Evaluation Of A Feedback vs. Scheduled Approach To Pix Application

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Abstract

Two field experiments were conducted in 1993 in Arizona to compare a scheduled approach (based on stage of growth) versus a feedback approach (based on vegetative status) to mepiquat chloride (PIX_{TM}) applications on Upland cotton (Gossypium hirsutum L.). PIX feedback treatments received no PIX applications due to plants lacking vegetative tendencies based upon height:node ratios (HNRs) and established baselines. Scheduled PIX applications ranged from 0.5pt./acre to 0.75 pt./acre, and were applied at early bloom (approx. 1500 heat units after planting (HUAP), 86/55°F threshold) and post early bloom (approx. 2000 HUAP). PIX treatments did consistently reduce plant heights compared to an untreated check. Statistically significant differences ($P \leq 0.05$) in lint yield were observed among the treatments (feedback vs. scheduled)at the Safford location only. Evidence from these studies do reinforce the use of a feedback approach from the standpoint of conserving inputs and maintaining optimum growth control.

Introduction

In cotton production excessive vegetative growth can lead to losses in reproductive components (squares, flowers, bolls). In general, this is why a balance between reproductive and vegetative structures needs to be attained. Mepiquat chloride, or PIX_{TM}, is a growth regulator that has been used in commercial cotton production to reduce vegetative growth. This gibberellic acid suppressant is absorbed by green parts of the plant and reduces celelongation, and thus overall plant height. Theoretically, this then allows the plant to direct more energy towards reproductive structures. Many cotton production operations worldwide have incorporated PIX into their general management structure, however, the manner in which it is used has varied considerably. In the past 18 years much research has been done by growers and scientists in an effort to determine optimal application guidelines. To date, results have yet to show any consistent significant increases in lint yield from PIX applications due to any particular application strategy. However, much information has been gained regarding the many variables which influence PIX response in cotton. During the past six years numerous studies have been conducted in Arizona (Silvertooth et al., 1988, 1989, 1990, 1991, 1992 and 1993) in an attempt to determine optimum rates, timings, and strategies of multiple PIX applications that should be implemented.

In 1988 and 1989, field studies on Upland and Pima (G. Barbadense L.) cotton investigated the effects of early, low rate (1/4 pt./acre or less), multiple applications of PIX at initiation of match head square (900-1000 HUAP), early bloom (approx. 1500 HUAP), and 14 days post early bloom (approx. 2000 HUAP). In these studies, PIX did consistently reduce plant height, however, plants outgrew PIX affects in approximately two weeks, eventually reaching the height of the untreated plants. This compensatory growth is common in low desert cotton production, particularly when cotton is produced under full season conditions. This may explain why there were no significant increases from PIX applications observed in lint yield, except in one case in Yuma Valley in 1989. A severe wind and rain storm on July 27th caused this study to be prematurely terminated. The storm eliminated any late season fruiting potential and the chance for plants to outgrow PIX affects. Significant lint yield increases were observed under these reduced season conditions apparently due to enhanced earliness with PIX treatments.

Studies conducted in 1990 on Upland and Pima cotton by Silvertooth et al. employed higher rates (1/2 to 3/4 pint/acre) of PIX for an extended period of time over the fruiting cycle: early bloom, 14 days post early bloom and 28 days post early bloom. One study in 1990 resulted in significant lint yield increases. In this study, plants exhibited definite vegetative tendencies with excessive height (inches):node ratio (HNR) measurements (> 1.5) and low fruit retention levels, therefore, making them a good candidate for PIX application.

In 1991, field studies were conducted to further evaluate Upland cotton yield and development responses to PIX applications. The purpose was to continue to refine both application rates and timings of PIX applications. The timing of the applications was the main variable studied and was based on the growth stage as measured by heat unit accumulations since planting (HUAP, 86/55° F thresholds). Treatments were made from early bloom to cutout (approx. 1200, 1600, 2000 and 2400 HUAP) and were applied at the maximum allowable rate of 1.5 pt. of PIX/acre (total), with a maximum of four applications throughout the season.

In one study, no significant yield differences were observed. However, it was noted that these plants were not strongly vegetative, based on HNRs and fruit retention levels, from the onset of the experiment, and therefore did not benefit from PIX application. One study, however, showed a statistically significant increase in yield response (approximately 100 lbs. of lint/acre above the untreated check for all PIX treatments). In this particular case, HNRs were high, relative to established baselines, and fruit retention levels were low. This evidence supports the idea that PIX should not be applied unless plants exhibit vegetative tendencies, which can be determined by the use of simple monitoring techniques, such as HNRs.
Simple in-field measurements such as plant height, number of mainstem nodes (to determine HNR), and general fruit retention patterns were used as indicators in determining vegetative growth and were found to be reliable tools. Overall, it was also found that fewer PIX applications at higher rates (1/2 to 1 pt./acre) were commonly most effective.

In 1991 and 1992, Husman et al., conducted four field studies to further clarify response trends that had been observed in previous field studies. All treatments were at the maximum label rate (1.5 pt/acre total). Timing was the main variable and was based on growth stage and HUAP consistent with Silvertooth et al.(1989 and 1990). Significant lint yield increases of approximately 100 lbs./acre were observed in two of the four studies across all PIX treatments in contrast to the untreated check. Those PIX treatments which resulted in significant lint yield increases both had high HNR measurements, relative to previously defined baselines developed in Arizona.

Field experiments in 1992 evaluated cotton crop response to several regimes of multiple applications of PIX (Silvertooth et al. 1993 and Hood et al. 1993). In some cases, treatments exceeded currently labeled maximum use rates in order to evaluate the possible need to increase these rates. In all locations, crop conditions were not necessarily vegetative (medium to low HNRs and high fruit retention levels) and consequently did not respond positively to PIX applications. No increases in lint yield were observed due to any PIX treatment regime. In fact, decreases in lint yield occured in some cases. One of the 1992 experiments (Hood and Silvertooth, 1992) was designed to evaluate the activity of a high rate PIX use on Upland cotton. In this study a high fruit retention level and low to moderate HNRs were observed throughout the growing season. When PIX was applied at label and above label rates, lint yield was reduced significantly in comparison to the non-treated check plants. This information further supported observations from previous experiments in Arizona (Silvertooth et al., 1989, 1990). Information gained from these experiments further demonstrated the need for the use of a feedback approach through the use of plant measurements and exsisting guidelines, as opposed to a more arbitrary factor such as stage of growth, calendar date, or general inference.

Another aspect to consider when making PIX applications is the relationship between PIX and nitrogen (N), due to the growth promoting tendencies associated with N fertilizer applications.
Many experiments have been conducted to help understand the interaction between PIX and N. In one study (Stedman et al., 1982), cotton response to PIX was investigated at four N levels: 100, 200, 300, and 400 lbs./acre. Lint yields were greater in 7 of 8 PIX treatments, however, nitrate -N levels (determined by petiole analysis) and lint yields were not significantly different among the N treatments. Other studies have indicated that additional N inputs have increased lint yield. In one study (Han et al., 1990) four N levels (40, 80, 120 and 160 lbs./acre) were tested. Total N uptake, seed N content and lint yields were significantly higher at the greatest N level. In 1993, Silvertooth and associates conducted a PIX X N interaction study to better understand variable results that are seen among PIX and N experiments. The objectives of the experiments conducted in 1993 were: 1) to compare a feedback versus a scheduled approach to PIX application management, and 2) to evaluate the effects of scheduled and feedback applications of PIX in combination with scheduled and feedback applications of N.

Materials and Methods

Two replicated field studies were conducted in Arizona in 1993 at the University of Arizona Maricopa and Safford Agricultural Centers. Planting date and irrigation termination data for both locations is presented in Table 1. Treatments that were used are outlined in Tables 2,3, and 4 for each experiment. Nitrogen application rates are shown in Table 5. All treatments were arranged in a randomized complete block design with at least 4 replications. At Maricopa, plots extended the full length of the irrigation run (600 ft.) and were 4, 40 in. rows wide. PIX treatments were applied by the use of ground rig applicators for both experiments. Plots were 40 ft. long and 4, 40 in. rows wide at Safford. Approximately every 14 days a complete set of plant measurements (plant height, mainstem node numbers, bloom counts per 150 $ft.^2$ area, nodes above the top white bloom (NAWB), percent fruit retention, and percent canopy closure) were taken from each plot. Plant maps were also made from composite samples of each PIX treatment, at all locations, for several dates to record the progress of crop development. Nitrogen levels within the plant were monitored during the season by sampling petioles and analyzing their nitrate-N concentration levels. Management of the plots was carried out in a uniform manner with regard to irrigation, pest control, and nutritional needs. A mechanical picker was used to harvest internal areas of each plot (experimental unit) in order to obtain yield estimates. Data was analyzed in accordance to procedures outlined by the SAS Institute (1985).

Results

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Tables 3 and 4 outline the treatments employed. The HNRs collected for each treatment are outlined in Figure 1, as a function of stage of growth or HUAP. The HNRs that were measured are plotted upon the HNR baselines that were developed for several Upland cotton variety types as well as Pima (Silvertooth et al., 1992). The general expected baseline is represented by the dark center line in Figure 1. The parallel lines above and below the central line represent the upper and lower thresholds. All treatments exhibited similar HNRs throughout the experiment. This indicates that there were little or no differences observed (in HNRs) between the feedback and the scheduled treatments of PIX and N. Figure 2 represents fruit retention levels in relation to established baselines for Upland cotton (Silvertooth et al., 1992). Scheduled PIX treatments did not appear to improve fruit retention levels in comparison to the PIX feedback treatments or N treatments. Lint yield data (Table 6) shows that there were no significant differences among treatments 1-5. Treatments 1-5 also had similar nitrate-N levels throughout the season (Figure 3), however, treatments 4 and 5 (scheduled N -200 lbs./acre) did have higher nitrate-N levels than treatments 1-3 (feedback N -100 lbs./acre).

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Treatments employed are outlined in Table 2. The HNRs obtained for each treatment are presented in Figure 4. For all treatments, HNRs were approximately the same until about 2000 HUAP. At 2000 HUAP treatments 1 and 2 remained about the same whereas treatment 3 exhibited a reduction of HNR. The percent fruit retention data (Figure 5), indicates that the control dropped below treatments 2 and 3 (the PIX applications) beyond 2500 HUAP. There was a significant lint yield increase between the untreated check and treatment 2 (> 100 lbs./acre), however, treatment 3 was not significantly different from treatment 1 or 2 (Table 7).

Summary

For the past 18 years, growers and researchers have made considerable efforts to determine optimal PIX application guidelines. Experimental programs have been oriented toward practical criteria and questions such as: 1) what constitutes "rank" cotton, 2) when should PIX be applied, 3) what rates should be used, and 4) how many applications are needed. Each year new information is gained that leads to a better understanding of PIX responses in cotton. Overall, some common trends have been observed.

Lint yield decreases can occur when scheduled PIX applications (based on stage of growth) are made to cotton that does not exhibit excessive vegetative tendencies (Silvertooth et al., 1992 and 1993). This is why it is important to first determine if these tendencies are present through the use of in-field plant measurements, such as HNRs. When crop conditions are indicative of vegetative conditions, significant increases in lint yield have been recorded from PIX applications (Burmester et al., 1990, Silvertooth et al., 1990 &1991, Husman et al., 1992). However, if PIX application rates are too high or not needed, lint yields may be decreased even if plants were initially vegetative (Hood et al., 1992). This occurs due to the reduction of structural growth and fruiting site development, thus reducing the yield potential.

Field results from experiments conducted in 1992 and 1993 by Silvertooth et al., reinforce the need for the use of a feedback approach (based on vegetative status) as opposed to a scheduled approach (based on stage of growth). This approach involves making PIX applications only when plants exhibit vegetative tendencies based on in-field plant measurements (HNRs) and the use of current existing guidelines. Ultimately, this can eliminate unnecessary PIX applications that may result in reduced yield potentials. There is also merit in following a feedback approach from the standpoint of conserving inputs and maintaining optimum growth control. Future studies in this area will focus on further refinement to the feedback approach to PIX applications to Upland and Pima cotton.

Acknowledgement

The support provided by BASF Corp. is gratefully acknowledged.

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Table 1. PIX Experiments, Maricopa and Safford Ag. Centers, 1993.*

Location	Variety	Planting Date	I.T. Date
Maricopa	STV KC 311	5 April	17 August
Safford	DPL 90	2 April	29 July

*Each location received approximately 2.0 inches of rainfall between 26 August and 29 August. Cut-out occured at MAC from 5 to 10 August and near 1 September at SAC.

Table 2. PIX Rate X Timing Experiment, Safford, AZ, 1993.

Treatment	Growth Stage - HUAP	
	2500 (5 Aug)	2500 (20 Aug)
	pt PIX/acre	
1	--	--
2	1/2	--
3	1/2	3/4

Table 3. N X PIX Experiment, Maricopa Ag. Center, AZ, 1993.

Treatment	N Strategy	PIX Strategy
1	Feedback	Feedback
2	Feedback	Scheduled
3	Scheduled	Feedback
4	Scheduled	Scheduled
5	Feedback	------------

Table 4. PIX Applications, N X PIX Experiment Maricopa, AZ, 1993.

Treatment	Date	Rate pts. PIX/acre
2 and 4	22 June	1/2
2 and 4	15 July	1/2

Table 5. Fertilizer N Applications for Each N X PIX Treatment, Maricopa Ag. Center, AZ, 1993.

			Treatment Number				
Date	Form	Method	1	2	3	4	5
			-----------------lbs N/acre------------------				
20 May	Urea (46-0-0)	SD*	50	50	50	100	100
14 June	Urea (46-0-0)	SD	0	0	0	50	50
29 June	Urea (46-0-0)	SD	50	50	50	50	50
Total			100	100	100	200	200

*SD=Sidedress

Table 6. Lint yields, N X PIX Experiment, Maricopa Ag. Center, AZ, 1993.

Treatment	Lint Yield
	----lbs lint/acre----
1	1271 a*
2	1286 a
3	1296 a
4	1268 a
5	1262 a
$LSD_{0.05}$	NS
OSL	0.5020
CV%	2.3

*Means followed by the same letter are not significantly different according to pairwise comparisons using a Fisher's LSD.

Table 7. Lint yield, PIX Rate X Timing Experiment, Safford Ag. Center, AZ, 1993.

Treatment	Lint Yield ----lbs lint/acre----
1	1291 b*
2	1530 a
3	1430 ab
OSL	0.0155
CV%	9.6

*Means separations were determined by use of single degree of freedom orthogonal contrasts.

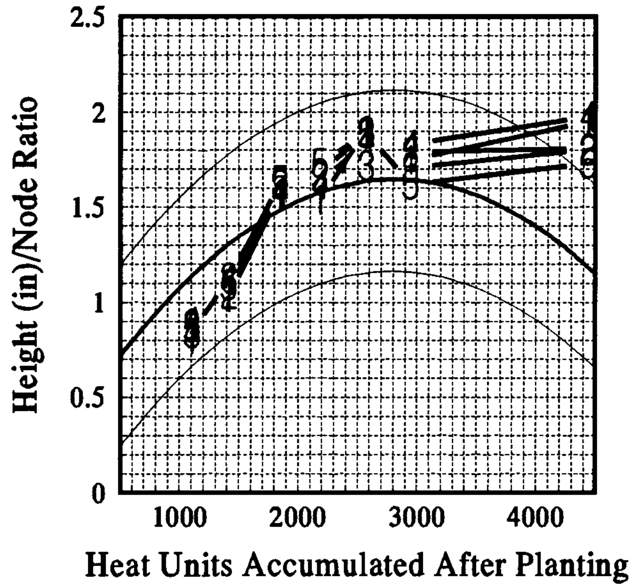

Fig. 1. Height(inches):Node ratios from N*PIX experiment Maricopa Ag. Center, AZ, 1993.

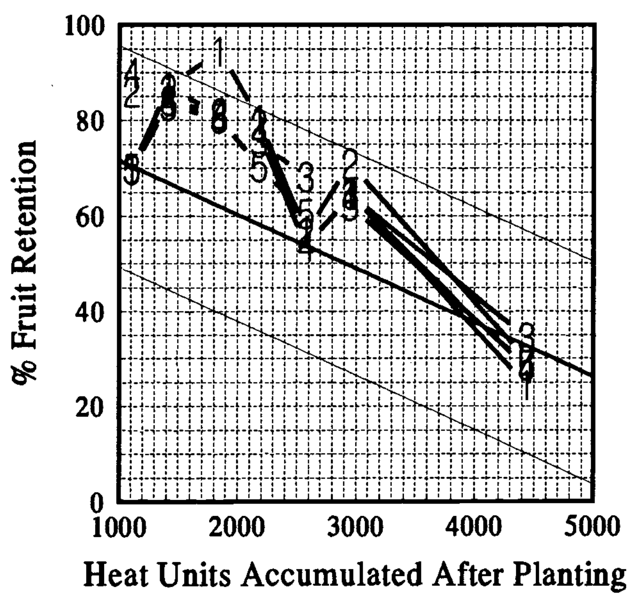

Fig. 2. Percent fruit retention levels from N*PIX experiment Maricopa Ag. Center, AZ, 1993.

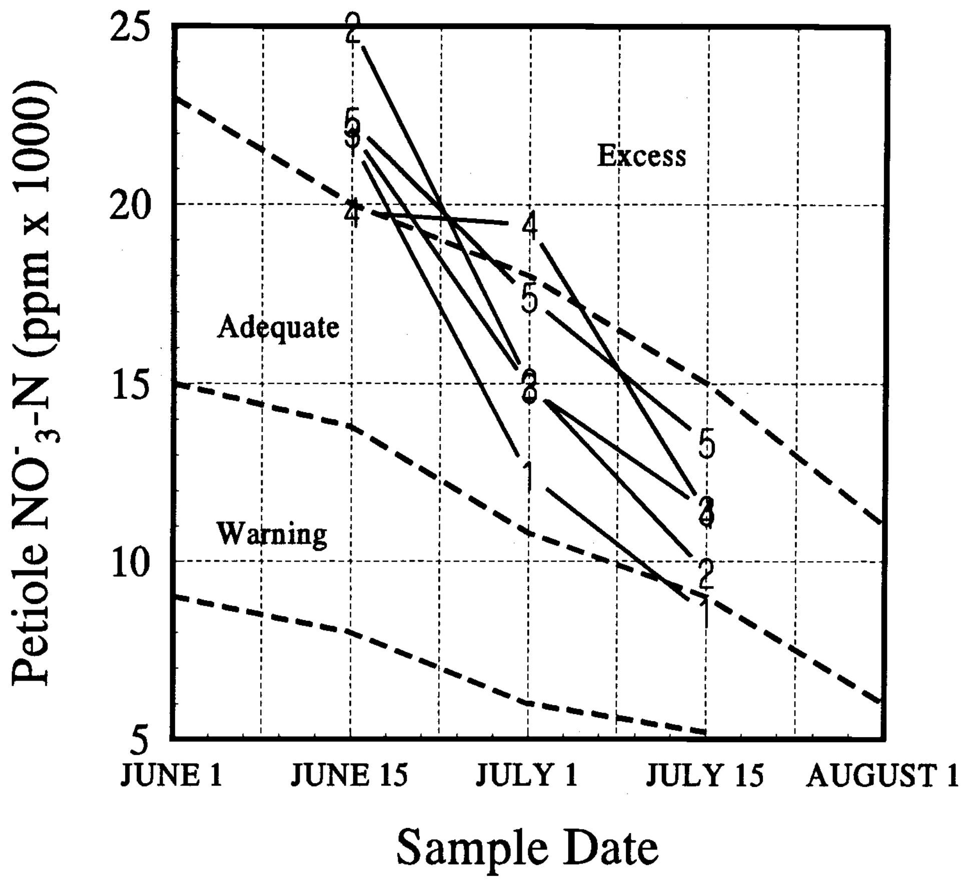

Fig. 3. Petiole Nitrate-N levels for N*Pix experiment
Maricopa Ag Center, AZ, 1993

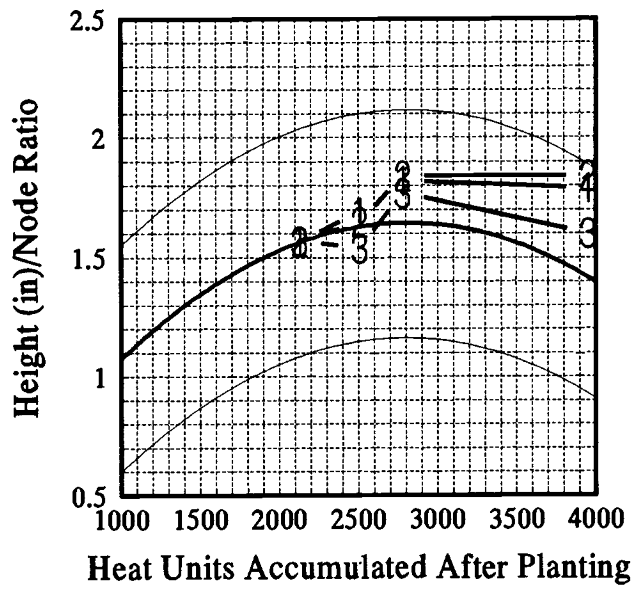

Fig. 4. Height(inches):Node ratios from Pix experiment Safford Ag. Center, AZ, 1993.

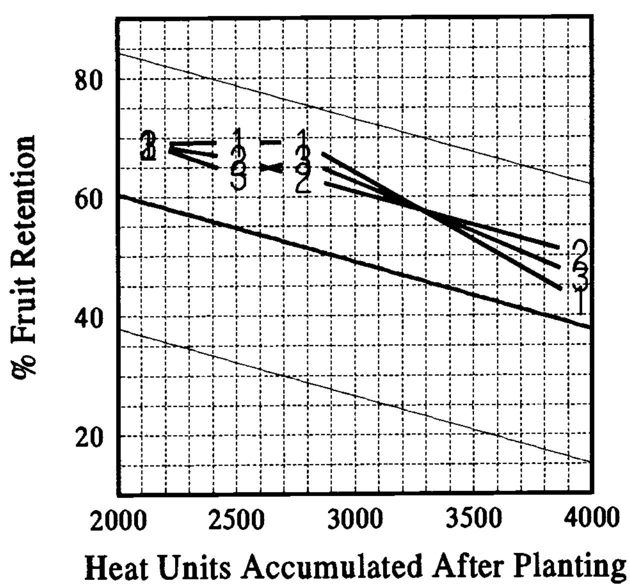

Fig. 5. Percent fruit retention levels fromPix experiment Safford Ag. Center, AZ, 1993.