plant measurement data was plotted by treatment against long-term average baselines for the parameters listed above. No statistical analysis was performed on growth and development data.

Results and Discussion

Plant Growth and Development

Plant measurements collected over the course of the season are displayed in Figures 1-3. Height to node ratio levels (Figure 1) show increasing trends of high vigor up through approximately 1700 heat units. At this point the application of PGRs was made. A significant drop in vigor was experienced by all treatments receiving an application of PGR. Little difference was observed between the three PGR applications with respect to control of plant height. All three were effective in accomplishing this task. Fruit retention levels were above normal (Figure 2) for most of the season. This high level of fruit load also had a significant impact on plant height. The control that did not receive a PGR application was very near the height to node ratios of the treated plots near the end of the season. Due to the high fruit load and PGR applications the crop in general progressed rapidly toward cut-out (Figure 3). Levels of nodes above the top fresh bloom were below the normal baseline for each of the dates that data was collected. There did not appear to be any effect on general earliness of the crop due to PGR application in part due to the general high fruit retention level.

Lint Yield

Significant differences in lint yield were observed among the four treatments. The highest yield was produced by the Pentia treatment which was statistically higher than the other three treatments. The control, Mepex, and Pix Ultra treatments were not statistically different from each other (Table 2 and Figure 4). The results from this trial are consistent with other work when comparing the BASF PGR products with Pentia performing better than previous formulations (Norton et. al, 2005).

Fiber Quality

Interesting trends were observed in several of the fiber quality parameters in this trial. Table 2 shows fiber quality parameters for each of the four treatments. These are graphically displayed in Figures 6-9. Fiber staple (Figure7) showed trends to increasing levels with the PGR applications. A similar trend was seen in both fiber strength (Figure 8) and fiber uniformity (Figure 9). These differences in fiber quality are also evidenced by the premium received for each of the treatments (Table 2). The control received nearly one cent less premium than the next lowest treatment (Mepex) and nearly two cents less than the Pentia treatment.

Acknowledgments

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Table 1. Application date and rates for each of the three PGR formulations for the PGR evaluation project, Safford, AZ, 2005.

	Treatments			
	Control	Mepex	Pentia	Pix Ultra
18 July 2005	---	16 fl. oz./acre	16 fl. oz./acre	16 fl. oz./acre

Table 2. Lint yield and fiber quality results for the PGR evaluation trial conducted in Safford, AZ, 2005.

Variety	Lint Yield lbs./acre		Turn-out %	Staple 32nds	Micronaire	Strength g/tex	Length inches	Uniformity %	Premium Points	Crop Value $/acre
Pentia	1796.0	a	34.4	36.5	4.7	32.1	1.14	81.7	637	$1,048.00
Control	1674.0	b	33.9	35.0	4.6	29.3	1.10	79.6	463	$948.00
Mepex	1660.8	b	33.6	35.5	4.6	31.6	1.11	80.6	523	$950.00
Pix Ultra	1610.1	b	32.3	36.5	4.7	30.8	1.14	81.5	604	$935.00
LSD§	117.0		0.4	1.0	NS	NS	0.03	1.2	NS	$72.00
OSL†	0.0320		0.0001	0.0157	0.1846	0.0657	0.0166	0.0131	0.0763	0.0204
CV‡	4.3		0.8	1.7	1.8	4.2	1.5	0.9	15.8	4.6

*Means followed by the same letter are not statistically different according to a Fisher's least significant difference means separation test.

§ Least Significant Difference

† Observed Significance Level

‡ Coefficient of Variation

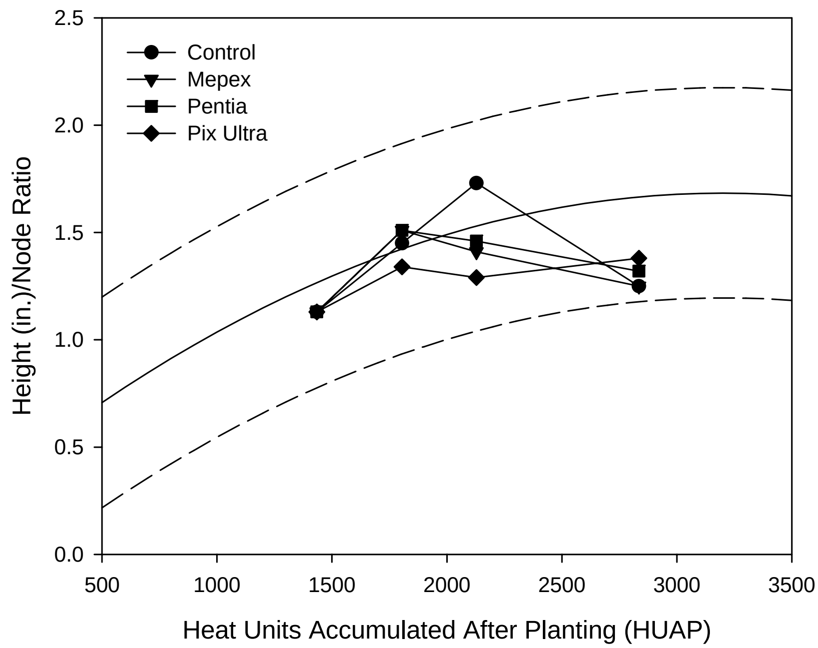

Figure 1. Height to node ratio levels for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

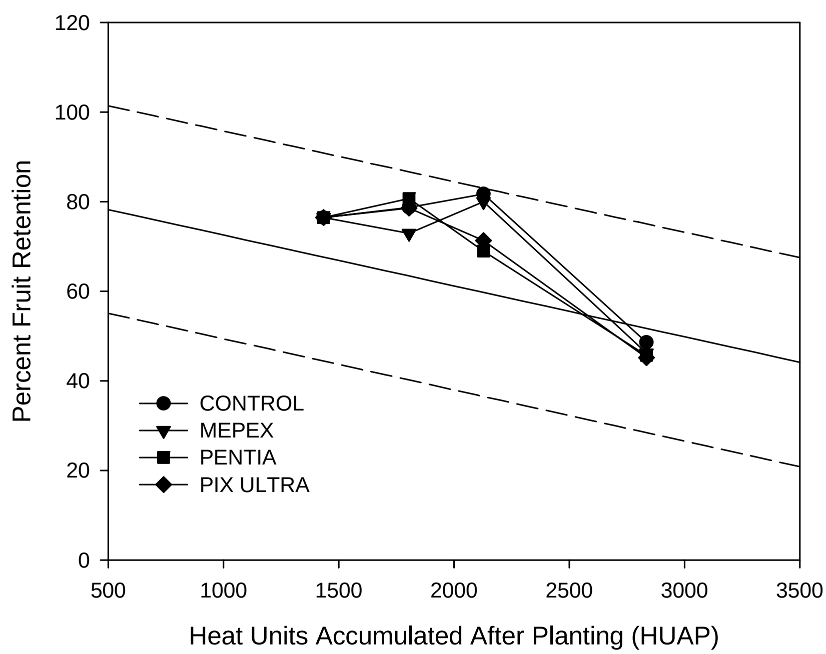

Figure 2. Percent fruit retention levels for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

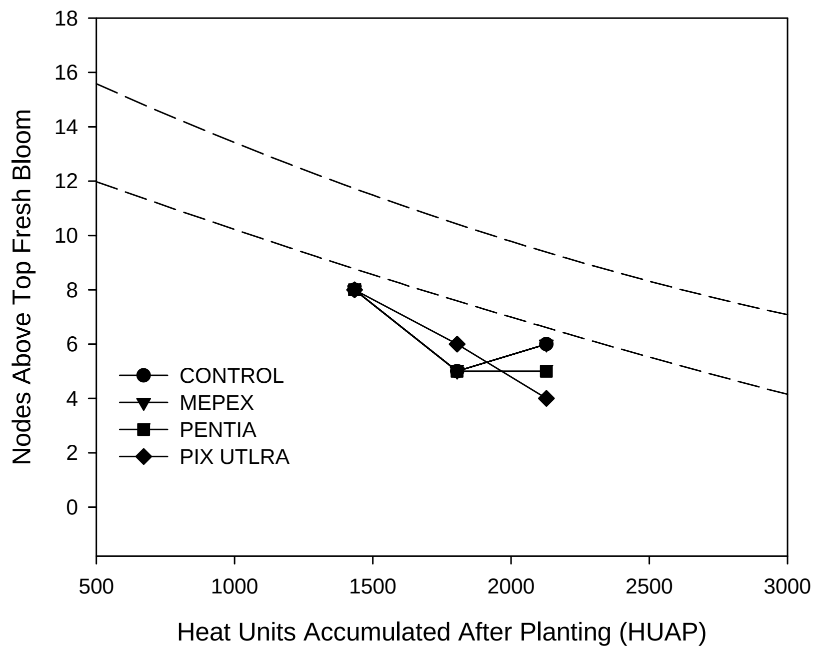

Figure 3. Numbers of nodes above top fresh bloom for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

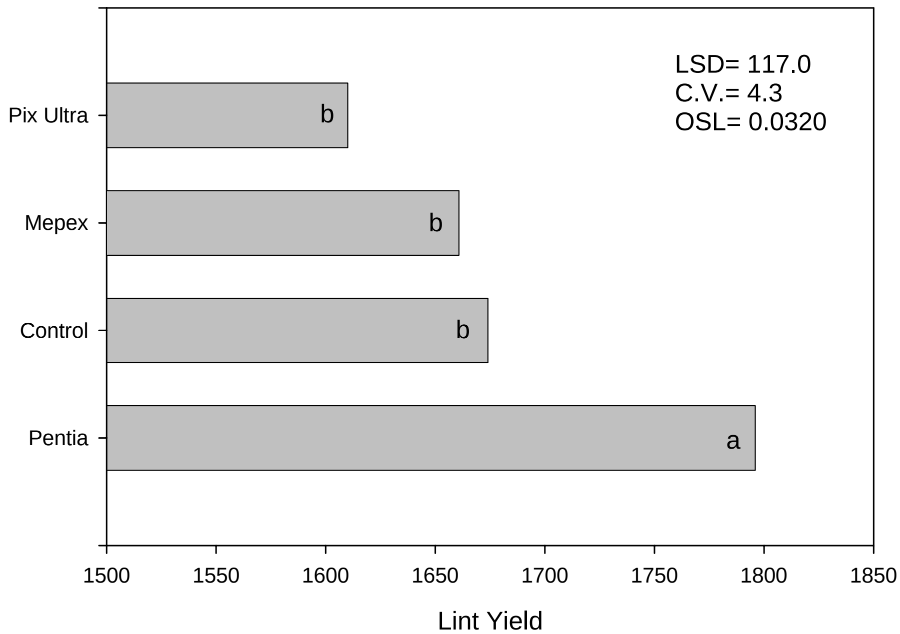

Figure 4. Lint yield for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

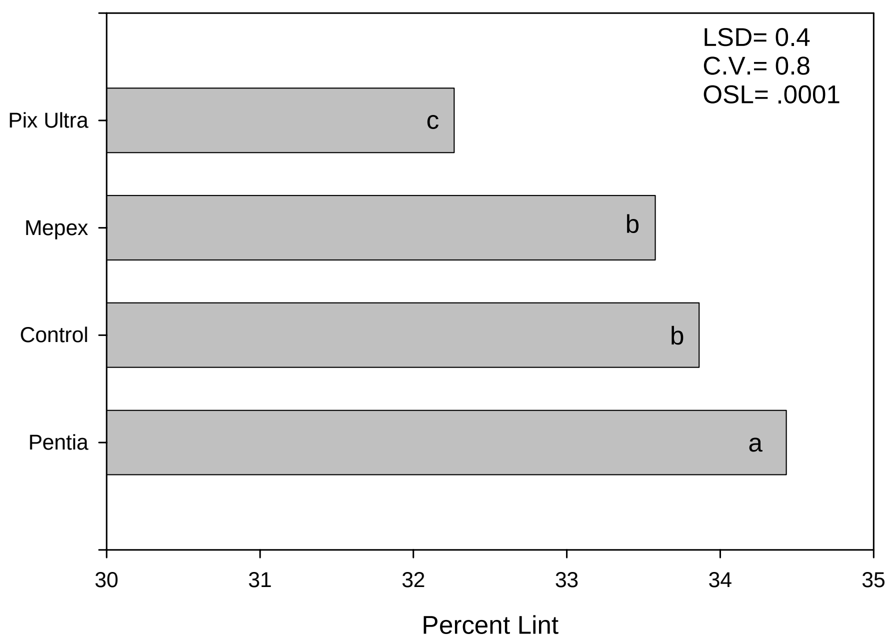

Figure 5. Percent lint for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

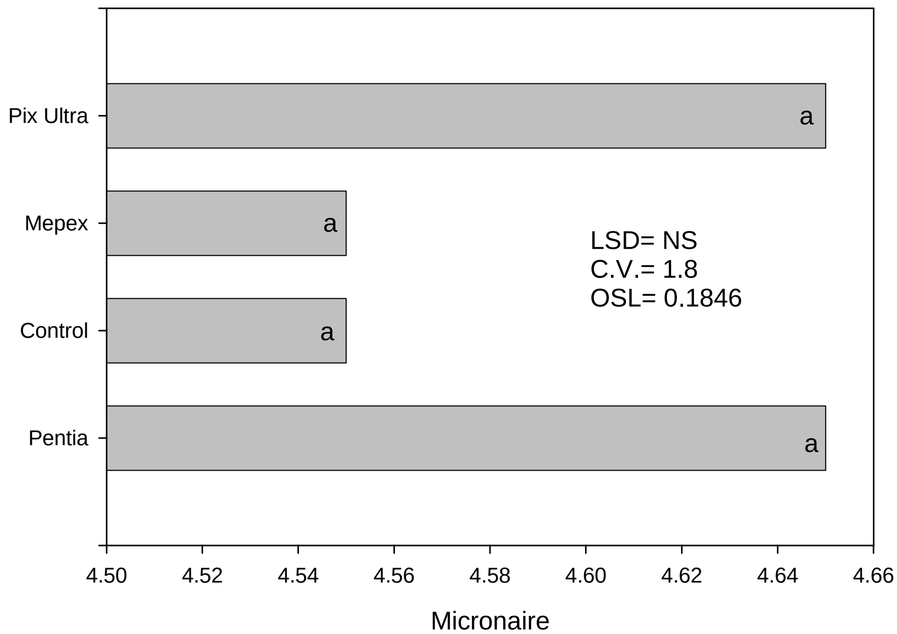

Figure 6. Fiber micronaire levels for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

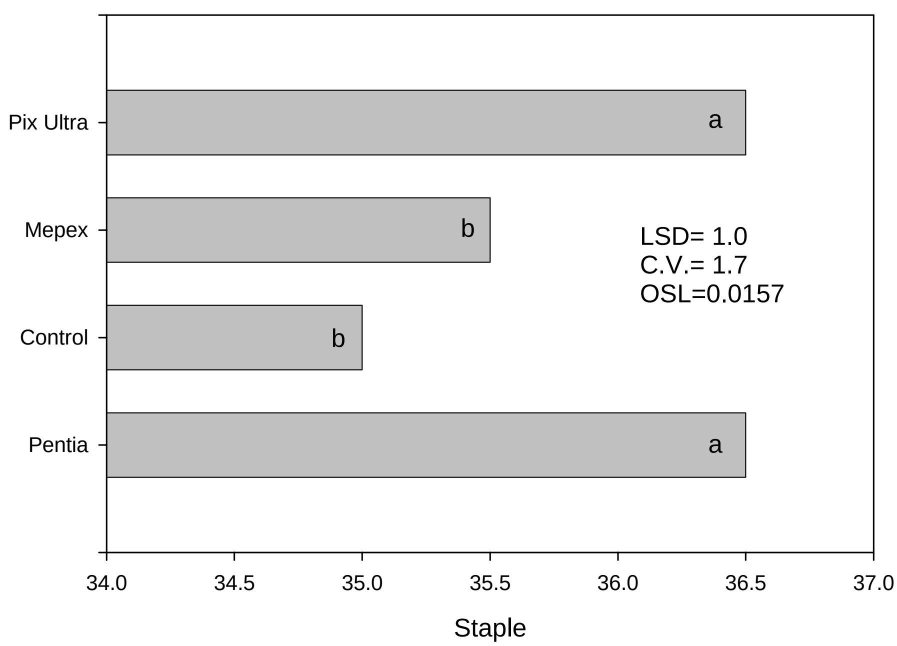

Figure 7. Fiber staple levels for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

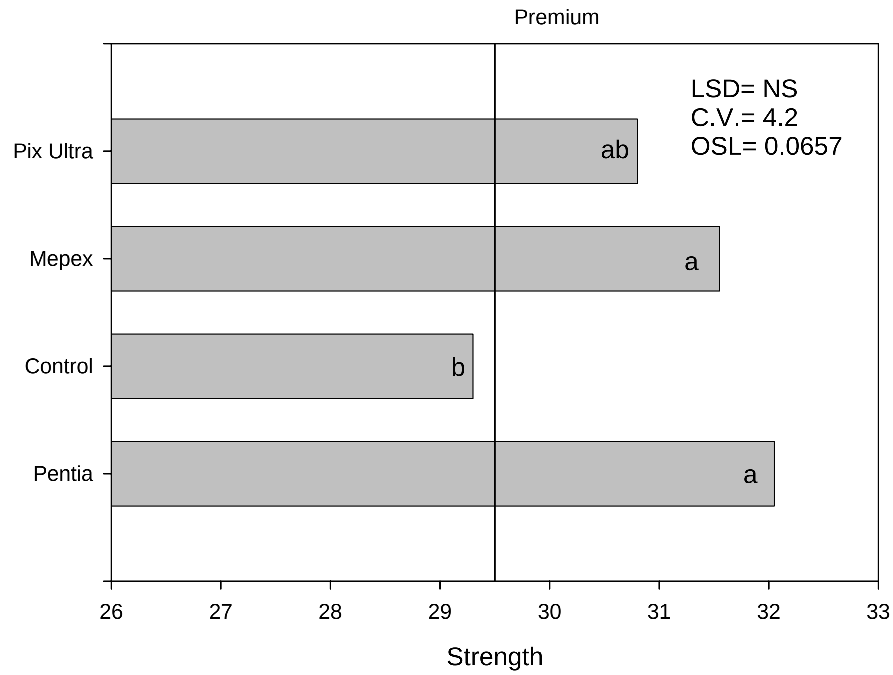

Figure 8. Fiber strength for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.

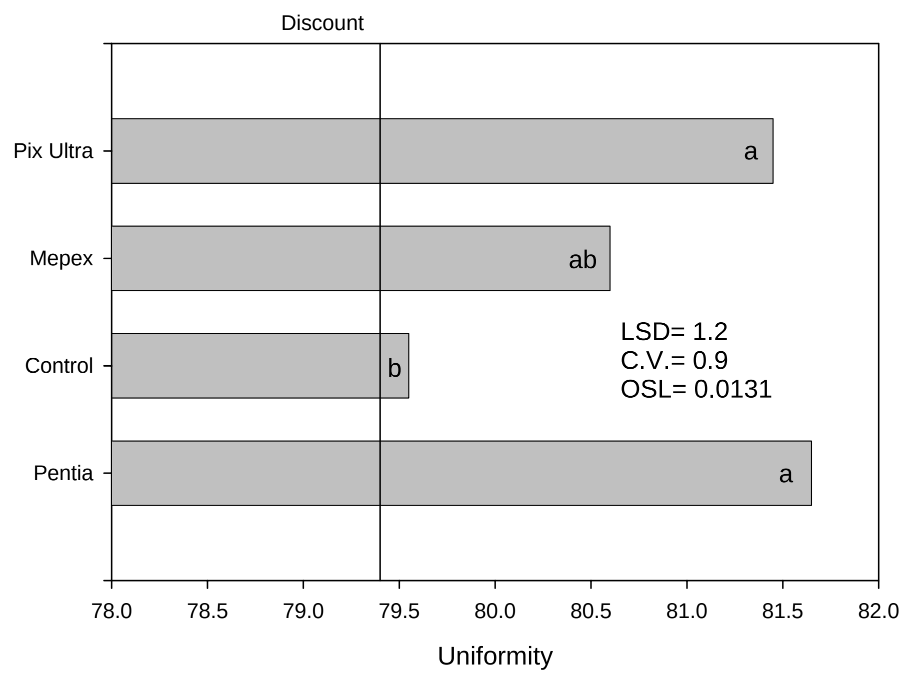

Figure 9. Fiber uniformity for each of the four PGR treatments in the PGR evaluation conducted at Safford, AZ, 2005.