Cotton Response to Applications of PIX, 1992.

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Abstract

Four field experiments were conducted in 1992 in Arizona to evaluate cotton crop response to several treatment regimes of multiple applications of PIX_{TM} (an anti-gibberellicacid plant growth regulator). Treatment regimes used in 1992 employed higher rates of PIX/acre/application and extended times of applications later into the fruiting cycle than earlier experiments in 1988 through 1991. Some treatments used exceeded currently labeled maximum use rates in an attempt to evaluate the possible need of increasing maximum rates. Similar to earlier experiments, results in 1992 demonstrated the ability of some PIX treatments to significantly reduce plant height, relative to the untreated check treatments. Excellent fruit retention levels were experienced in each experimental site in 1992, irrespective of PIX treatments. Lint yield results revealed significant differences ($P \leq 0.05$) between several selected treatments at two of the locations in 1992.

Introduction

PIX_{TM} (mepiquat chloride) is a compound used in cotton production as an agent of plant height control. Its proposed mode of action is found as a suppressant of gibberellic acid formation and activity, thereby reducing cell elongation. In cotton production, the use of PIX is directed toward controlling vegetative growth, particularly in situations conducive to rank or excessive vegetative growth. Strategically, PIX provides a tool by which a grower can control vegetative growth at critical stages in crop development. Theoretically, the energy (essentially the carbon) that would have been used in vegetative growth and development can be allocated to other sinks, particularly fruiting forms (squares, flowers and bolls). The intention is to encourage and preserve fruiting form development that might otherwise be lost or aborted due to limitations physiologically (Guinn, 1982).

The use of PIX has been incorporated into the general management structure of many cotton production operations. The manner in which it is used varies considerably. In the past 15 years, a large number of experiments have been conducted in a variety of situations and locations across the cotton-growing areas of Arizona. The results have been quite variable and have not indicated a direct consistency in terms of predictable crop management and recommendation guidelines.

In 1988, a series of field experiments were initiated in Arizona to evaluate the response of both Upland and Pima cotton to multiple applications of PIX (Silvertooth et al., 1989; Silvertooth et al., 1990; Silvertooth et al., 1991; and Husman et al., 1992). The treatment regime used in the early experiments (1988 and 1990) utilized treatments with low doses (≤ 1/4 pt. PIX/acre), which were initiated at the match-head square point of crop development, followed by applications at early bloom and then again approximately 10 to 14 days past early bloom. These stages of growth corresponded with approximately 1000, 1500, and 2000 Heat Units (HU, 86/55°F limits) accumulated after planting.

Results from these experiments were rather consistent. Plant heights could regularly be reduced for most of the treatments used, compared to the untreated check plots, for a period of usually two to three weeks after application. However, plant height differences usually diminished as crop development progressed, and became indistinguishable as the crop matured. Yield differences among treatments that were statistically significant ($P \leq 0.05$), were encountered in only one of the eight experiments conducted in 1988 and 1989 (Silvertooth, et al., 1990).

A revised treatment program was drafted for extending the PIX application period and increasing single application rates, for use in experiments planned for the 1990 growing season. Accordingly, the PIX application regime implemented for the 1990 experiments, for the purpose of extending applications from early bloom, through peak flowering stages, and into later stages of the first fruiting cycle as the crop approached cut-out. Therefore, the development of this overall project has reflected the experience gained from earlier experiments with an inclusion of higher rates and extended periods of application. Positive results from this change in protocol were experienced in 1990 (Silvertooth et al., 1991) and 1991 (Husman et al., 1992). The experiments conducted in 1992 are a direct extension of this developing research program. The objectives of these experiments in 1992 were 1) to measure any response to PIX applications in terms of basic plant growth parameters, 2) to measure yield responses associated with the various PIX application treatments, and 3) refine current guidelines regarding PIX use (timing and rates) based upon plant measurements taken in-season.

Methods

Four field experiments were conducted in Arizona in 1992 at the locations shown in Table 1. Treatments which were actually employed are outlined in Tables 2, 3, 4, and 5 for each experiment. In each case, treatments were arranged in randomized complete block design with four replications. Plots at each location extended the full length of the irrigation run. All treatments were applied by use of ground rig applicators. 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), and percent canopy closure) were taken from each plot on approximately 14 day intervals throughout the growing season. In addition to the basic plant measurements, plant maps were made from composite samples of each PIX treatment, at all locations, for several dates in the progress of crop development. Each experiment was managed in an optimal and uniform manner with regard to irrigation, pest control, and nutritional needs. Yield estimates were obtained by harvesting internal areas of each plot with a mechanical picker. All data sets were analyzed in accordance to procedures outlined by the SAS Institute (1985).

Results

Mohave

Actual treatments used are outlined in Table 2. The height(inches):node ratios (HNRs) obtained from each treatment are shown in Figure 1 as a function of stage of growth or heat units after planting (HUAP, 86/55 F thresholds), including the points of PIX applications. Actual HNRs measured are plotted upon the HNR baselines developed for several Upland cotton variety types as well as Pima (Silvertooth et al., 1992). The solid, center line in Figure 1 represents the general expected baseline, with the parallel dashed lines representing the upper and lower thresholds. As evidenced by the actual HNRs measured from the Mohave Valley location, the field was not in a vegetative state, or tendancy at anytime. Reductions in HNRs from various PIX treatments are evident in relation to the check (treatment 1). Fruit retention levels are shown in Figure 2 in relation to the established baselines for Upland cotton. Excellent fruit retention levels were experienced for this field over the entire growing season. Several PIX treatments created increased fruit retention levels by the end of the season, in comparison to the check. However, in review of the total node data shown in Figure 3, the number of nodes generated were reduced in most of the PIX treatments, which would reflect a reduction in the number of fruiting branches and total fruiting sites. Therefore, with a reduction in total fruiting sites with several of the PIX treatments, an increase in measured fruit retention could be misleading.

This point is reinforced in review of the lint yield data shown in Table 6. The actual lint yield results found the check treatment (1) yielding higher than all other treatments, and being statistically higher than treatments 4, 5, 6, and 7. The reductions in yield were quite substantial in several of the treatments. This information reinforces the approach to PIX applications or plant height control efforts based upon a crop feedback approach as opposed to making the applications according to a more arbitrary factor such as stage of growth. Apparently, the reductions in yield were created by a reduction in the total number of fruiting branches and fruiting sites, as previously discussed. The suppression of the apical meristem's activity,as evidenced by reduced node numbers and HNRs, was also expressed in a reduction in lateral growth. The estimates of percent canopy closure for all treatments are shown in Figure 4, with substantial reductions being measured for the higher rate PIX treatments.

Gila Bend

The treatments used in this experiment are shown in Table 3. Figure 5 outlines the HNR patterns for all treatments over the season. All HNR measurements tended to be on the lower side of the HNR threshold range, which is indicative of a more compact plant structure. Fruit retention levels (Figure 6) revealed relatively high levels for all treatments throughout the season. No real differences were detected among any treatments regarding total mainstem nodes (Figure 7) or percent canopy closure estimates (Figure 8). Yield results are shown in Table 9, where no statistical differences among treatments were detected. Based upon the results of the Mohave Valley experiment, and the HNR patterns, conditions which were prevelant in this field all season were not necessarily conducive to further height suppression through PIX applications. Although yields were not reduced in this case, it is important to point out the lack of a positive yield response as well.

Pearce (Sunsites)

The actual treatment regime used at this location is listed in Table 4. The HNR measurements are shown in Figure 9, indicating a well-balanced pattern of growth all season for this Pima crop. This is further reinforced by the fruit retention levels (Figure 10) which were excellent for all dates of sampling. No real differences were measured in terms of total node number or canopy closure (Figures 11 and 12). Yield results are listed in Table 8, with all treatments being similar statistically, with the exception of treatment 5 being significantly lower in final lint yield than treatments 1, 3, and 4. Treatment 5 received two, 1 pt. PIX/acre applications (Table 4), in comparison to somewhat lighter rates for the other three treatments of difference.

A second experiment was conducted at this location in 1992 consisting of PIX applications being made on a single date, corresponding approximately with the occurence of cut-out (Table 5). This experiment utilized four treatments, with three rates of PIX ranging from 1/2, 1.0, and 1 1/2 pt. PIX/acre. The intention with this experiment was to test the validity in reducing further vegetative growth following cut-out and allocating available energy and nutrients to the existing fruit load, and then perhaps improving upon the maturity and earliness of the crop. The yield results for this experiment are listed in Table 9 for first pick, second pick, and total lint yields. There were no differences among any treatments for either of the harvest dates. However, there was a slight trend towards an improvement in crop earliness as expressed by the improvement in percent first pick for treatment 4 (1 1/2 pt. PIX/acre). There is quite a bit of interest on the part of growers in the state relative to this type of PIX use strategy late in the season. This is the first experiment of this type, and even though no clear improvement in yield or earliness was found, the results are somewhat encouraging.

Summary

The experimental program directed at PIX use and response on cotton in Arizona has been oriented toward practical criteria and questions concerning 1) when to apply PIX, 2) what rates to apply, and 3) what strategy of multiple applications should be pursued. These essential three points concerning PIX, or any similar plant growth regulator material, must be addressed in an effort to gain a satisfactory degree of consistency and reliability as a crop management tool. The use of PIX seems most appropriate in response to actual crop conditions that exhibit a need for control of excessive vegetative growth. Determination of vegetative growth tendancies are being related to crop monitoring techniques such as HNRs and fruit retention levels, where guidelines for these measures have been developed specifically for Arizona conditions and common varieties (Silvertooth et al., 1992).

Evidence presented from these 1992 experiments reinforce the use of a feedback approach through the use of plant measurements and existing guidelines. The three cases outlined from Mohave Valley, Gila Bend, and Pearce each revealed crop conditions which were not necessarily vegetative (medium to low HNRs and high fruit retention levels) and did not respond positively to PIX treatments, and even produced decreases in lint yields in some cases.

This information is consistent with a number of other experiments conducted in Arizona (Silvertooth et al., 1989 and Silvertooth et al., 1990). Similarly, increases in lint yield have been recorded from applications of PIX when crop conditions were indicative of more vegetative conditions (high HNRs) (Silvertooth et al., 1991 and Husman et al., 1992).

Current guidelines for PIX use are based upon HNR patterns taken from actual crop measurements. This strategy utilizes a simple approach requiring plant height measurements (base of the plant or cotyledon node to the terminal, inches) and a count of the total mainstem nodes. A simple ratio can then be calculated and referenced to HNR guidelines available through the University of Arizona Cooperative Extension System. Basically, as HNRs are recorded near or above the upper thresholds, initiation of PIX applications are recommended. Rates ranging from 1/2 to 1.0 pt. PIX/acre are recommended, based upon the extent of vegetative tendancies, with 3/4 pt. PIX/acre providing a somewhat optimal rate. Therefore, the feedback approach to this area of cotton crop management in Arizona seems to be valid, particularly in comparison to the use of PIX applications based upon stage of growth, calendar date, or general inference.

Research efforts such as these are prerequisite to the development and further refinement of application guidelines. Additional objectives regarding further improvement in the feedback approach to PIX applications during the course of the growing season are in order and will be the focus of future activities in this area. Also, the use of late season applications of PIX in an attempt to improve crop maturity and earliness may also have merit.

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Table 1. Arizona PIX rate and timing experiments (1992).

Location	Elevation)	Variety
Mohave Valley	600 ft.	DES 119
Gila Bend	750 ft.	DPL 5461
Pearce	4,000 ft.	Pima S-6

Table 2. Treatments for PIX Experiment, Mohave Valley, Az, 1992.

Treatment	Growth Stage - HUAP		
	1427	1872	2514
	-------------pts. PIX / acre-------------		
1	--	--	--
2	1	1/2	--
3	3/4	3/4	--
4	3/4	3/4	3/4
5	2	1	1
6	1	3/4	1
7	2	1 1/2	--

Table 3. Treatments for PIX experiment, Gila Bend, Az, 1992.

Treatment	Growth Stage - HUAP		
	1686	2509	----
	-------------pts. PIX / acre-------------		
1	--	--	--
2	1	1/2	--
3	3/4	--	--
4	3/4	3/4	--
5	1	1	--
6	1/2	3/4	--
7	1	1 1/2	--

Table 4. Treatments for PIX experiment, Sunsites, Az, 1992.

Treatment	Growth Stage - HUAP		
	1571	1881	----
	-------------pts. PIX / acre-------------		
1	--	--	--
2	1	1/2	--
3	3/4	--	--
4	3/4	3/4	--
5	1	1	--
6	1/2	3/4	--
7	1	1 1/2	--

Table 5. Treatments for PIX late-season experiment, Sunsites, Az, 1992.

Treatment	Rate
	------------pts. PIX / acre----------
1	--
2	1/2*
3	1
4	1 1/2

* All treatments applied on 4 September, 2400 HUAP, NAWB = 5, Mainstem Nodes = 23.
Variety: 1517-88

Table 6. Line yield means from PIX experiment, Mohave Valley, Az, 1992.

Treatment	Lint Yield
	-----------lbs. lint / acre-----------
1	1502 a
2	1357 a b
3	1386 a b
4	1277 b
5	1247 b c
6	1108 c
7	1091 c
$LSD_{0.05}$	159
OSL	0.0003
CV %	8.4

Table 7. Lint yields from PIX experiment, Gila Bend, Az, 1992.

Treatment	Lint Yield
	------------lbs. lint / acre---------
1	1148
2	1124
3	1097
4	1182
5	1173
6	1086
7	1008
$LSD_{0.05}$	NS
OSL	0.3315
CV %	9.6

Table 8. Lint yield means from PIX experiment, Sunsites, Az, 1992.

Treatment	Lint Yield	
	------------lbs. lint / acre----------	
1	495	a*
2	446	a b
3	475	a
4	505	a
5	388	b
6	437	a b
7	471	a b
OSL	0.1225	
CV %	12.3	

* Mean seperations performed by use of single degree of freedom orthogonal contrasts.

Table 9. Lint yield means for PIX late - season experiment, Sunsites, Az, 1992.

Treatment	Lint Yield		
	1st Pick	2nd Pick	Total
	------------lbs. lint / acre------------		
1	823	234	1057
2	832	206	1038
3	837	225	1062
4	909	172	1081
$LSD_{0.05}$	NS	NS	NS
OSL	0.6088	0.1520	0.9558
CV %	9.9	14.2	9.04

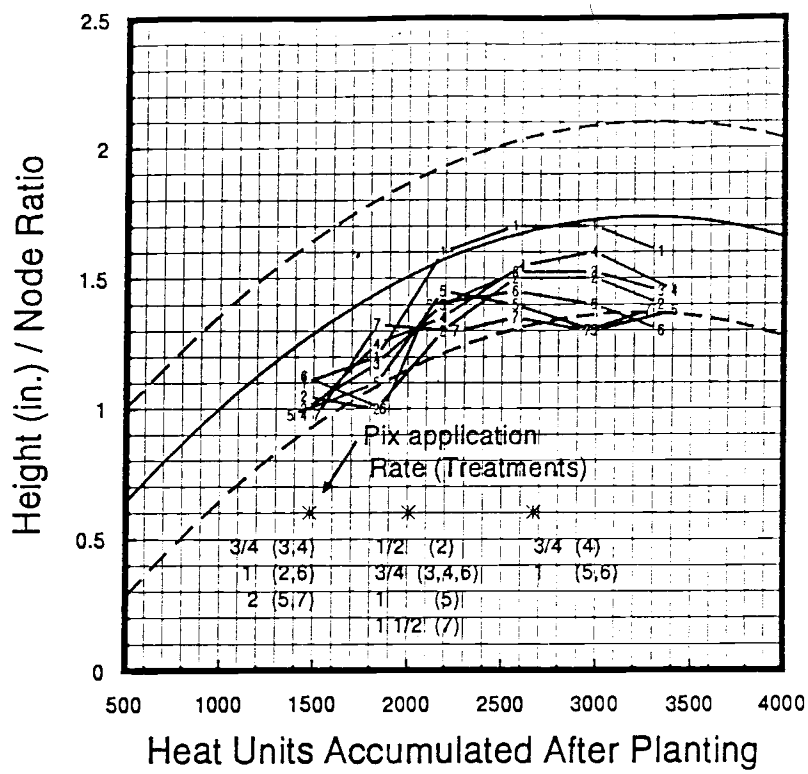

Figure 1. Height/node ratios from Pix experiment, Mohave Valley, Az., 1992.

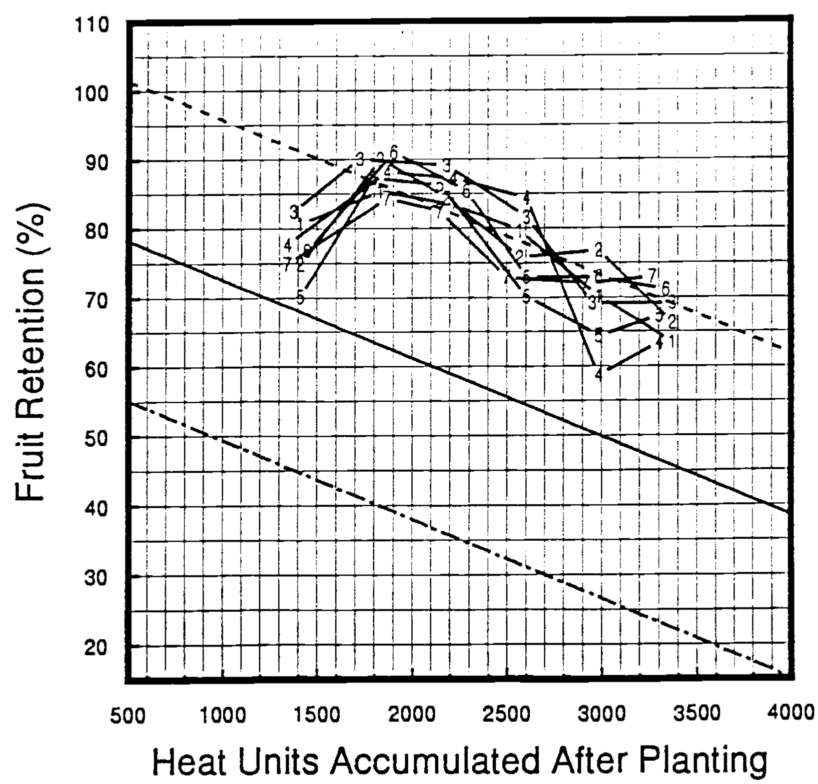

Figure 2. Fruit retention levels from Pix experiment, Mohave Valley, Az., 1992.

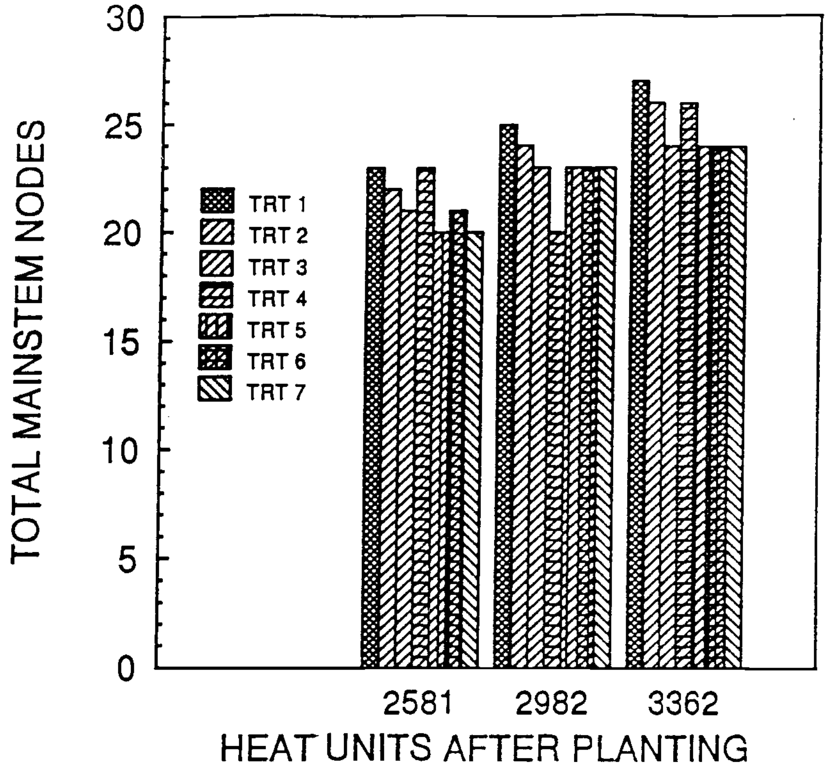

Figure 3. Number of mainstem nodes from Pix experiment Mohave Valley, Az., 1992.

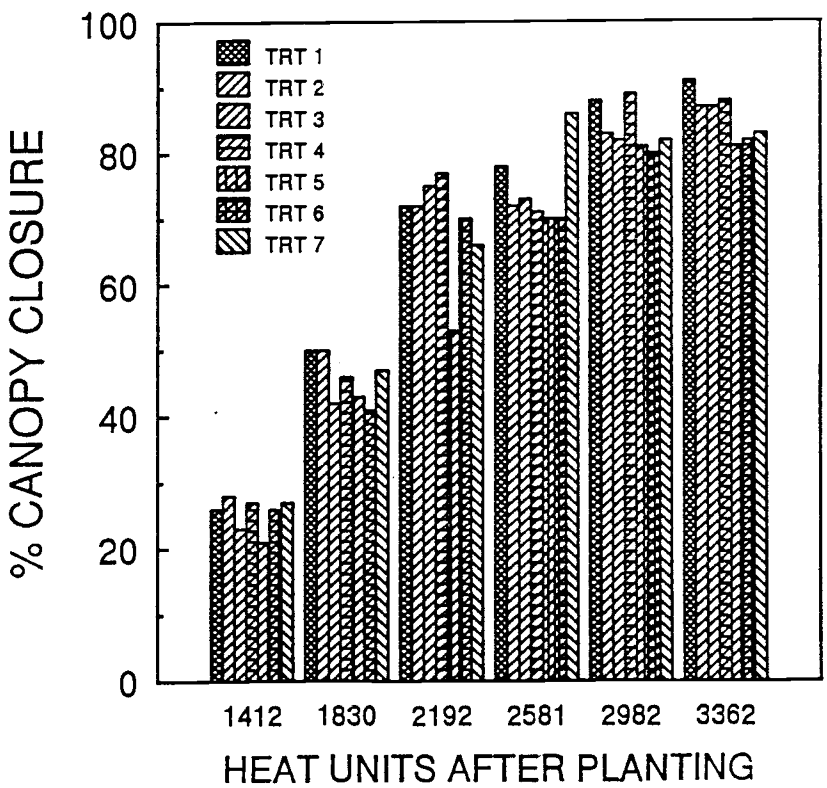

Figure 4. Percent canopy closure from Pix experiment Mohave Valley, Az., 1992.

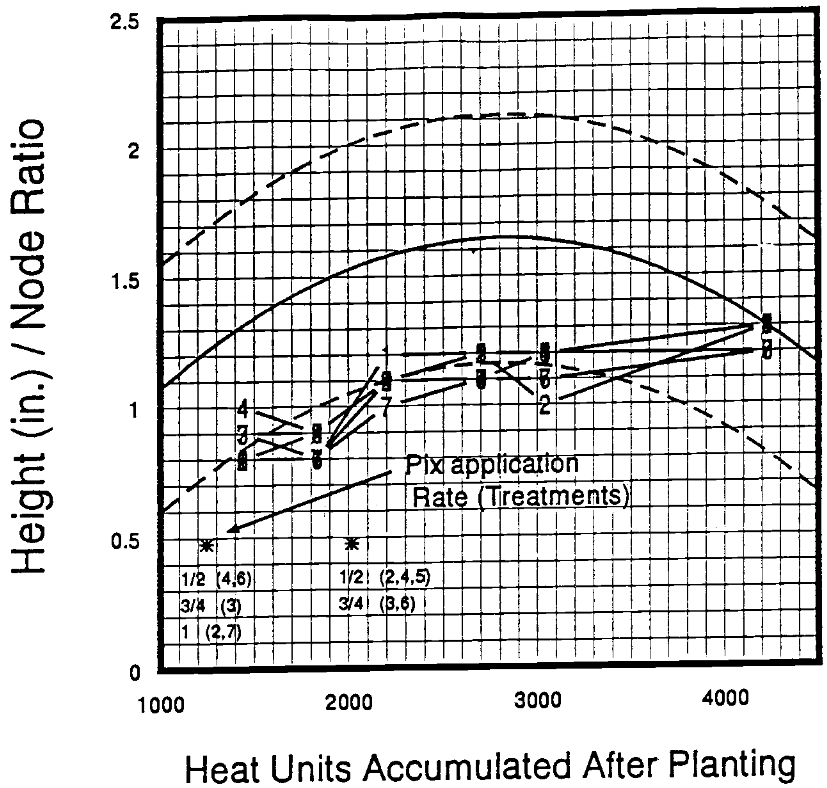

Figure 5. Height/node ratios from Pix experiment, Gila Bend, Az., 1992.

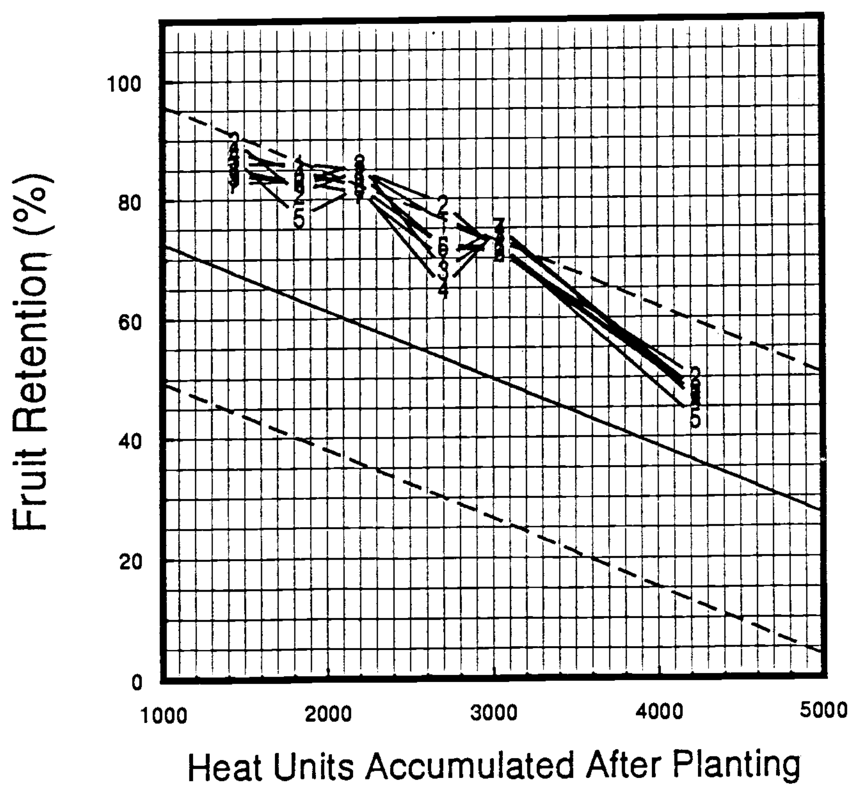

Figure 6. Fruit retention levels from Pix experiment, Gila Bend, Az., 1992.

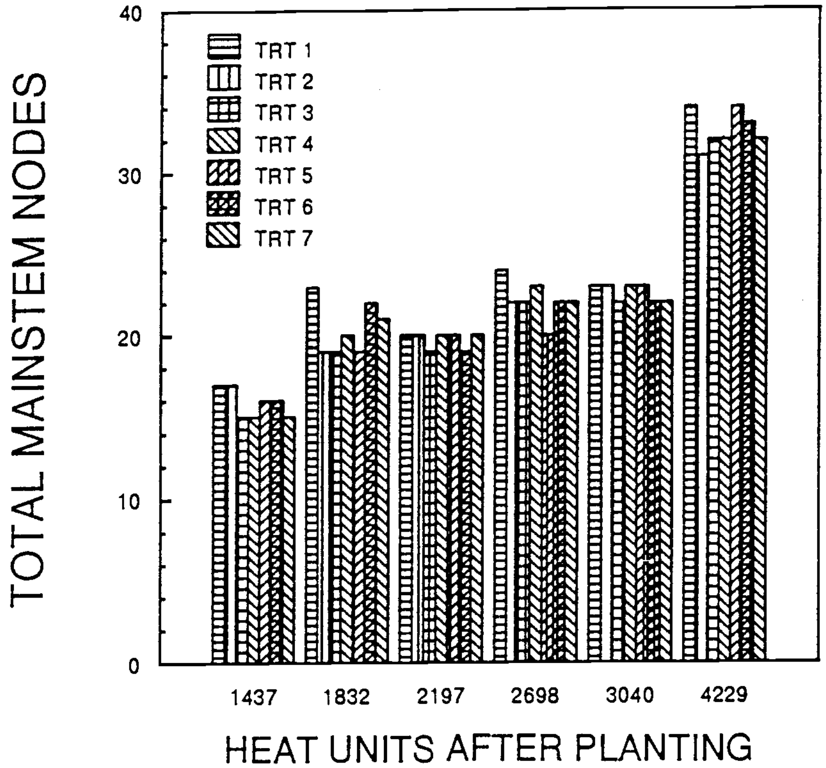

Figure 7. Number of mainstem nodes from Pix experiment, Gila Bend, Az., 1992.

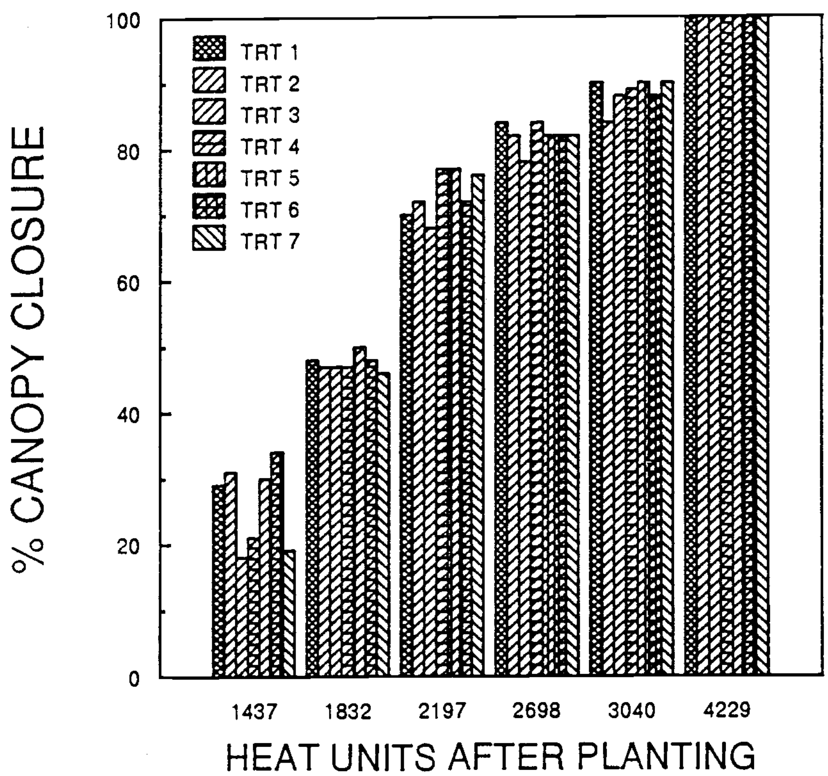

Figure 8. Percent canopy closure from Pix experiment Gila Bend, Az., 1992.

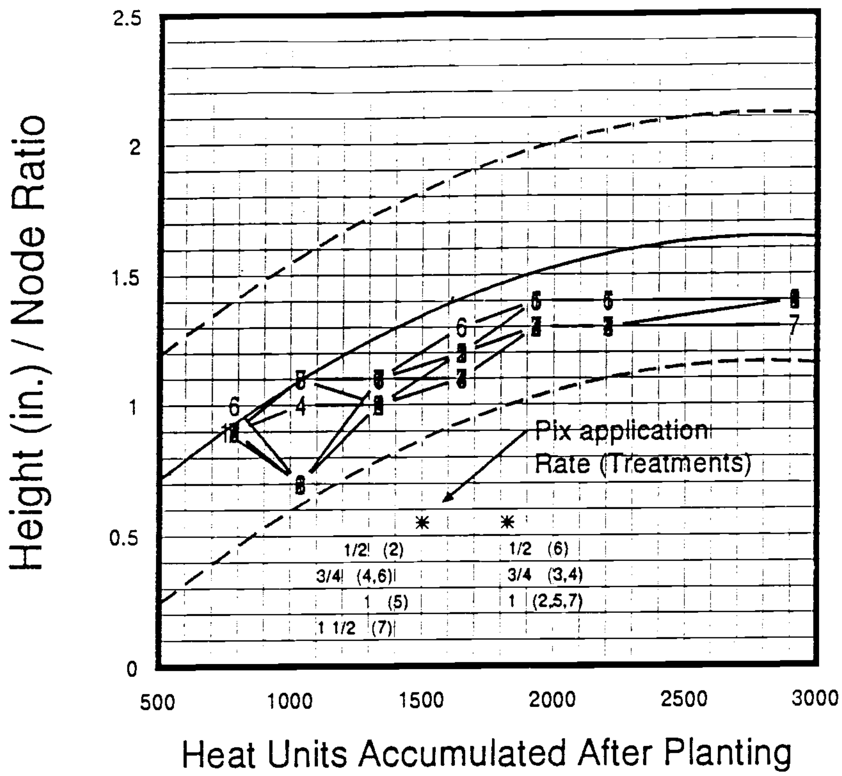

Figure 9. Height/node ratios from Pix experiment, Sunsites, Az., 1992.

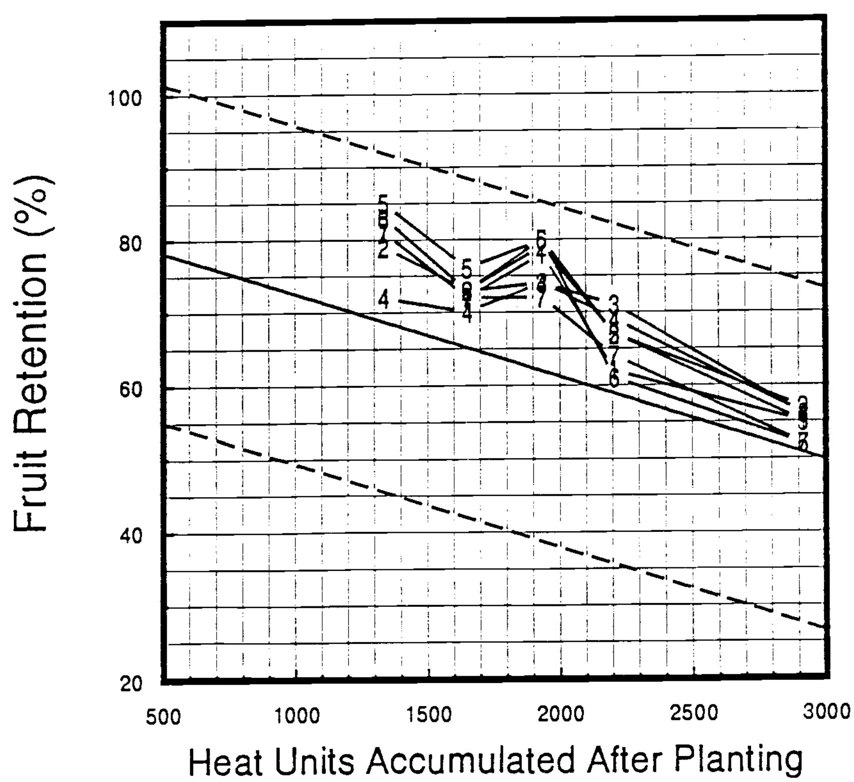

Figure 10. Fruit retention levels from Pix experiment, Sunsites, Az., 1992.

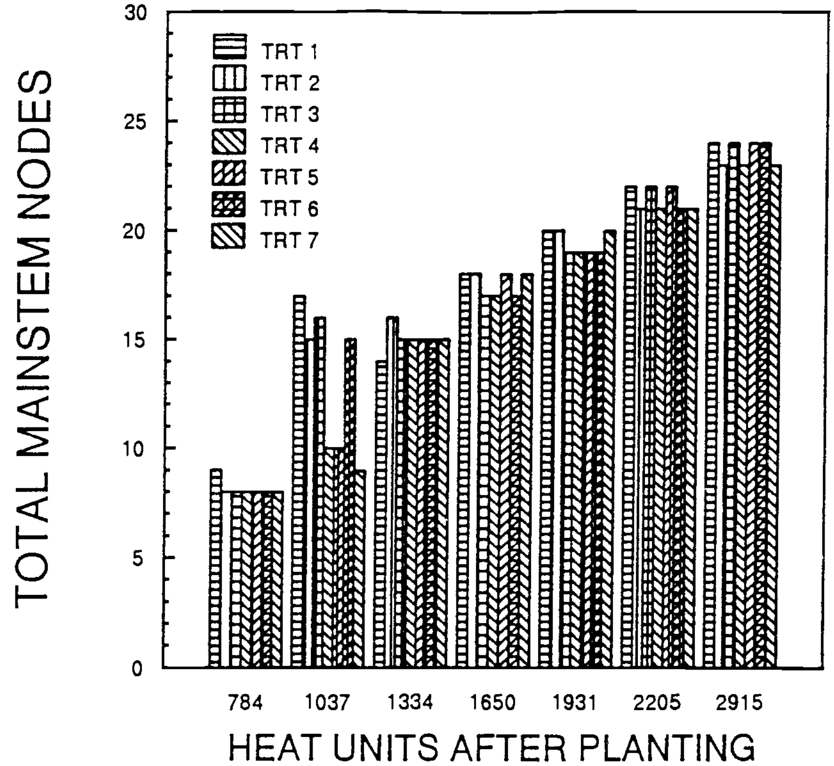

Figure 11. Number of mainstem nodes from Pix experiment, Sunsites, Az., 1992.

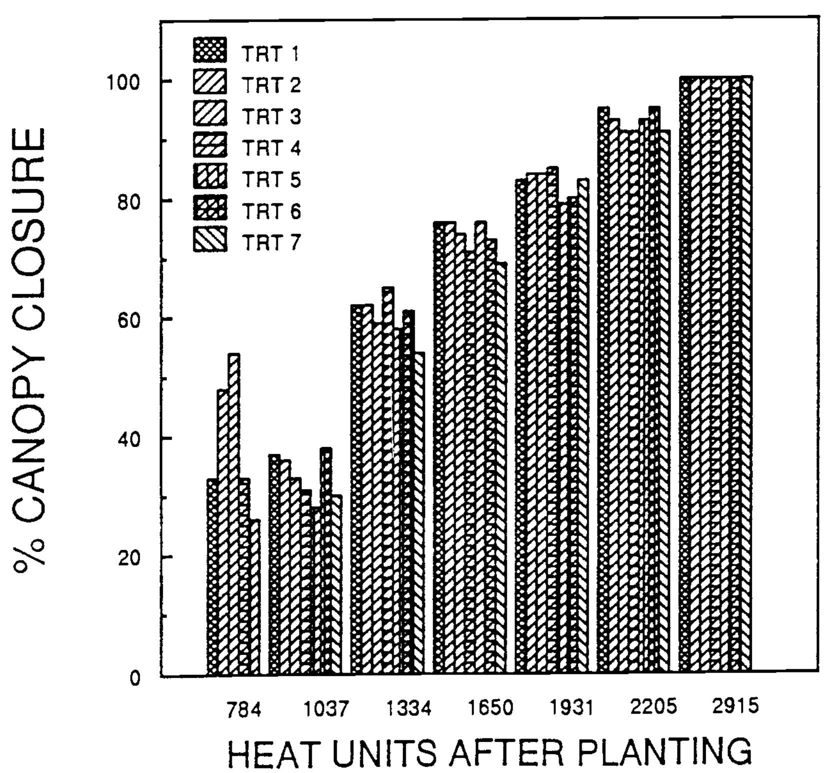

Figure 12. Percent canopy closure from Pix experiment, Sunsites, Az., 1992.