Evaluation of a Feedback Approach to Nitrogen and Pix Applications, 1998 and 1999

E.J. Norton, J.C. Silvertooth, and E.R. Norton

Abstract

A single field experiment was conducted at Marana, AZ in 1988 and 1999 to evaluate a scheduled (based upon stage of growth) versus a feedback approach (based upon growth parameters and crop conditions) to nitrogen (N) and mepiquat chloride (Pix_{TM}) applications on Upland cotton (Gossypium hirsutum L.). The parameters used in the feedback applications for both N and Pix included fruit retention (FR) levels and height to node ratios (HNRs) with respect to established baselines for irrigated cotton grown in the desert Southwest. Treatments consisted of all combinations of feedback and scheduled applications of both N and Pix. In 1998, the highest lint yields occurred in the treatment consisting of Pix feedback and N feedback (treatment two) management. However, there were no significant differences (P‡0.05) among any of the treatments with respect to yield. In 1999, significant light yield increases ($P \leq 0.05$) were found in the treatments consisting of Pix feedback and N feedback (treatment two), Pix scheduled and N scheduled (treatment three), and Pix scheduled and N scheduled (treatment five) management approaches.

Introduction

Much of the dynamic nature of the cotton (*Gossypium spp*.) plant stems from the fact that it is a true perennial. This presents specific challenges when managing the plant as an annual in a cropping system. Foremost among these challenges is that of maintaining a proper balance between vegetative and reproductive growth. Excessive vegetative tendencies in cotton can often lead to a loss of reproductive structures (squares, flowers, and bolls)(Gausman, et al., 1979; York, 1983b; and Fletcher et al., 1994). The actual physiological mechanism involved in the control of the vegetative/reproductive balance is a subject of considerable debate and research. Many processes have been reported to be associated with this phenomenon. The loss of carbohydrate sinks (reproductive structures) can shift energy from reproductive to vegetative portions of the plant, resulting in rapid proliferation of the vegetative main stem (Mauney, 1986). Self-shading may contribute to the loss of these reproductive structures in some cases due to the fact that the major portion of the assimilate supply for these structures is obtained from the subtending leaf (Ashley, 1972; Benedict and Kohel, 1975). When these leaves are shaded by excess vegetative growth, assimilate supply is depleted due to decreased photosynthetic ability and the abortion of fruiting structures can result (Mauney, 1986; York, 1983b). Environmental and cultural stresses can also exacerbate these problems. The most likely culprit is not one single event, however, but combinations of these factors and several processes acting in concert. Collectively, these morphological and physiological processes can serve to initiate a cycle of reproductive structure loss and a decline of overall fruit retention (FR) on the plant (Guinn, 1982).

Mepiquat chloride (Pix_{TM}) is a plant growth regulator that has been used in cotton production for several decades as a management tool in controlling vegetative growth. Pix is a gibberellic acid suppressant that is absorbed by the green portions of the plant and serves to reduce cell elongation, thus reducing overall plant height (York, 1983a and Kerby, 1985). Theoretically, the plant is then allowed to redirect energy from vegetative structures to reproductive structures. Much research has been devoted to determining optimum rates and application regimes (McConnell, et

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al., 1992; Boman and Westerman, 1994). However, application strategies that result in consistent significant increases in lint yield from Pix have yet to be identified or demonstrated.

Many studies have been conducted in several years in Arizona (Silvertooth et al., 1989, 1990, 1991c, 1993b, and Fletcher et al., 1994) to determine optimal rates and application regimes of multiple Pix applications for Upland (*G. hirsutum* L.) and Pima (*G. barbadense* L.) cotton. The results from these studies have been used to develop a feedback type approach to Pix applications based upon actual crop conditions and measured growth parameters in-season. Naturally, this type of feedback approach with respect to inputs such as Pix requires established baselines. Being able to understand and interpret what is "normal" with regards to the vegetative/reproductive balance of the plant is crucial. Accordingly, guidelines relative to height to node ratios (HNRs) and fruit retention (FR) levels have been developed for this purpose (Silvertooth et al., 1991a; Silvertooth et al., 1992a; Fletcher et al., 1994; Silvertooth et al., 1995b; and Silvertooth and Norton, 1996b, 1997b, and 1998b). Management guidelines for fertilizer N inputs to cotton have been developed and tested with the same basic rationale in a feedback versus scheduled type approach (Silvertooth et al., 1991b, 1992b, 1993a, 1994, 1995a; and Si1vertooth and Norton, 1996a, 1997a, and 1998a).

In 1998 and 1999 a single field experiment was conducted with the objective of evaluating the effects of scheduled and feedback applications of both Pix and N. The present studies are a continuation of a long-term project in Arizona.

Methods and Materials

A field study was conducted in 1998 and 1999 at the University of Arizona Marana Agricultural Center at Marana, AZ (1,972 ft. elevation) on a Pima clay loam soil (Typic Torrifluvent). Upland cotton (var. DP NuCotn 33b) was planted into moisture in mid-April both years (Tables 1 and 2). Treatments were arranged in a randomized complete block design with four replications. Treatments consisted of all combinations of N and Pix feedback and scheduled applications (Table 3). Fertilizer N application dates and rates are shown in Tables 4 and 5 and Pix application dates and rates are shown in Tables 6 and 7. Plots consisted of 8, 40 in. rows that extended the full length of the irrigation run (600 ft.). Pix treatments were applied via ground rig applications with 20 gallons/acre carrier. A complete set of plant measurements (plant height, mainstem node numbers, bloom per 167 $ft.^2$, nodes above top white flower (NAWF), percent fruit retention (FR), and percent canopy closure) were taken on approximately 14 day intervals from each plot. Nitrogen fertility levels were also monitored throughout the season by sampling petioles and analyzing their NO_3^- -N concentrations on approximately 14 day intervals. Management of the studies with respect to irrigation and pest control was carried out in a uniform and optimal manner for the entire study area. Final irrigations were made on 5 September 1998 and 28 August 1999 in order to provide a sufficient amount of water to accomplish full development of the fruit set established up to cut-out. Defoliants were applied by a ground rig application on 28 October 1998 and 29 September 1999. A mechanical picker was used to harvest the center four rows of each plot on 17 November 1998 and 19 October 1999 to obtain yield results. Data was analyzed in accordance with procedures outlined by Steele and Torrie (1980) and the SAS Institute (1997).

Results

1998

Figure 1 summarizes the FR and HNRs of all treatments over the course of the season. Significant fruit loss occurred early in the season due to insect damage and terminal loss (due in part to wind), resulting in increasing HNRs. Pix applications are outlined in Table 6. As HNRs continued to increase, the first application of 1.5 pint Pix/acre was made to all treatments (feedback and scheduled) at approximately 1900 heat units accumulated after planting (HUAP), 86/55^{o} thresholds (near peak bloom). Effective control of vegetative growth was accomplished. As HNRs slowly increased again, a late season application of 1.0 pint Pix/acre was applied to the feedback treatments at approximately 3100 HUAP. From the plant measurement information taken late in the season, the second application of Pix appeared to have little affect on the vegetative growth (HNR) of the plants. The control plot (treatment one) exhibited extreme vigor with high HNRs as would be expected with low FR and no Pix applications.

Fertilizer N was applied in split applications to feedback treatments so as to provide a total of 100 lbs. N/acre. This approach was based in part on a projected yield goal of three bales per acre, assuming a requirement of 60 lbs. N/bale and attributing approximately 70 lbs. N/acre to a 18 ppm NO_3^- -N residual preseason soil level test. Applications of fertilizer N were split from pinhead square to peak bloom (Table 4). Fertility status of the crop with respect to N is summarized in Figure 2 with petiole NO_3^- -N concentrations shown over time. The N fertility level of the crop remained well above the baseline throughout the season. Treatments four and five showed a substantial increase toward the end of the season, which coincides with the extra fertilizer N application given to the scheduled N treatments at approximately 1700 HUAP (prior to peak bloom).

Yield results are displayed in Table 8. Means are also separated according to single degree of freedom orthogonal contrasts (Table 10). No significant differences occurred among any of the treatments ($P \geq 0.05$). Highest lint yields (arithmetically) were realized from treatment two, which utilized a feedback approach to the applications and management of Pix and N. Lower yields corresponded to the more aggressive N regimes and the higher N fertility conditions.

1999

Figure 3 summarizes the FR and HNRs of all treatments during 1999. Similar trends with respect to FR and HNR occurred in 1999 as were seen in 1998. However, overall FR levels were not as low as those encountered in 1998. A significant drop in FR was experienced at about first bloom (~1200 HUAP). Accordingly, a steady increase in the HNR values were also seen at this stage. As HNRs continued to increase, the first application of 0.75 pint Pix/acre was made to all treatments at approximately 1800 HUAP (near mid-bloom). Effective control of vegetative growth was accomplished. A second application of 1.0 pint Pix/acre was applied to the scheduled Pix treatments at approximately 2300 HUAP (near peak bloom). From plant measurement information, the late application of Pix appeared to have an effect on the vegetative growth of the plants as indicated by the HNR parameter.

Fertilizer N was applied in split applications to feedback treatments so as to provide a total of 80 lbs. N/acre. This approach was based in part on a projected yield goal of three bales per acre, assuming a requirement of 60 lbs. N/bale and attributing approximately 70 lbs. N/acre to a 18 ppm NO_3^- -N residual preseason soil level test. Applications of fertilizer N for all treatments (scheduled and feedback) were split from pinhead square to peak bloom (Table 5). Fertility status of the crop with respect to N is summarized in Figure 4 with petiole NO_3^- -N concentrations shown over time.

Yield results are displayed in Table 9. Means are also separated according to single degree of freedom orthogonal contrasts (Table 11). Treatments two, three, and five realized a significant positive lint yield response ($P \leq 0.05$) in relation to the control. These results serve to reinforce the feedback management approach, particularly for N, and for the use of Pix.

Summary and Conclusions

The utilization of a feedback approach to N and Pix management offers many positive features. The ability to improve upon efficiencies associated with crop inputs such as N and Pix are the most significant. However, it is also important to realize that the use of a feedback approach requires site-specific management, regular and timely field evaluation, and well-established references or baselines. The use of a feedback approach allows the grower to respond to in-season changes in crop conditions in a timely manner. For example, it is unlikely that a cotton crop would respond similarly every season to scheduled Pix applications. Therefore, the use of a feedback approach provides flexibility and improves the ability of the grower to better determine when a positive yield response to Pix can be realized.

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Table 1. General experimental description, Nitrogen x Pix experiment, Marana, AZ, 1998.

Planted:	17 April (391 HU/Jan 1)
Variety:	DP NuCotn 33B
Harvested:	17 November

Table 2. General experimental description, Nitrogen x Pix experiment, Marana, AZ, 1999.

Planted:	14 April (623 HU/Jan 1)
Variety:	DP NuCotn 33B
Harvested:	19 October

Table 3. Nitrogen x Pix experiment, Marana, AZ. 1998 and 1999.

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

Table 4. Nitrogen applications for each treatment, Nitrogen x Pix experiment, Marana, AZ, 1998.

			Nitrogen Treatments				
Date	Form	Method	1	2	3	4	5
			lbs. N/acre				
5 June HUAP 790	21-0-0	SD	50	50	50	50	50
23 June HUAP 1192	21-0-0	SD	50	50	50	100	100
15 July HUAP 1779	21-0-0	SD	0	0	0	55	55
		Total	100	100	100	205	205

Table 5. Nitrogen applications for each treatment, Nitrogen x Pix experiment, Marana, AZ, 1999.

Date	Form	Method	Nitrogen Treatments 1	2	3	4	5
			lbs. N/acre				
4 June HUAP 839	21-0-0	SD	40	40	40	40	40
30 June HUAP 1508	21-0-0	SD	40	40	40	80	80
		Total	80	80	80	120	120

Table 6. Pix applications for each treatment, Nitrogen x Pix experiment, Marana, AZ, 1998.

Date	Pix Treatments 1	2	3	4	5
	pints Pix/acre				
20 July HUAP 1914	0	1.5	1.5	1.5	1.5
3 September HUAP 3117	0	1.0	0	1.0	0
Total	0	2.5	1.5	2.5	1.5

Table 7. Pix Plus applications for each treatment, Nitrogen x Pix experiment, Marana, AZ, 1999.

Date	Pix Treatments 1	2	3	4	5
	pints Pix/acre				
13 July HUAP 1861	0	0.75	0.75	0.75	0.75
2 August HUAP 2364	0	0	1.0	0	1.0
Total	0	0.75	1.75	0.75	1.75

Table 8. Lint yield results, Nitrogen x Pix experiment, Marana, AZ, 1998.

Treatment	Lint Yield lbs. lint/acre
1, NF	997 a*
2, NF+PF	1009 a
3, NF+PS	989 a
4, NS+PF	952 a
5, NS+PS	936 a
OSL	0.3661
CV%	5.87

*Means followed by the same letter are not significantly different according to the single degree of freedom orthogonal contrasts.

Table 9. Lint yield results, Nitrogen x Pix experiment, Marana, AZ, 1999.

Treatment	Lint Yield lbs. lint/acre
1, NF	1077.29 b
2, NF+PF	1188.97 a
3, NF+PS	1186.00 a
4, NS+PF	1154.38 ab
5, NS+PS	1213.68 a
OSL	0.0314
CV%	4.64

*Means followed by the same letter are not significantly different according to the single degree of freedom orthogonal contrasts.

Table 10. Single degree of freedom orthogonal contrast results, Nitrogen x Pix experiment, Marana, AZ, 1998.

Contrast	OSL
2 vs. 5, NF+PF vs. NS+PS	0.0946
2 vs. 4, NF+PF vs. NS+PF	0.1852
2 vs. 3, NF+PF vs. NF+PS	0.6237
1 vs. 2 & 3, NF vs. (NF+PF, NF+PS)	0.9527
1 vs. 2, NF vs. NF+PF	0.7622
1 vs. 3, NF vs. NF+PF	0.8453
4 vs. 5, NS+PF vs. NS+PS	0.6896

Table 11. Single degree of freedom orthogonal contrast results, Nitrogen x Pix experiment, Marana, AZ, 1999.

Contrast	OSL
2 vs. 5, NF+PF vs. NS+PS	0.530
2 vs. 4, NF+PF vs. NS+PF	0.383
2 vs. 3, NF+PF vs. NF+PS	0.939
1 vs. 2 & 3, NF vs. (NF+PF, NF+PS)	0.006
1 vs. 2, NF vs. NF+PF	0.012
1 vs. 3, NF vs. NF+PF	0.014
4 vs. 5, NS+PF vs. NS+PS	0.146

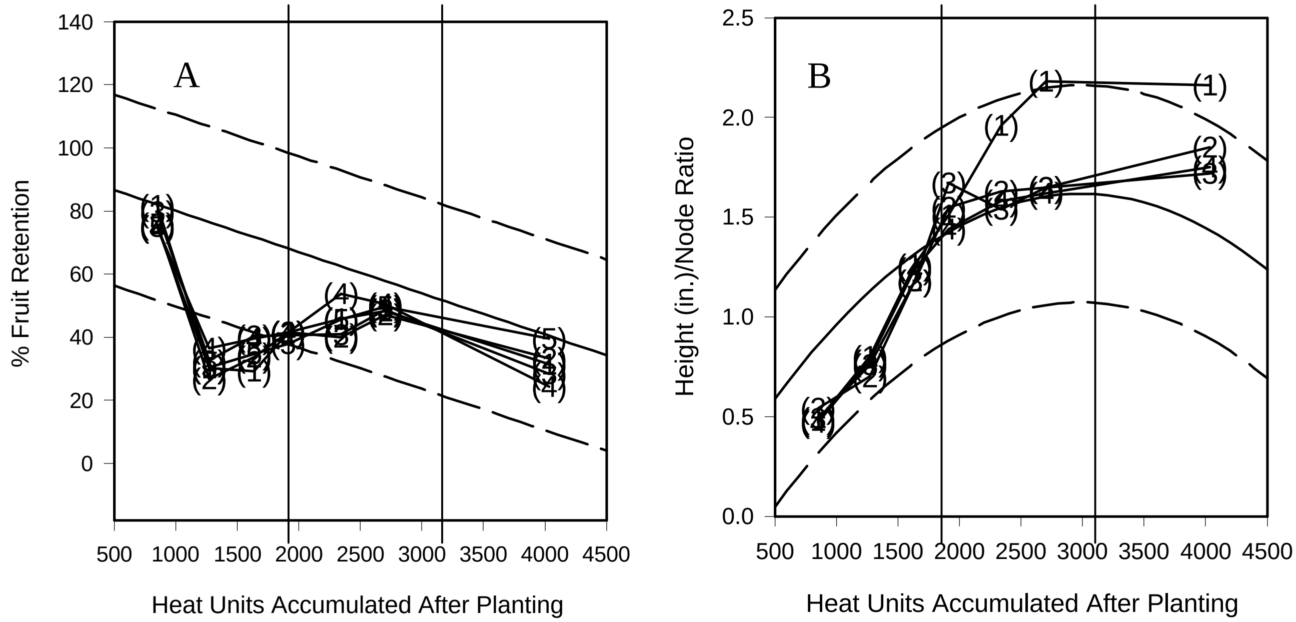

Fig 1. Summary of (A)fruit retention and (B)height to node ratios for Nitrogen by Pix study, Marana, AZ, 1998.
| = Pix application

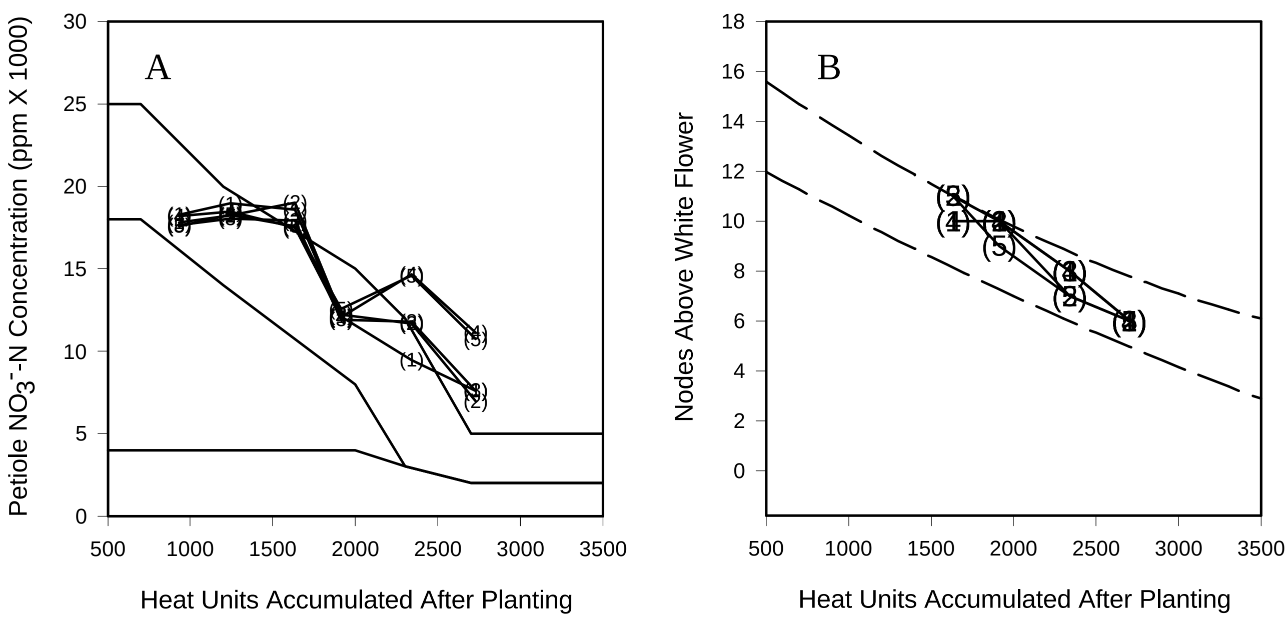

Fig. 2 Summary of (A)petiole NO_3^- -N and (B)nodes above white flower for Nitrogen by Pix study, Marana, AZ, 1998

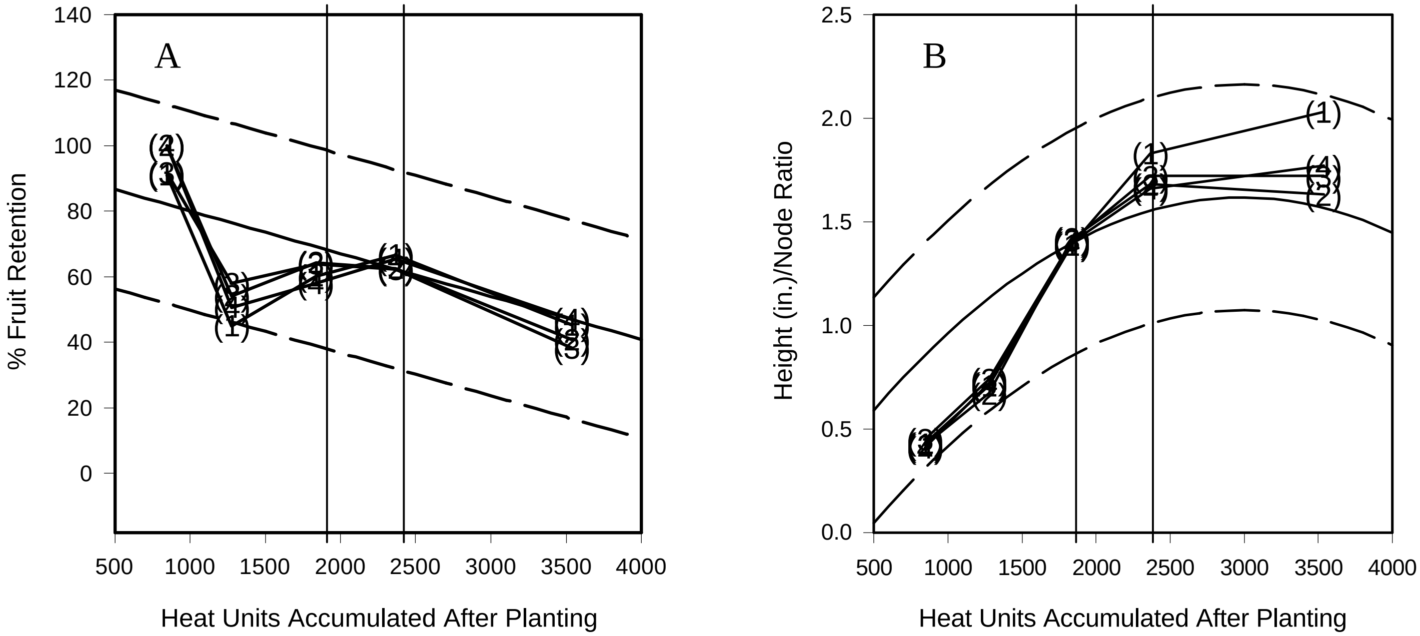

Figure 3. Summary of (A)fruit retention and (B)height to node ratios for Nitrogen by Pix study, Marana, AZ, 1999.

| = Pix event

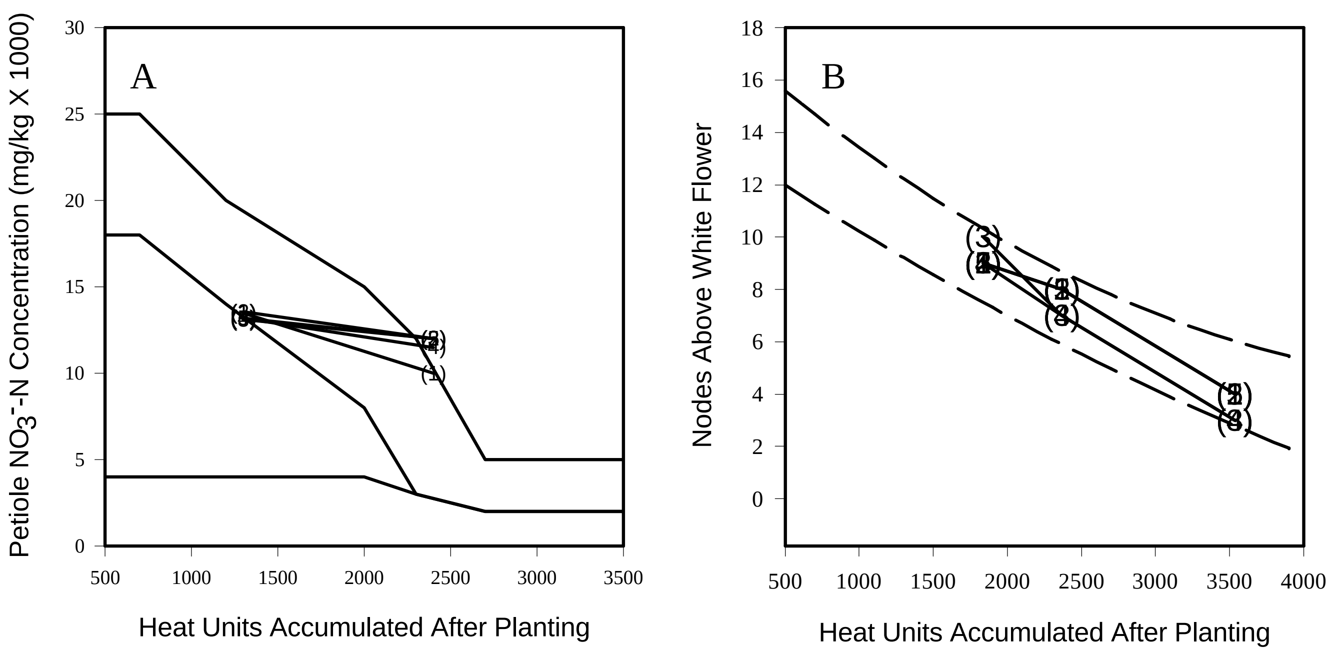

Figure 4. Summary of (A)petiole NO3-N and nodes above white flower for Nitrogen by Pix study, Marana, AZ, 1999.