Nitrogen Management Experiments For Upland and Pima Cotton, 1994.

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Abstract

Three field experiments were conducted in Arizona in 1994 at three locations (Maricopa, Marana, and Safford). The Maricopa and Safford experiments have been conducted for six consecutive seasons, with consistent plot locations; the Marana site was initiated in 1994. The purposes of the experiments were to validate and refine nitrogen (N) fertilization recommendations for both Upland and Pima cotton. The experiments each utilized N management tools such as pre-season soil tests for NO_3^--N, in-season plant tissue testing (petioles) for N fertility status, and crop monitoring to ascertain crop fruiting patterns and crop N needs. Results at each location revealed a strong relationship between the crop fruit retention levels and N needs for the crop. This pattern was further reflected in final yield analysis as a response to the N fertilization regimes used. The effects of N fertility levels have been consistently evident in crop maturity and its relationship to lint yields.

Introduction

The management of fertilizer nitrogen (N) is a very important component of any cotton (Gossypium spp.) production program in Arizona. Water, and N are normally the most limiting inputs to successful cotton production in most desert soils. It is important for farmers to use fertilizer N efficiently to maintain optimum return in yield for the amount of fertilizer N provided. Also, from an environmental standpoint, it is important to manage fertilizer N so that downward movement of NO_3^--N in the soil profile, can be minimized.

For cotton production systems in the desert Southwest, there are several N management tools available to manage fertilizer N inputs efficiently in terms of economic, agronomic, and environmental concerns. These tools include: residual soil NO_3^--N levels from preseason soil samples, inputs of NO_3^--N through irrigation water, petiole samples taken in-season for NO_3^--N analysis, consideration of fruit load and growth pattern of the crop in terms of N needs, and the use of split applications of fertilizer N through the course of the season (Silvertooth and Doerge, 1990).

Recommendations from University of Arizona Cooperative Extension personnel concerning N management in cotton usually include these aforementioned tools. Growers are usually discouraged from making fertilizer N applications based purely on conjecture or guesswork. Therefore, two field experiments were conducted in 1993 as an extension of the 1989, 1990, 1991, and 1992 experiments (Silvertooth et al., 1990; Silvertooth et al., 1991b, Silvertooth et al., 1992, Silvertooth et al., 1993, and Silvertooth et al., 1994) to develop better guidelines for recommendations concerning the integration of N management tools to improve overall efficiency for the grower. Objectives for these experiments are: 1) to compare several fertilizer N management strategies for cotton in terms of N fertility status of the crop, and yield; and 2) develop refinements in the fertilizer N recommendations associated with in-season N fertility assessments using cotton petiole analysis and fruit load development.

Materials and Methods

Field experiments were conducted in 1994 at the University of Arizona Maricopa Agricultural Center (MAC), Marana Agricultural Center (MAR), and Safford Agricultural Center (SAC).

Both Upland (G. hirsutum L., var. DPL 5415) and American Pima (G. barbadense L., var. Pima S-7) were planted on a Casa Grande sandy loam on 7 April at Maricopa. The experimental structure was a split plot within a randomized complete block design with three replications. Whole plots were cotton varieties (DPL 5415 and Pima S-7), with subplots being N treatments (Table 1). Subplots were eight, 40 inch rows wide and extended the full length of the irrigation run (600 ft.). A similar experimental design was employed at Safford with respect to N treatments and varieties (species) used. At Safford, DPL 90 and Pima S-7 were planted on a Grabe clay loam soil on 21 April. At Marana, only Upland cotton, DPL 5415, was planted on 18 April in plots which were eight, 40 inch rows wide and 600 ft. in length, with N treatments (Table 1) arranged in a randomized complete block design with four replications. All pest control and irrigation management practices were carried out on an as-needed basis at each location.

Surface soil samples were collected preseason at each location, to which routine soil analyses were performed. Routine soil test results are shown in Table 2.

Basic plant measurements were carried out within each plot on a regular 14 day basis for the entire season. These measurements included plant heights, number of mainstem nodes per plant, flower numbers per 167 $ft.^2$ areas, and the number of nodes above the top white bloom to the terminal (NAWB). Petioles were also sampled on a routine basis throughout the season and analyzed for NO_3^--N. Plant mapping was performed on each distinct treatment (variety and N treatment) at five dates during the course of the season. Results from the plant mapping provide information concerning the percent total fruit retention (sum of positions one and two on each fruiting branch) for each treatment and a record of the general vegetative/reproductive balance maintained by the various treatments over time.

The N fertilization regimes utilized at each location are outlined in Tables 3, 4, and 5 for Maricopa, Marana, and Safford, respectively. Concentrations of soil NO_3^--N present to a depth of one foot are shown in tables 6, 7, and 8 for Maricopa, Marana, and Safford, respectively.

Lint yields were obtained for each treatment by harvesting the entire center four rows of each plot with a two row mechanical picker. Seedcotton subsamples were collected for ginning, from which lint turnout estimates were made. Results were analyzed statistically in accordance to procedures outlined by Steel and Torrie (1980) and the SAS Institute (SAS, 1988).

Results

Fruit retention (FR) and height to node ratios (HNR) results are presented for all locations, varieties, and treatments in Figures 1, 2, and 3; with the petiole NO_3^--N concentrations shown in Figures 4,5, and 6. Lint yield results are presented in Table 9 for Maricopa, Marana, and Safford.

Maricopa

Fruit retention levels developed from the plant mapping data are shown in Fig. 1 for both the DPL 5415 and the Pima S-7. Petiole NO_3^--N concentrations observed for each treatment are illustrated in Fig. 4 for both DPL 5415 and Pima S-7. Heavy fruiting patterns which resulted in low height to node ratios were experienced throughout the season for both the Upland (DPL 5415) and Pima (S-7) crops (Fig. 1). The development of a substantial boll load is indicative of a strong N sink and a high N demand. Fruit retention levels and NO_3^--N concentration patterns in petioles led to the 5 June, 16 June, and 6 July applications of fertilizer N to treatments 3 and 4 (Table 3). The response to the application of higher rates of N (treatments 2 and 4) can be seen by the resultant increases in petiole NO_3^--N levels in early July, followed by a sharp decline in the late season, apparently due to the continued development of a boll load as evidenced by the fruit retention levels. The petiole trends associated with treatment

3 are indicative of an adequate N fertility status for both the Upland and Pima.

Visual symptoms of N deficiency became apparent in check plots for both DPL 5415 and Pima S-7 in early July. The DPL 5415 plots for treatment 3 progressed towards cut-out near 5 August (approx. 2700 HUAP), which is consistent with a medium season Upland variety supporting a strong boll load, as this crop was. The final irrigation was applied on 19 August in an effort to provide adequate soil moisture to accomplish full development of bolls set by cut-out. Defoliants were applied on 16 September to all plots.

Plots were mechanically harvested on 21 October. Yield data for both the DPL 5415, and Pima S-7 are shown in Table 9. Significant differences were detected among the N treatments for both varieties with the check treatment (1) yielding less than any of the other three treatments. Similar to the results from previous seasons (Silvertooth et al., 1991; Silvertooth et al., 1992; Silvertooth et al., 1993 and Silvertooth et al., 1994), there was no benefit in terms of yield from the 2X feedback treatment (4) which received a total of 270 lbs. N/acre applied over three applications, or from the more aggressive treatment no. 2, with a total of 315 lbs.N/acre, split over five applications. For both the Upland and Pima crops, optimum yields were attained with a total of 135 lbs. N/acre, applied in three 45 lb. N/acre increments from pinhead square to early bloom.

Marana

The DPL 5415 at Marana developed a very strong fruit load early, which was reasonably sustained throughout the season (Figure 2) providing a corresponding N demand. The differences between the check treatment (0 lbs. N/acre) and those receiving fertilizer N were quite apparent in the first year of this study in terms of growth and development (Figure 2), petiole N levels (Figure 5), as well as visual symptoms of N deficiency. There was also a clear and reasonable seperation among the various N fertilization treatments at several dates of sampling for FR, HNRs, and petiole N levels with respect to the rates and timings of fertilizer N applications.

Safford

Fruit retention data for the DPL 90 and the Pima S-7 at Safford are shown in Fig. 3. The early season fruit retention levels were high, relative to baseline figures (Silvertooth et al. 1991a) for both the DPL 90 and Pima S-7. The sharp drop in fruit retention levels experienced at about first bloom (approx. 1200 HUAP) shown in Figure 3, coincide with the drastic increase in petiole NO_3^--N concentrations (Figure 6). This was apparently due to a short-term, yet severe period of water stress. Subsequent irrigations were corrected and adequate fruit retention levels recovered.

From the N treatments used, treatment 3 received 138 lbs. N/acre, applied by two sidedress applications on 21 June and 11 July, as compared to the same total amount applied to treatment 2 which utilized an earlier application schedule. Treatment 4 received a total of 276 lbs. N/acre with no apparent benefit being gained from this higher level of N input to either the Upland or Pima crop. This has been apparently due to delays in crop maturity in this and previous seasons with the higher rates of N, which have been particularly damaging to yields when an early frost is experienced.

The lint yield results shown in Table 9 revealed statistically similar (or higher) yields with the 0 N treatments (check plots) at Safford for either DPL 90 or Pima S-7. This fact is particularly interesting in relation to this particular experiment in that the integrity of these plots have been maintained since 1989. Therefore, the checkplots (N treatment one) have not received any fertilizer N for five consecutive cotton seasons over 1989, 1990, 1991, 1992, 1993, and 1994. Analyses of the irrigation water has revealed an average concentration of about 5.0 ppm NO_3^--N. Therefore, approximately 27 lbs. NO_3^--N/acre were provided in roughly 3 lb. NO_3^--N/acre increments over the season through the irrigation system. The lack of a yield response to any of the N treatments by DPL 90 or Pima at this location illustrates the necessity of monitoring both crop and soil conditions in an effort to maintain efficient use of N and other crop production inputs, and also the importance of timeliness in management responses.

Summary

The 1994 experiments at Maricopa, Marana, and Safford demonstrate the value and utility of incorporating various N and crop management tools into cotton production systems of Arizona. The dynamic nature of the cotton crop (Upland and Pima) requires management of inputs such as fertilizer N that are critical in attaining optimum efficiency agronomically, economically, or environmentally. The difficulty in predicting crop N needs for any given season in advance indicate the need to follow actual crop conditions while managing the N fertilization program. In-season crop monitoring techniques for fruit load development and N fertility status compliment each other for managing N inputs for better efficiency.

Results from 1994 are consistent with the trends revealed from the previous work on this project. Higher rates of fertilizer N, as commonly used in treatments 2 and/or 4, are not providing the basis for higher yields. In fact, the rather consistent trend has been for higher N treatments to cause a depression in yields. This is often attributed to a delay in crop maturity from high N fertility levels and an increase in general vegetative tendencies. This represents a management factor which needs to be considered within the context of the current interest on the part of cotton growers to improve the earliness of a crop. Incentives to achieve improved earliness includes whitefly populations, late season pink bollworms, and the limits in the length of the growing season at higher elevations.

The use of crop management tools such as petiole NO_3^--N analyses in-season, can also benefit the decision making process such as timing, form, and rate of N fertilization when used in conjunction with good crop monitoring practices. Petiole samples taken regularly at close intervals (approximately every two weeks), and in combination with regular trips through the field for crop inspection (or plant mapping) serve as a more complete approach for the management of fertilizer N applications.

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Table 1. Nitrogen fertilization treatments used at the Maricopa and Safford Agricultural Centers, 1989-1994.

N Treatments No.	Fertilizer N Management
1	Check (No fertilizer N)
2	Standard: Preplant & Side dress
3	Feedback approach from soil and petiole NO_3^--N analysis, 1X rate.
4	2X rate from soil and petiole NO_3^--N feedback

Table 2. Preseason soil test results for each N treatment at Maricopa, Marana, and Safford, AZ, 1994.

Treatment	Ca*	Mg	Na	K	Zn**	NO_3^--N***	P†	pH	EC	ESP§
	ppm							(1:1 H_2O)	ds/m	-%-
			Maricopa							
1	5250	332	267	390	.9	15	10.0	8.4	1.9	3.7
2	5200	340	242	430	1.0	24	12.0	8.4	1.9	3.4
3	4590	315	224	410	1.0	12	7.9	8.5	1.6	3.5
4	4560	302	235	415	.9	18	13.0	8.4	1.9	3.7
			Marana - Post-Season							
1	7100	400	185	520	---	5.6	12	8.0	1.5	2.0
2	7200	390	163	570	---	14	14	8.1	1.6	1.7
3	7200	373	164	520	---	7.6	20	8.2	1.4	1.7
4	7100	373	178	510	---	14	18	8.1	1.7	1.9
			Safford							
1	6630	613	857	666	1.6	17	10.0	8.1	4.3	8.5
2	6230	670	910	754	1.9	16	8.1	8.2	3.5	9.3
3	5810	600	977	680	1.5	16	6.8	8.3	3.5	10.6
4	6000	615	940	720	1.4	18	6.6	8.2	3.5	10.0

* Exchangeable cations using neutral molar ammonium acetate.
** DTPA extractable Zn.
*** NO_3^--N using specific ion electrode.
† $NaHCO_3$ extractable P
§ Computed - exchangeable sodium percentage.

Table 3. Fertilizer N applications for each N management treatment, MAC, 1994.

Date	Form	Method*	Treatment Number 1	2	3	4
			lbs N/acre			
(at planting) 29 March	$(NH_4)_2SO_4$ (21-0-0)	SD	0	45	0	0
9 May	$(NH_4)_2SO_4$ (21-0-0)	SD	0	45	0	0
2 June	$(NH_4)_2SO_4$ (21-0-0)	SD	0	90	45	90
16 June	$(NH_4)_2SO_4$ (21-0-0)	SD	0	45	45	90
6 July	$(NH_4)_2SO_4$ (21-0-0)	SD	0	90	45	90
		TOTAL	**0**	**315**	**135**	**270**

*SD = sidedress

Table 4. Fertilizer N applications for each N management treatment, Marana, AZ, 1994.

Date	Form	Method*	Treatment Number 1	2	3	4
			lbs N/acre			
31 May	$(NH_4)_2SO_4$ (21-0-0)	SD	0	50	0	0
21 June	$(NH_4)_2SO_4$ (21-0-0)	SD	0	100	50	100
11 July	$(NH_4)_2SO_4$ (21-0-0)	SD	0	50	50	100
		TOTAL	**0**	**200**	**100**	**200**

*SD = sidedress

Table 5. Dates and rates of N fertilizer applied at Nitrogen Management study, Safford, 1994.

Date of Application	Form of Fertilizer N	Treatment -lbs N/acre- 1	2	3	4
1 June	Urea	0	46	0	0
20 June	Urea	0	46	46	92
29 July	Urea	0	46	46	92
12 July	Urea	0	0	46	92
	Totals	**0**	**138**	**138**	**276**

Table 6. Preseason soil NO_3^--N mean concentrations for each N treatment at Maricopa, AZ, 28 March, 1994.

Treatment	Depth	NO_3^--N	
	-feet-	-ppm-	-lbs./acre-
		DPL 5415	
1	1	10.0	40.0
2	1	19.6	78.4
3	1	8.0	32.0
4	1	12.0	48.0
		Pima S-7	
1	1	8.4	33.6
2	1	8.8	35.2
3	1	8.8	35.2
4	1	8.0	32.0

Table 7. Preseason soil NO_3^--N mean concentrations for each N treatment at Marana, AZ, 1994.

Treatment	Depth	NO_3^--N	
	-feet-	-ppm-	-lbs./acre-
		DPL 5415	
1	1	5.6	22.4
2	1	14.0	56.0
3	1	7.6	30.4
4	1	14.0	56.0

Table 8. Preseason soil NO_3^--N mean concentrations for each N treatment at Safford, AZ, 2 April, 1994.

Treatment	Depth	NO_3^--N	
	-feet-	ppm	lbs./acre
		DPL 90	
1	1	8.0	24.0
2	1	20.0	80.0
3	1	13.6	54.4
4	1	17.2	68.8
		Pima S-7	
1	1	20.4	81.6
2	1	13.6	54.4
3	1	13.2	52.8
4	1	23.2	92.8

Table 9. Lint yields for each N management treatment at Maricopa, Marana, and Safford, 1994.

Maricopa

Treatment	Yield	
	DPL 5415	Pima S-7
	---lbs. lint/acre---	
1	701 b*	499 b*
2	1292 a	743 a
3	1257 a	755 a
4	1279 a	792 a
§$LSD_{0.05}$	90.92	105.45
†OSL	0.0001	0.0018
‡C.V. (%)	4.01	7.56

Marana

Treatment	Yield
	DPL 5415
	---lbs. lint/acre---
1	892 b*
2	1052 a
3	981 ab
4	1027 a
§$LSD_{0.05}$	NS
†OSL	0.0809
‡C.V. (%)	8.09

Safford

Treatment	Yield	
	DPL 90	Pima S-7
	---lbs. lint/acre---	
1	1132 a*	527 a*
2	1059 ab	543 a
3	1022 b	571 a
4	1003 b	541 a
§$LSD_{0.05}$	NS	NS
†OSL	0.0876	0.9292
‡C.V. (%)	6.25	17.43

* Means followed by the same letter are not significantly different according to a Fisher's LSD test.
§ $LSD_{0.05}$=Least Significant Difference
† OSL=Observed Significance Level
‡ C.V.=Coefficient of Variation

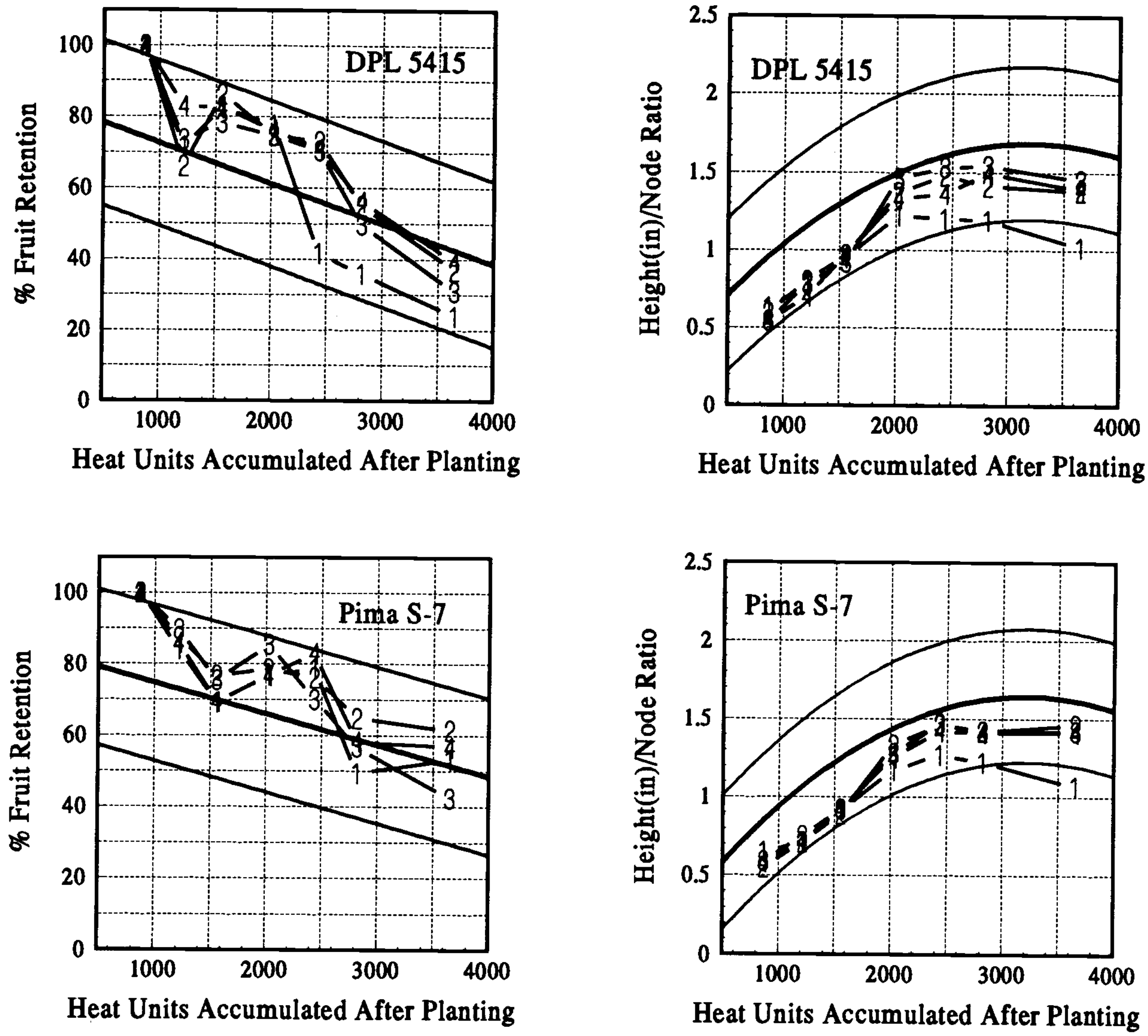
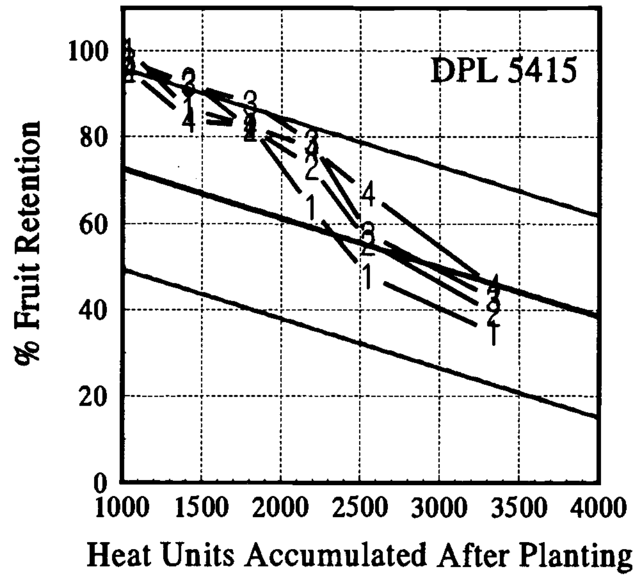


Figure 1. HNR and FR data for each N-management treatment at MAC, 1994.



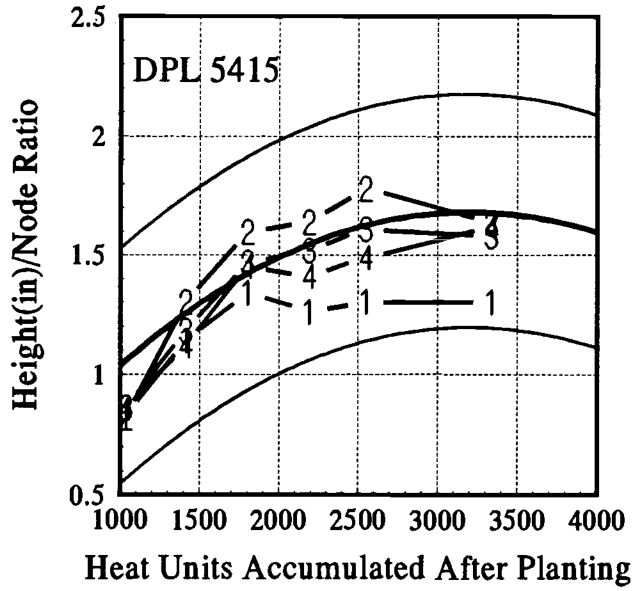


Figure 2. HNR and FR data for each N-management treatment at Marana, AZ, 1994.

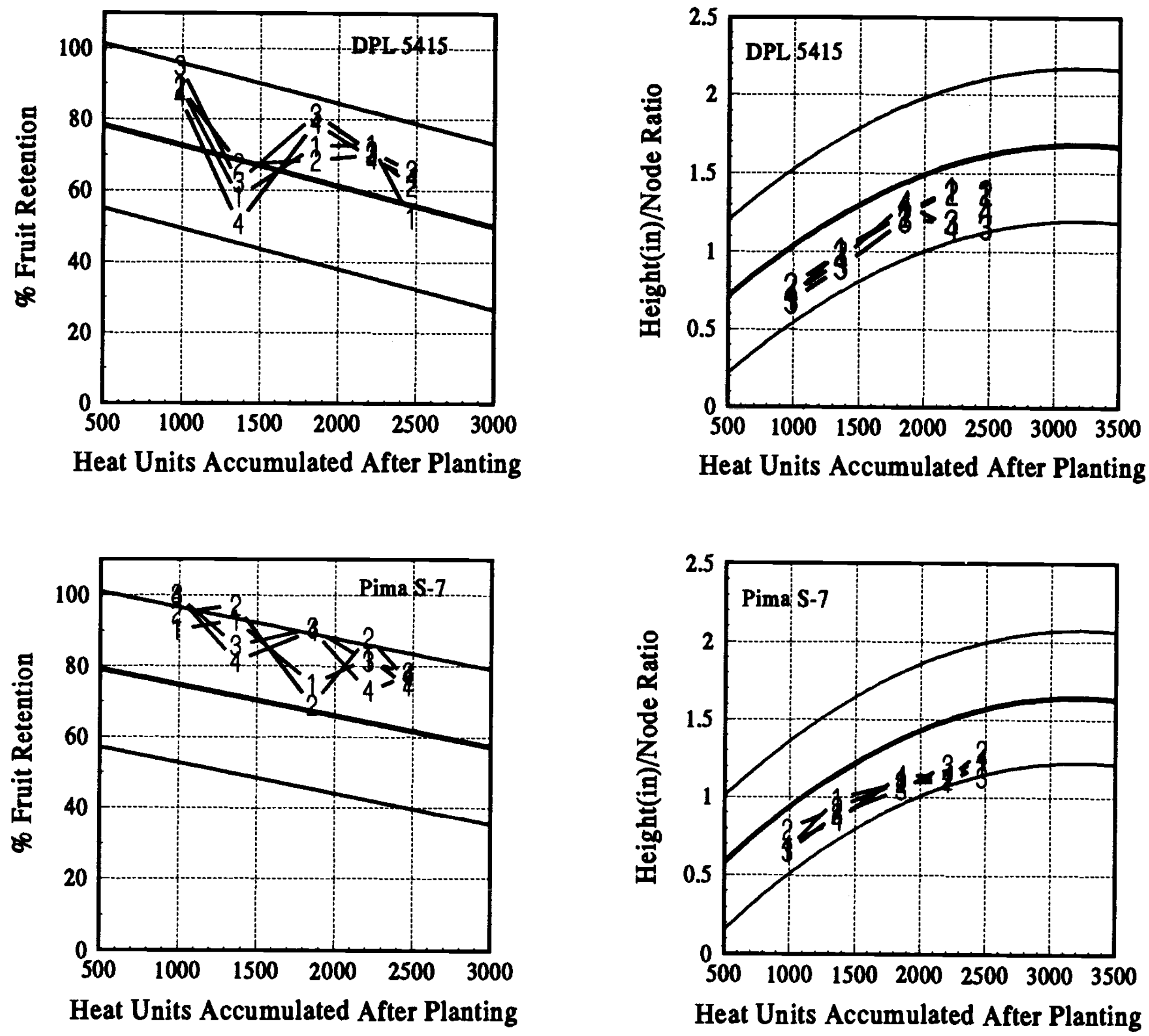


Figure 3. HNR and FR data for each N-management treatment at Safford, AZ, 1994.

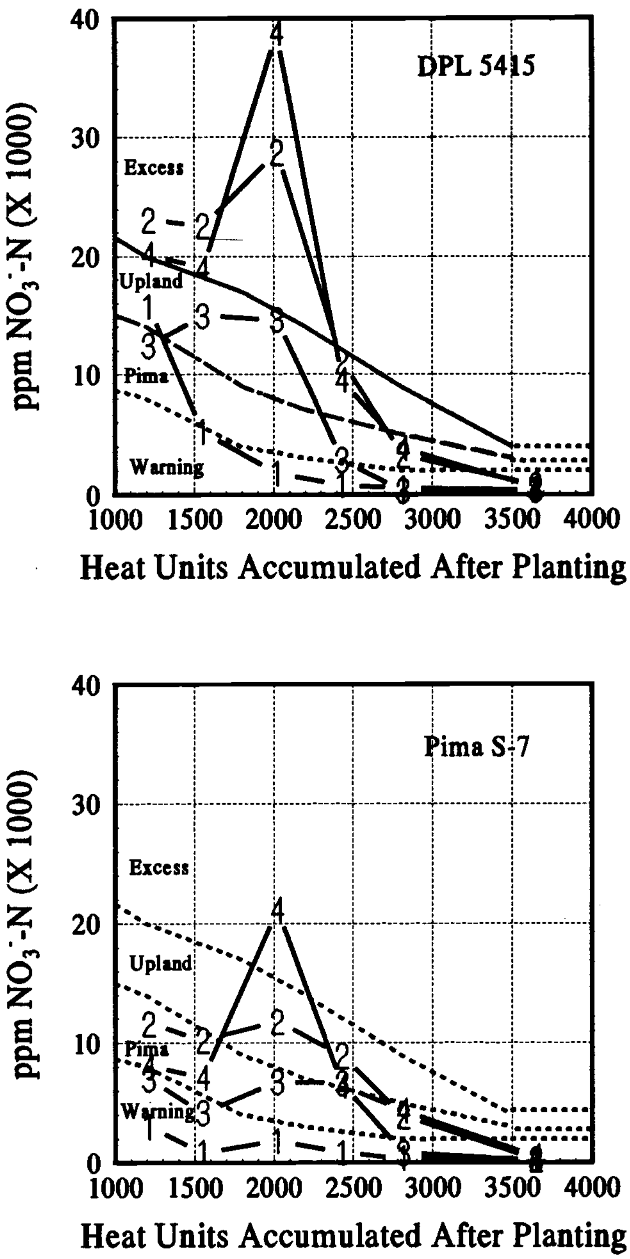


Figure 4. Petiole nitrate-N levels for each N-management treatment at MAC, 1994.

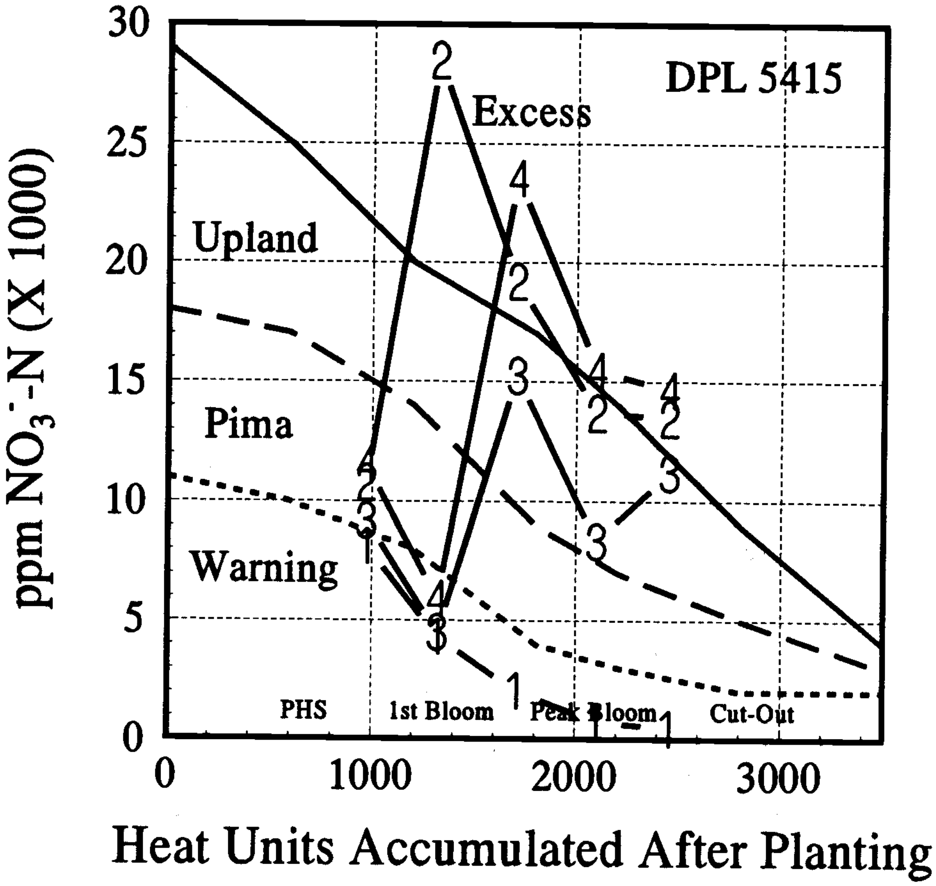


Figure 5. Petiole nitrate-N levels for each N-management treatment, Marana, AZ, 1994.

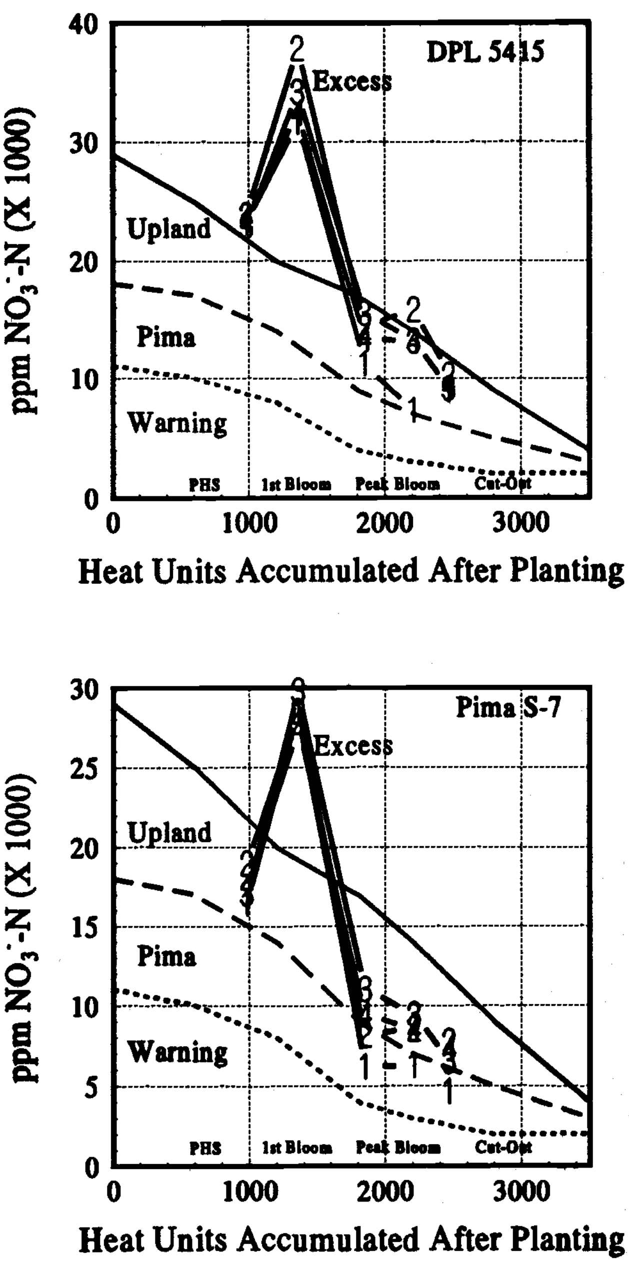


Figure 6. Petiole nitrate-N levels for each N-management treatment at Safford, AZ, 1994.