2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

MEPIQUAT FORMULATION EVALUATION IN SOUTHEASTERN ARIZONA

E.R. Norton and L.J. Clark
The University of Arizona
Safford, AZ

Abstract

A series of experiments were conducted in 2003 in the Upper Gila River Valley in Safford, AZ to evaluate several different formulations of the plant growth regulator (PGR) Pix manufactured by BASF. Two experiments were conducted at the Safford Agricultural Center (SAC) while the third was conducted on a grower-cooperator field in the same valley. Experiments conducted at SAC involved evaluating the four formulations of Pix (Pix, Pix Plus, Pix Ultra, and Pentia) in a standard (STD) treatment regime and a low rate multiple (LRM) regime. The untreated control plots in both the LRM and STD experiments produced higher yields than any of the other PGR formulations. Comparing only the PGR formulation treatments the Pentia treatment produced the highest yield in both the STD and LRM experiments. No significant differences were observed in fiber quality for either the LRM or STD experiment. The third experiment conducted on a grower-cooperator field was a Pentia demonstration experiment. Three treatments including a control, a standard, single Pentia application, and an aggressive split application of Pentia were employed. The highest yield was produced in the most aggressive Pentia treatment. Results from this set of experiments demonstrate the importance of incorporating information from plant monitoring techniques when making decisions about PGR applications.

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 expensive 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 these 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 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.

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).

The objectives of the current studies were two-fold. First, to evaluate all four formulations of mepiquat that has been produced by BASF with respect to cotton growth, development, yield, and fiber quality. The second was to perform a large scale demonstration evaluation of the new Pentia product in a field scale experiment once again evaluating crop growth, development, yield, and fiber quality.

Materials and Methods

A series of studies was conducted in an effort to compare the effectiveness of the varying formulations of the PGR Pix, manufactured by BASF. Four generations of Pix products (Pix, Pix Plus, Pix Ultra, and Pentia) were compared in two separate studies designed to evaluate different application scenarios. The first involved a series of low rate multiple (LRM) applications while the second involved a more standard (STD) application regime of one, higher rate application. The latter treatment regime is more indicative of what local producers commonly employ. A third experiment was conducted on a grower-cooperator field with the objective of evaluating the new Pentia product from BASF on a field scale demonstration experiment. All PGR applications were scheduled and applied regardless of crop growth and development trends.

STD and LRM Experiments

Both the LRM and STD treatment experiments were constructed using small plots consisting of 4, 36” rows wide and 40 feet in length. Each experiment consisted of a control plus four additional treatments (Pix, Pix Plus, Pix Ultra, and Pentia). Application dates and rates are summarized in Table 1. Plots were arranged in a randomized complete block design with four replications. Plots were planted to the cultivar Deltapine DP655BR on 18 April and harvested on 10 November. Basic plant measurements were taken over the course of the season which included plant height, number of mainstem nodes, first fruiting branch, and number of retained fruiting forms (squares, flowers, and bolls). Yield estimates were obtained by weighing the seedcotton harvested from the center two rows of each plot. Subsamples were collected from each plot and were used to obtain fiber quality characteristics for each individual treatment. All data collected was subjected to analysis of variance using the statistical software package SAS. Analysis of variance was performed according to guidelines outlined by Steel and Torrie (1980) and the SAS Institute (2002).

Pentia Demonstration Experiment

The Pentia demonstration experiment was conducted on a grower-cooperator field and consisted of three treatments (control, standard application, and an aggressive application regime). These treatments application dates and rates are summarized in Table 2. Demonstration plots were 18, 36” rows wide and extended the full length of the irrigation run (~1250 feet). Plots were arranged in a randomized complete block design with four replications. Plots were planted to 1/3 Deltapine DP5690R and 2/3 Deltapine DP655BR on 21 April and harvested on 26 November. Plant measurement data was collected from the demonstration plots in a similar manner to that described above. Lint yield estimates were obtained by harvesting the middle eight rows from every plot and weighing the seedcotton with a boll buggy equipped with load cells. Subsamples were collected from each plot for fiber quality analysis. All data was subjected to analysis of variance in accordance with procedures outlined above.

Results and Discussion

LRM Experiment

Plant measurement summaries for the LRM treatments are found in Figures 1 and 2. Estimates of HNR (Figure 1) indicate that all PGR applications provided very similar height control with the control treatment having significantly higher HNR levels. HNR levels for the control trended near normal for the entire season with the PGR applications resulting in lower than normal vigor for the crop. FR levels for all LRM treatments were very similar for the season with all treatments completing the season near 60% FR. The control had a slightly high level of FR at seasons end which may have contributed to the higher yields experienced in the control treatments when compared to the PGR treated plots. Lint yield estimates for the LRM treatments are summarized in Figure 3. Lint yield differences were not significant at the $\alpha = 0.05$ level. However, trends indicate the highest yield was observed in the untreated control. Among the three PGR treatments, Pentia produced a slightly higher yield than the other three PGR formulations. Fiber quality data for the LRM treatments are summarized in Table 3. No statistical differences were observed in any of the fiber quality parameters among the control and four PGR applications.

STD Experiment

Results for the STD treatments were very similar to those of the LRM treatments. Figures 4 and 5 present the plant measurement summaries. HNR trends (Figure 4) indicate similar growth control on the part of all PGR formulations with the greatest control achieved by the Pentia application. The differences between the control and the PGR formulation treatments were much less than with the LRM treatments. Once again the control plots trended close to normal HNR levels for the entire season while the PGR treatments experienced below average vigor. FR levels presented in Figure 5 indicate similar end of season averages of near 60% FR. Lint yield response was similar to the LRM treatments with the control experiencing the highest yield. Of the four PGR formulations, Pentia produced the highest yield. Differences among lint yield estimates were not significantly different at the $\alpha = 0.05$ level. Fiber quality data for the STD treatments are summarized in Table 4. No significant differences or trends were observed in any of the fiber quality parameters for any of the STD treatments.

Pentia Demonstration Experiment

Results from the Pentia demonstration experiment provided a different conclusion. Crop growth trends as described by plant measurements are summarized in Figures 7 and 8. HNR trends for the control indicate a higher potential for increased vegetative tendencies than with the LRM and STD experiments. The control experienced excessive vegetative growth throughout the season. Both the standard and the aggressive treatment resulted in decreased plant height and overall vigor of the crop. At season's end the aggressive treatment was slightly below normal vigor levels with the control and standard treatments remaining above the normal curve for crop vigor. FR levels for all three treatments were very similar throughout the season with final FR levels near 65%. Lint yield estimates for the Pentia demonstration experiment are summarized in Figure 9. Differences among lint yield was not statistically significant at the $\alpha = 0.05$ level, however the most aggressive Pentia application resulted in the highest yield. Fiber quality data for these three treatments are summarized in Table 5. No significant differences or trends were observed in any of the fiber quality data.

Conclusions

Results from this series of experiments indicate the need for crop monitoring when making the decision for the application of a PGR. Application of PGR on cotton that is normal or slightly below normal with respect to crop vigor may result in no yield response or a possible negative response as demonstrated by the LRM and STD experiments. When comparing the four PGR formulations, both the LRM and STD experiments indicate superior performance with respect to yield enhancement for the new BASF product Pentia. With the higher growth potential observed in the Pentia demonstration experiments trends toward increased yield with the application of Pentia were observed. The results from these experiments are consistent with the ten-year review summarized by Norton and Silvertooth (2000). Plans for the 2004 season will include evaluations of these products using a feedback approach to scheduling PGR applications in an effort to improve the likelihood of a positive yield response with the application of PGRs.

Acknowledgements

We acknowledge the valuable help from the staff at the Safford Agricultural Center, Bret Whitmer from Whitmer Farms as the grower cooperator on the Pentia demonstration experiment and the financial and product support from BASF for these projects.

References

Kerby, T.A. 1985. Cotton response to mepiquat chloride. Agron. J. 77:515-518.

Mauney, J.R. 1986. Vegetative growth and development of fruiting sites. p. 11-28. In J.R. Mauney and J. Stewart (eds.) Cotton Physiology, Number One, The Cotton Foundation Reference Book Series. The Cotton Foundation, Memphis, Tenn.

Norton, E.J. and J.C. Silvertooth. 2000. Mepiquat chloride effects on irrigated cotton in Arizona. Cotton, A College of Agriculture and Life Sciences Report. The University of Arizona. Series P121 p. 72-85.

SAS Institute. 2002. SAS procedures guide. Version 9. SAS Inst., Cary, NC.

Silvertooth, J.C., P.W. Brown, and J.E. Malcuit. 1993. The development and delivery of a crop monitoring program for Upland and Pima cotton. Cotton, A College of Agriculture Report. University of Arizona. Series P-94:17-26.

Silvertooth, J.C. 1994. Practical uses of crop monitoring for Arizona cotton. Cotton, A College of Agriculture Report. University of Arizona. Series P-96:18-23

Silvertooth, J.C., E.R. Norton, and P.W. Brown. 1996. Cotton growth and development patterns. p. 75-97. Cotton, Univ. of Arizona Rep. P-103.

Silvertooth, J.C. and E.R. Norton. 1998. Cotton monitoring and management system. Publication no. AZ1049, University of Arizona, College of Agriculture, Tucson, AZ.

Silvertooth, J.C. and E.R. Norton. 2000. Planting date effects on soil temperature, crop growth, and yield of Upland cotton. P. 7-18. Cotton, Univ. of Arizona Rep. P-121.

Silvertooth, J.C., E.J. Norton, and E.R. Norton. 2001. Summary of Nitrogen Management Experiments in Irrigated Cotton. Cotton, A College of Agriculture and Life Sciences Report, University of Arizona. Series P-???.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York.

York, A.C. 1983. Cotton cultivar response to mepiquat chloride. Agron.J. 75:663-667.

Table 1. Application dates and rates for each of the four PGR formulations for both the LRM and STD treatment scenarios, Safford, AZ, 2003.

	Control		**Pix**		**Pix Plus**		**Pix Ultra**		**Pentia**	
	LRM	**STD**	**LRM**	**STD**	**LRM**	**STD**	**LRM**	**STD**	**LRM**	**STD**
30 JUN 03	--	--	12 oz	--	12 oz	--	12 oz	--	12 oz	--
8 JUL 03	--	--	12 oz	24 oz	12 oz	24 oz	12 oz	24 oz	12 oz	24 oz

Table 2. Application dates and rates for each of the three treatments in the Pentia demonstration experiment, Safford, AZ, 2003.

	Application Dates	
Treatment	**23 JUN 03**	**10 JUL 03**
Control (1)	--	--
Standard (2)	--	12 oz
Aggressive (3)	12 oz	12 oz

Table 3. Fiber quality data for the control and each of the four PGR formulations in the LRM experiment, Safford, AZ, 2003.

Treatment	**Micronaire** --	**Staple Length** 32^{nds}	**Fiber Strength** g tex^{-1}	**Uniformity Index** %	**Leaf Grade** --
Control	5.1	34.3	30.1	80.3	2.0
Pix	4.8	35.0	31.7	80.3	2.3
Pix Plus	5.0	34.0	31.2	81.0	2.0
Pix Ultra	4.9	34.0	30.9	80.3	1.7
Pentia	4.9	34.3	30.0	81.0	1.7
$LSD_{0.05}$	NS	NS	NS	NS	NS
OSL	0.1179	0.7673	0.0518	0.6912	0.2319
CV(%)	2.5	3.1	2.3	1.0	18.8

Table 4. Fiber quality data for the control and each of the four PGR formulations in the STD experiment, Safford, AZ, 2003.

	Micronaire	Staple Length	Fiber Strength	Uniformity Index	Leaf Grade
Treatment	--	32nds	g tex^{-1}	%	--
Control	5.1	34.3	30.1	80.3	2.0
Pix	5.0	34.7	30.9	81.3	2.0
Pix Plus	4.9	35.3	31.6	81.0	1.7
Pix Ultra	5.0	34.3	30.8	80.3	1.7
Pentia	5.0	34.6	30.2	80.3	2
$LSD_{0.05}$	NS	NS	NS	NS	NS
OSL	0.3386	0.6051	0.5415	0.4267	0.6328
CV(%)	2.9	2.4	3.7	0.9	20.7

Table 5. Fiber quality data for the control and the two Pentia treatments in the Pentia demonstration experiment, Safford, AZ, 2003

	Micronaire	Staple Length	Fiber Strength	Uniformity Index	Leaf Grade
Treatment	--	32nds	g tex^{-1}	%	--
Control	4.4	36.7	33.3	82.3	2.7
Standard	4.4	36.3	32.2	81.7	2.7
Aggressive	4.5	36.3	32.4	81.7	3
$LSD_{0.05}$	NS	NS	NS	NS	NS
OSL	0.8483	0.7901	0.3313	0.8301	0.6944
CV(%)	5.5	1.8	2.6	1.8	19.0

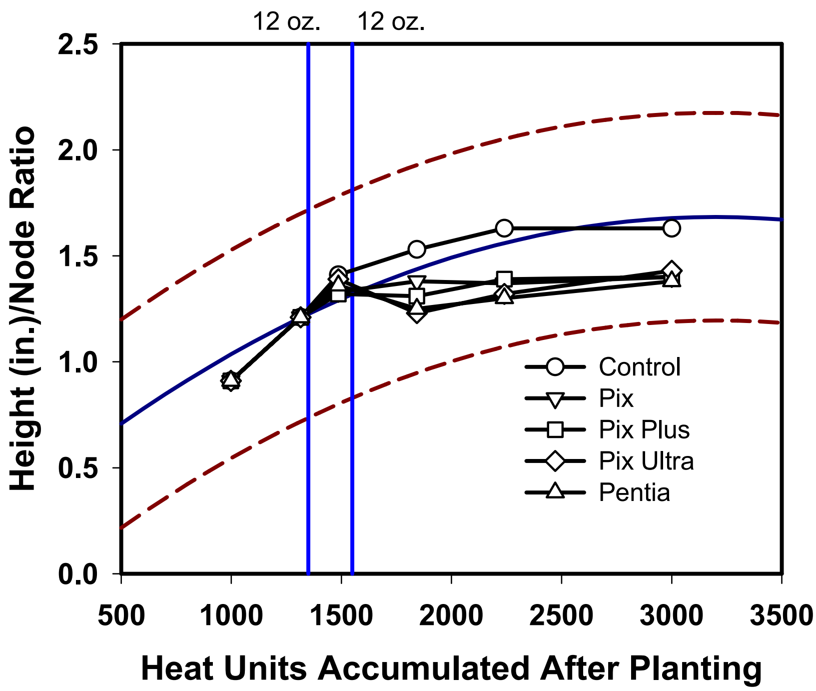

Figure 1. Height (inches) to node ratio trends for the control and four PGR formulations in the LRM study, Safford, AZ, 2003. Vertical lines indicate timing of PGR applications.

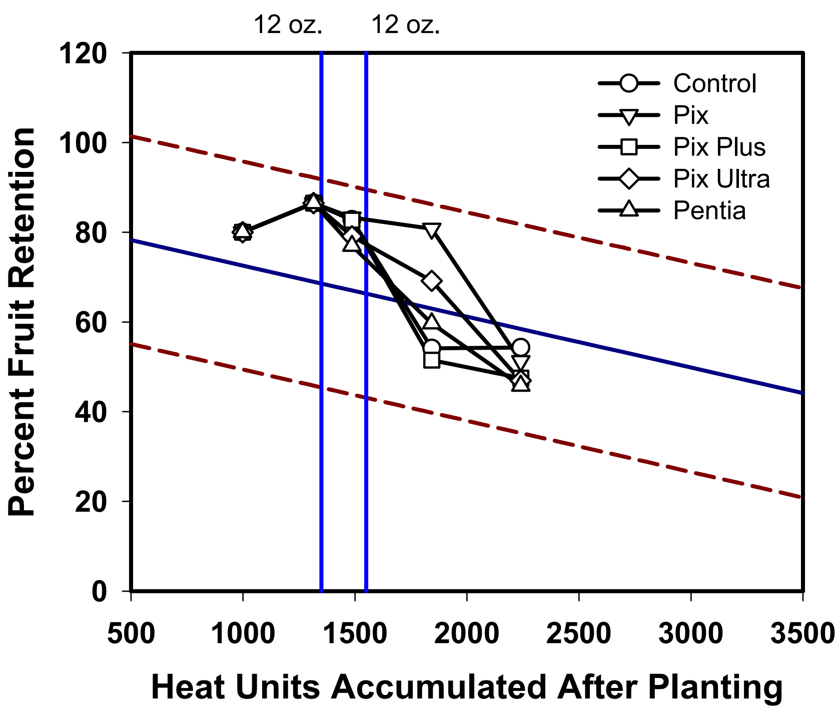

Figure 2. Fruit retention levels for the control and four PGR formulations in the LRM study, Safford, AZ, 2003. Vertical lines indicate timing of PGR applications.

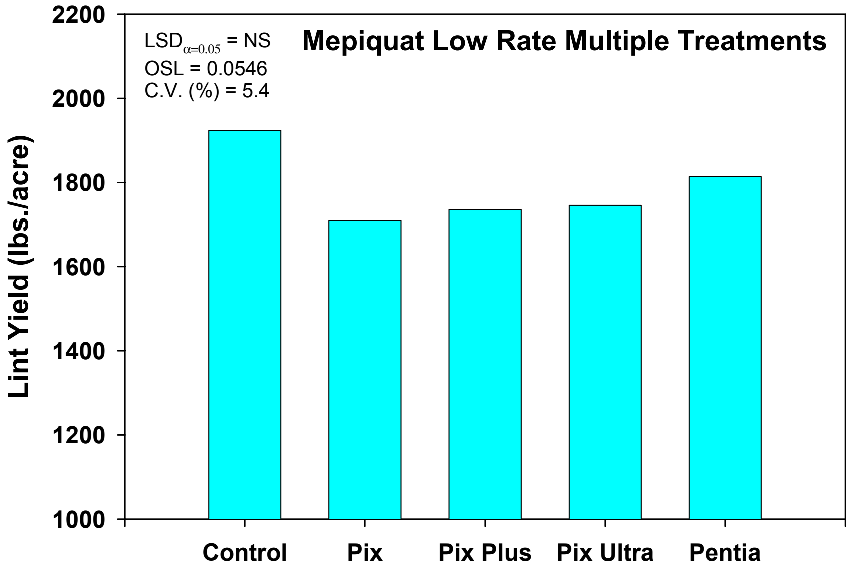

Figure 3. Lint yield estimates for the control and each of the four PGR formulations in the LRM experiment, Safford, AZ, 2003.

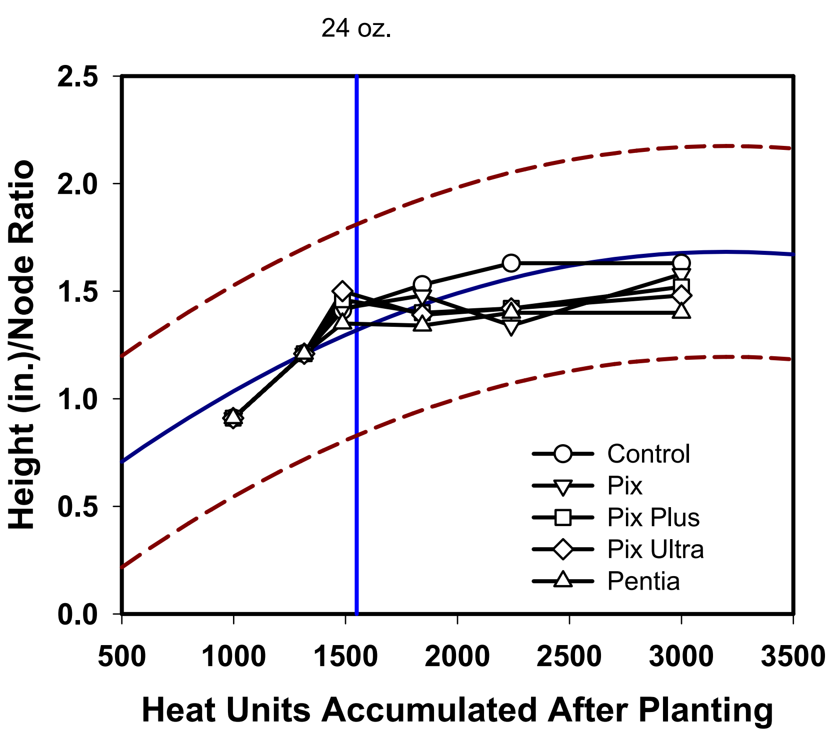

Figure 4. Height (inches) to node ratio for the control and four PGR formulations in the STD experiment, Safford, AZ, 2003. Vertical lines indicate timing of PGR applications.

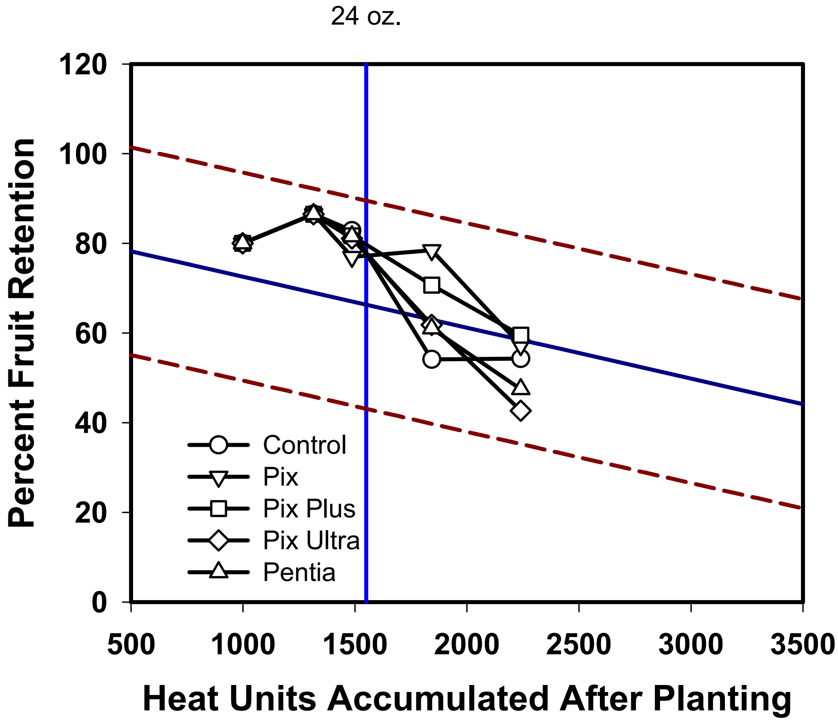

Figure 5. Fruit retention levels for the control and four PGR formulations in the STD experiment, Safford, AZ, 2003. Vertical lines indicate timing of PGR applications.

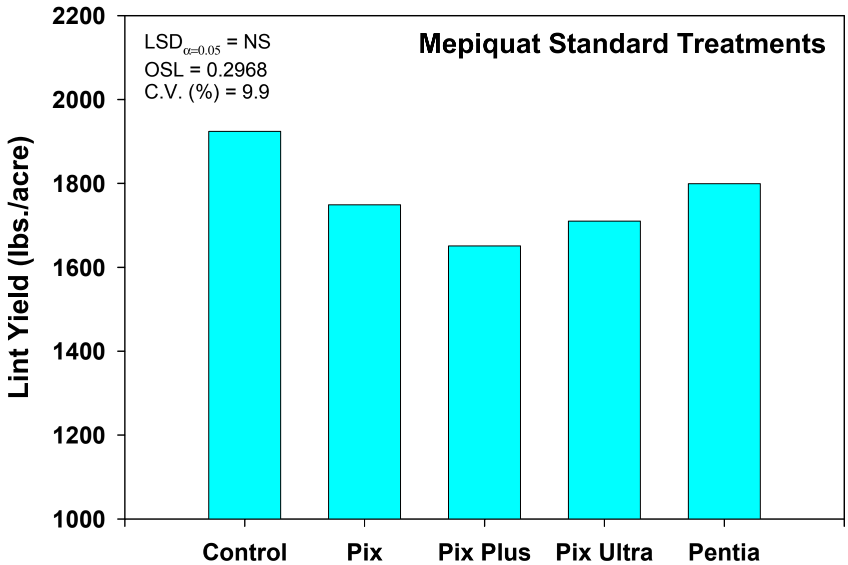

Figure 6. Lint yield estimates for the control and each of the four PGR formulations in the STD experiment, Safford, AZ, 2003.

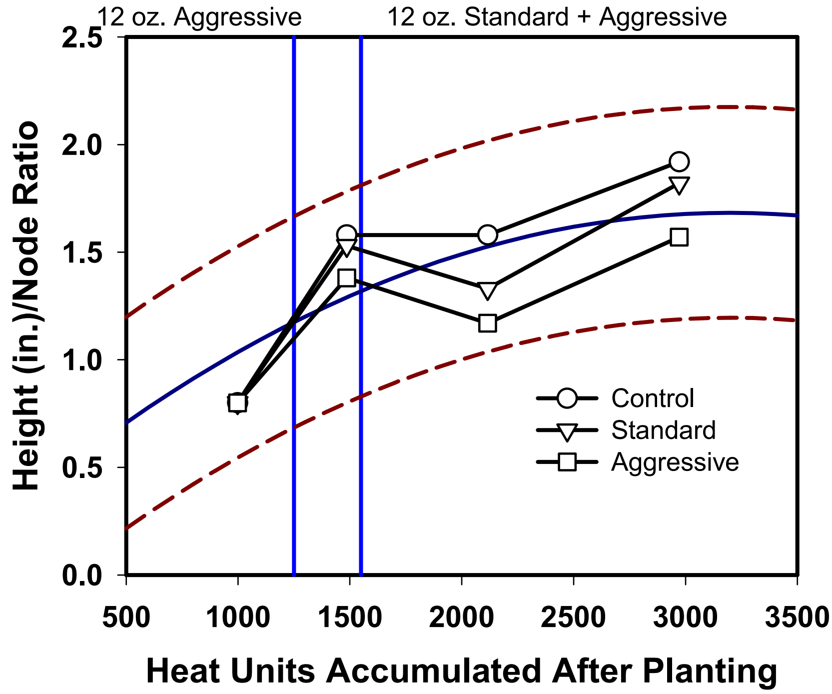

Figure 7. Height (inches) to node ratio for the control and the two Pentia treatments in the Pentia demonstration experiment, Safford, AZ, 2003. Vertical lines indicate timing of PGR applications.

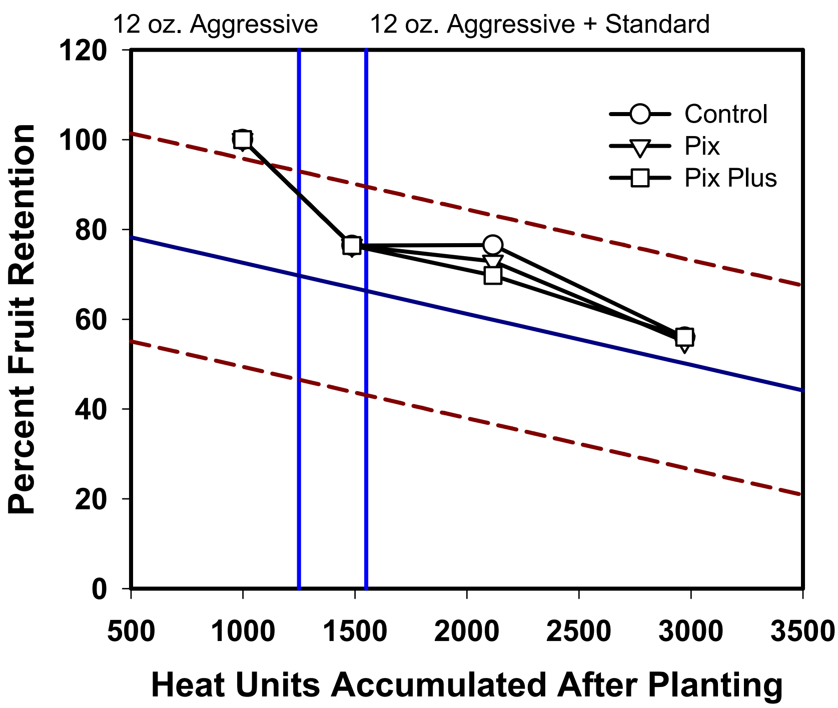

Figure 8. Fruit retention levels for the control and the two Pentia treatments in the Pentia demonstration experiment, Safford, AZ, 2003. Vertical lines indicate timing of PGR applications.

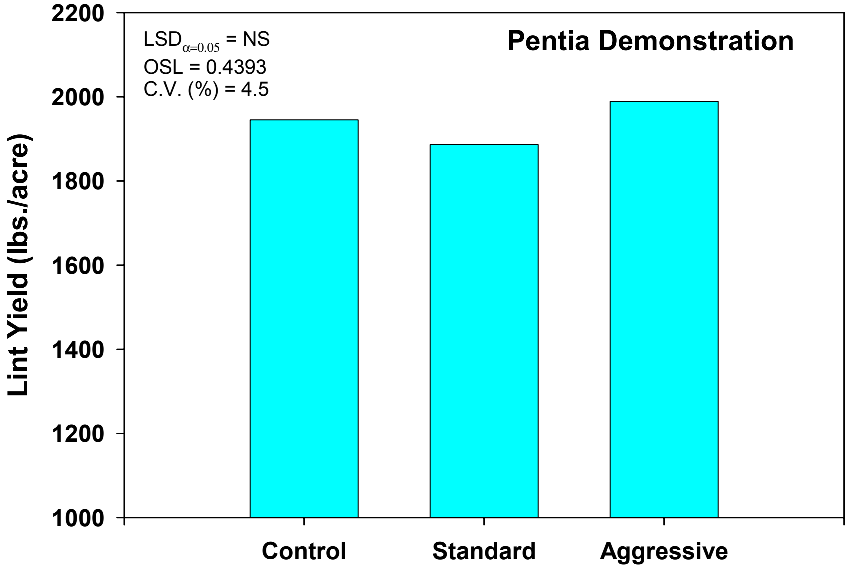

Figure 9. Lint yield estimates for the control and the two Pentia treatments in the Pentia demonstration experiment, Safford, AZ, 2003.