1968 Pima cotton responses to multiple plant growth regulator management regimes

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ABSTRACT

Field evaluations of the impacts of Mepiquat Chloride application timing on Pima yields and some growth parameters are described, including some interactions with irrigation practices and plant water stress. In summarizing the MC evaluations, there was a strong influence of varietal growth characteristics (determinate or indeterminate relative growth habit) and square and early boll retention on yield and growth responses to MC applications and application timing. Pre-bloom and first bloom applications were useful in vegetative growth control and to help avoid delays in defoliation, provided plant vigor was high enough to warrant these applications. High vigor plants with poor early square or boll retention have been the most likely plants to benefit from first bloom or prebloom MC applications for growth control. Under long growing seasons and very high yield potential conditions (>1700 kg lint ha^{-1}), field studies demonstrated that MC applications made too early (in terms of growth stage) can have little impact or even reduce the total number of fruiting sites, and therefore, lint yields. These studies confirm that decisions on the utility of plant growth regulators in Pima cotton require assessments of relative impacts of planned irrigation practices and varietal growth characteristics, plus potential impacts of early to mid-season fruit retention.

INTRODUCTION

Studies conducted in California and Arizona in the early to mid-1980's (Briggs, 1981; Kerby et al, 1986) demonstrated that applications of the plant growth regulator Mepiquat Chloride (MC) made near first bloom in Upland (*Gossypium hirsutum* L.) cotton increased harvestable bolls (relative to untreated plants) during the first 6 to 8 fruiting branches. The same research as well as numerous subsequent trials indicated that these applications had either no effect or even could result in small decreases in harvestable bolls in later-developing fruiting branches. Kerby et al (1986) demonstrated that if the growing season is of relatively long duration, untreated plants produced yields similar to MC-treated plants in terms of total yield. This was because the greatest impacts of this growth regulator on earliness (defined here as higher early boll set) have generally been found in improved boll set in the first 6 to 8 fruiting branches. The MC chemical was broadly tested and marketed under the trade name “Pix” (as well as a number of other trade names) in many of the earlier plant growth regulator studies in cotton.

Pima cotton was introduced into California’s San Joaquin Valley on a commercial scale in the late 1980’s, and early decisions on Pima growth management relied on use of MC management guidelines developed for Acala cotton (Kerby and Hake, 1996). These Acala MC guidelines called for first MC application decisions beginning near first bloom if plant vigor (height:node ratios) and fruit retention warranted. The rationale for initiating separate plant growth regulator studies for Pima *(Gossypium barbadense* L.) cotton is that Pima varieties generally differ from Acala cotton varieties in several important respects: (1) most Pimas require a longer growing season to mature out a high-yielding crop, with 3 to as many as 7 more fruiting branches than typical Acalas; (2) second, third and even fourth position fruit on fruiting branches are more important in high yield situation than in Acala varieties; and (3) Pima bolls require more heat units to open than Acala or non-Acala Upland varieties.

Munk et al (1997, 1998) summarized a broad set of field studies done in California with Pima cotton in the 1990’s. Studies involving first bloom MC applications with Pima varieties prevalent in the early 1990’s indicated that MC applications were very successful in controlling plant vegetative growth (height, main stem node number), but had few significant impacts on yields (Munk et al, 1997). Munk et al (1998) evaluated MC applications made during a broader range of growth stages (first bloom through 28 days after first bloom), and concluded that small yield responses (<5 percent improvement over untreated) occurred with mid- to late-bloom MC applications of 0.025 kg a.i. ha-1 beginning 14 days after first bloom, followed by sequential applications at 7 to 10 day intervals.

Grower and University of California experiences with varieties with a more determinate growth habit, with typical short to moderate heights generally still show acceptable performance with these first bloom and later MC applications for growth control. Even this generalization sometimes does not hold when early fruit retention is poor and boll development is reduced as an alternative sink. In recent years in California’s San Joaquin Valley, some newer varieties are more indeterminate in growth habit, and can exhibit higher vigor than a number of earlier tested varieties. In addition, since Pima is now planted across most of the San Joaquin Valley cotton growing area, some fields will be planted in rotation with vegetables and with land applications of manures, both situations that can lead to more vigorous growth.

The series of experiments described here represent some alternative plant growth regulator management approaches, including earlier first applications. Evaluations for efficacy in growth management and impacts on yield will be described.

MATERIALS AND METHODS

Field evaluations of Pima cotton responses to the plant growth regulator mepiquat chloride or pentaborate version of this plant growth regulator were done at the University of California West Side Research Center in Fresno County, California. The soil at the Fresno County location is a deep clay loam soil. Years represented in the data sets discussed cover the period from 1993 through 2005.

1993 through 1996 trials. Irrigation treatments in the 1993, 1995 and 1996 studies were imposed using a subsurface drip irrigation system with 0.45 m emitter spacing and 1.02 m lateral spacing, and the irrigation system was run 3 times per week to replace either 60, 80 or 100 percent of estimated crop evapotranspiration. The cotton variety in this series of trials was S-7. MC applications evaluated included two applications at a rate of 0.0375 kg a.i. ha-1, with the first applied at first bloom and the second 12 to 14 days later. These MC application treatments were compared with untreated controls.

1999 though 2002 trials. In studies conducted in 1999 through 2002, two furrow irrigation treatments were used, with one irrigation treatment scheduled when leaf water potential measurements (determined with a pressure chamber) reached -1.9 to -2.0 MPa and the other treatment scheduled to allow more water stress, reaching approximately -2.2 to -2.3 MPa prior to each subsequent irrigation. In these trials, each set of irrigation and MC application treatments were evaluated with two different varieties, S-7 and Phytogen-57. The variety S-7 under typical San Joaquin Valley growing conditions is a moderate stature, more determinate variety, while Phytogen-57 tends to be a larger, higher vigor and more indeterminate variety. MC treatments evaluated in both irrigation regimes and varieties included: (1) untreated control; (2) MC at first bloom followed by two additional applications 11 to 14 days apart (depending on the year); (3) first MC application 10 to 14 days after estimated first bloom, followed by one additional application 12 to 14 days later; and (4) MC applied first at 11 to 14 days after estimated first bloom, followed by the pentaborate MC 12 to 14 days later.

2004 and 2005 studies. Furrow irrigated field plots were established, and irrigations were scheduled when leaf water potentials reached -1.9 to -2.0 MPa in order to only allow moderate water stress prior to each irrigation. The cotton varieties S-7 and Delta Pine DP-HTO (shorter stature, more determinate), Delta Pine DP-744 (intermediate stature and growth habit), and Phy-76 (larger plant, more indeterminate) or Hazera HA-195 (larger plant, interspecific Pima hybrid) were evaluated for responses to MC rates and application timing. MC treatments evaluated included: (1) early MC applications at variable rates (shown in tables 1, 2) , with first applications initiated at 9 to 11 nodes and subsequent applications at first bloom and 12 to 14 days later; and (2) first applications initiated at first bloom. In both cases, the MC rate decisions were made using the maximum internode distance (MID) method, which is based on the internode between the 4th and 5th node from the main stem terminal. Final plant map measurements of plant height, fruiting branch number and boll retention were made in mid to late-September, several weeks prior to first harvest aid application each year.

RESULTS AND DISCUSSION

A wide range of approaches in MC (PIX and related materials) are currently used by Pima growers in California. In large part, the range of approaches used reflects some dissatisfaction and difficulties with growth management and yield results obtained with use of Acala cotton MC guidelines. Although many evaluations of Pima growth regulator responses have focused on impacts on lint yields and maturity/earliness, it has become evident in some years and environmental conditions that MC applications are needed as much for vegetation and growth control as for ability to impact yields.

Field evaluations of Pima variety S-7 responses to irrigation levels and 2 MC applications (Fig. 1) under four subsurface drip irrigation regimes in 1993 through 1995 showed that under limited water stress (100 all treatment) which received 100 percent replacement of estimated crop water use during the entire irrigation period, two MC applications improved yield relative to untreated control. Increasing levels of plant water stress imposed with deficit irrigation treatments (100/80/60 and 100/60/60 in Fig. 1) reduced plant height and growth (data not shown) and produced a negative impact of MC applications relative to the untreated plants.

Evaluations of two Pima varieties, S-7 and Phy-57 with three MC application treatments in 1999 through 2002 are shown in Figures 2, 3 and 4. Responses under a mild water stress (IRR1; irrigated at -1/9 to -2.0 MPa leaf water potential) versus moderate water stress (IRR2; -2.2 to -2.3 MPa leaf water potential at irrigation) showed that when early fruit retention was high (Fig. 2, 3), yields of both the less vigorous S-7 and more vigorous Phy-57 varieties were reduced by the delayed irrigation treatment (IRR 2) and MC applications had little impact or even reduced yields. When early fruit retention was lower (Fig. 4), yields in MC treatments were lower than or similar to untreated in the less vigorous S-7 variety under both irrigation regimes, while only in the more vigorous Phy-57 variety did MC applications improve yields, particularly with MC applications initiated at first bloom (Fig. 4). Impacts of more aggressive MC applications (Figs. 2 to 4) on yields were more variable as described here, but vegetative growth control was quite consistent with MC applications, as evidenced by plant height at final plant map timing (mid-September shown in Fig. 5).

Table 1 shows plant map and yield responses to two types of MC application regimes under high early fruit retention conditions, while Table 2 shows similar data for a field with moderate early fruit retention. These tables illustrate the impact of early initiation of MC applications (9 to 11 total main stem nodes at first application) versus a "standard" application regime beginning with a first bloom initial application. Height and maximum internode distance (4th to 5th node from terminal) at first bloom and again at final plant map timing demonstrates varietal differences in vigor and responses to MC applications. The most vigorous growing varieties (Phy-57 in Table 1 and HA-195 in Table 2) showed large yield improvements with the MC application regime begun at 9 to 11 nodes, even when early fruit retention was high (Table 1). The less vigorous varieties (DP-744 both years and S-7 or DP-HTO) showed more mixed responses in terms of plant height and growth responses, but were consistent in showing mild reductions in yield with MC regimes initiated at earlier growth stages (9 to 11 nodes).

Variety choices can now provide some measure of control to avoid excessive vegetative growth that would otherwise make management difficult for fruit maturation, preparation for defoliation and a timely harvest. However, vigorous growth varieties or varieties with low to moderate early fruit retention can also be managed by a combination of growth regulator use and management and irrigation management that produces delayed irrigations and moderate water stress.

In summarizing the MC evaluations of earlier (1990's) and these more recent studies, there are some generalizations we have developed that can be used a rough guidelines: (1) the most consistent improvements in yields in University of California studies have been with sequential applications beginning at either first bloom or full bloom, with a second application about 10 to 14 days later; (2) the most effective application rates have been 0.025 to 0.0375 kg a.i. ha^{-1}, with rates adjusted based upon relative plant vigor (some measure of growth or growth rate) and square and early boll retention; (3) pre-bloom and first bloom applications have been most useful in vegetative growth control and to help avoid delays in defoliation, provided plant vigor has been high enough to warrant these applications; and (4) high vigor plants with poor early square or boll retention have been the most likely plants to benefit from first bloom or prebloom MC applications for growth control; and (5) under long growing seasons and very high yield potential conditions (>1700 kg lint ha^{-1}), field studies have shown that MC applications made too early (in terms of growth stage) or at too high an application rate can actually reduce the total number of fruiting sites, and therefore, lint yields. This is particularly true in situations where early and mid-season fruit retention is good, which exerts some measure of control of vegetative growth. Plant growth measurements used in assessing relative vigor and fruit retention measurements can pay off in helping avoid unneeded or excessive applications and potential negative impacts.

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TABLES

Table 1. Final plant map (3 weeks prior to defoliation) in a high early fruit retention field site with early first MC application (at 9-10 total main stem nodes) versus standard first MC application timing. Varieties evaluated included earlier-maturing and more determinate (S-7), long-season, high vigor and less determinate (Phy-76), and intermediate growth habit (DP-744). MID=maximum internode distance; % ret. 95-FP1 &FP2 = percent fruit retention in first and second position fruiting sites in the 95% zone (fruiting branches where 95% of yield located).

Final Plant Map and Lint Yield Data in Low to Moderate Early Fruit Retention Site											
Variety	Early First MC Application (@ 10-11 total main stem nodes)						Standard First MC Application (between 1st bloom and 10 days after)				
	Plant height @ 1st bloom (in.)	Plant height @ final plant map	MID (in.) @ 10-11 nodes	MID (in.) @2 weeks into bloom			Plant height @ 1st bloom (in.)	Plant height @ final plant map	MID (in.) @ 10-11 nodes	MID (in.) @2 weeks into bloom	
Phy-76	25	58	2.8	3.2			28	64	2.7	3.4	
DP-744	22	49	2.5	2.9			24	52	2.5	3.2	
S-7	20	41	2.2	2.3			22	45	2.1	2.1	
	MC Applications (rate shown in parenthesis – in kg a.i. ha-1)			# Fruit branches 95% zone	% ret. 95-FP1 & FP2	Lint Yield (kg ha-1)	MC Applications (rate shown in parenthesis – in kg a.i. ha-1)		# fruit branches 95% zone	% ret. 95-FP1 & FP2	Lint yield (kg ha-1)
	1st applic	2nd applic	3rd applic				1st applic	2nd applic			
Phy-76	0.02	0.04	0.075	16.4	68	1867	0.04	0.08	17.2	63	1810
DP-744	0.015	0.035	0.045	15.3	70	1995	0.025	0.065	15.9	73	2112
S-7	0.010	0.02	0.025	14.2	73	1713	0.02	0.025	13.8	68	1788

Table 2. Final plant map (3 weeks prior to defoliation) in a lower to moderate early fruit retention field site with early first MC application (at 9-10 total main stem nodes) versus standard first MC application timing. Varieties evaluated included earlier-maturing and more determinate (S-7), long-season, high vigor and less determinate (Phy-76), and intermediate growth habit (DP-744). MID=maximum internode distance; % ret. 95-FP1 &FP2 = percent fruit retention in first and second position fruiting sites in the 95% zone (fruiting branches where 95% of yield located).

Final Plant Map and Lint Yield Data in Low to Moderate Early Fruit Retention Site											
Variety	Early First MC Application (@ 10-11 total main stem nodes)						Standard First MC Application (between 1st bloom and 10 days after)				
	Plant height @ 1st bloom (in.)	Plant height @ final plant map	MID (in.) @ 10-11 nodes	MID (in.) @2 weeks into bloom			Plant height @ 1st bloom (in.)	Plant height @ final plant map	MID (in.) @ 10-11 nodes	MID (in.) @2 weeks into bloom	
Phy-76	29	64	2.7	3.4			33	68	2.6	3.7	
DP-744	23	54	2.2	2.8			25	59	2.3	3.0	
S-7	21	40	1.8	2.4			22	41	1.8	2.4	
	MC Applications (rate shown in parenthesis – in kg a.i. ha-1)			# Fruit branches 95% zone	% ret. 95-FP1 & FP2	Lint Yield (kg ha-1)	MC Applications (rate shown in parenthesis – in kg a.i. ha-1)		# fruit branches 95% zone	% ret. 95-FP1 & FP2	Lint yield (kg ha-1)
	1st applic	2nd applic	3rd applic				1st applic	2nd applic			
Phy-76	0.02	0.05	0.08	17.0	57	1672	0.05	0.085	18.2	53	1581
DP-744	0.015	0.04	0.045	14.9	55	1471	0.02	0.05	15.9	59	1539
S-7	0.025	0.025	0.04	13.1	60	1286	0.02	0.03	13.8	56	1367

LIST OF CAPTIONS FOR FIGURES

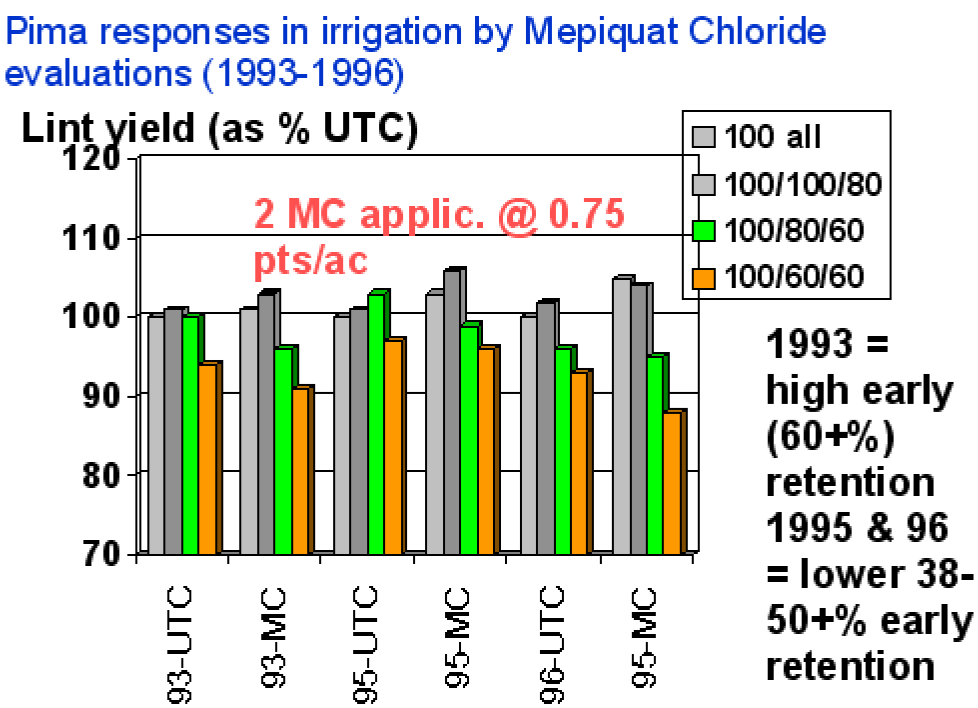


Figure 1.

Pima responses in irrigation by Mepiquat Chloride evaluations (year 1)

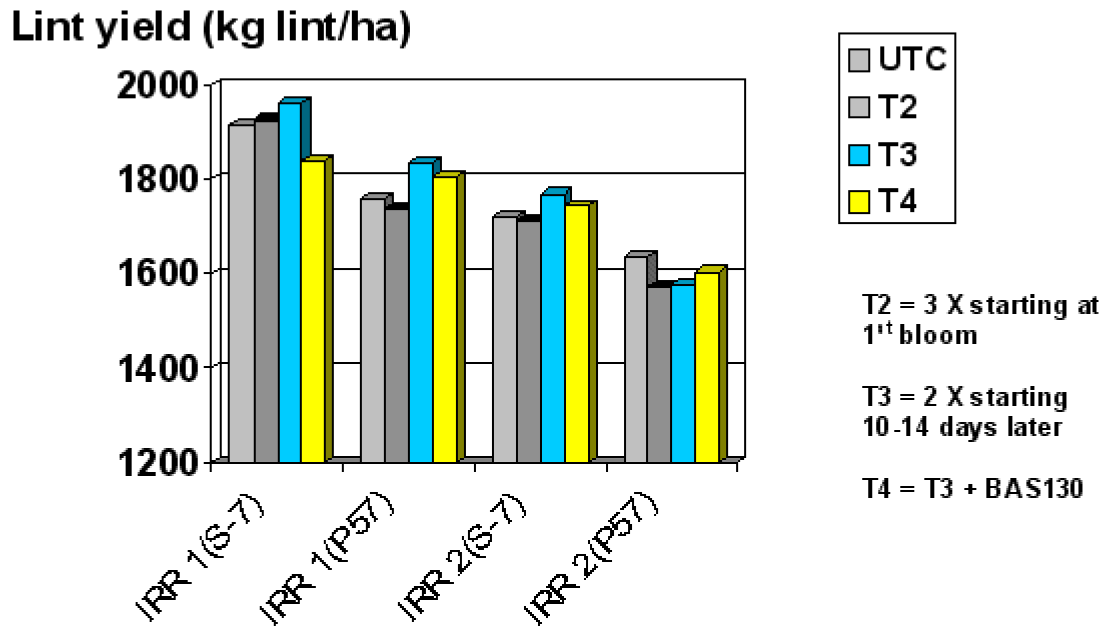


Figure 2.

Pima responses in irrigation by Mepiquat Chloride evaluations (year 2)

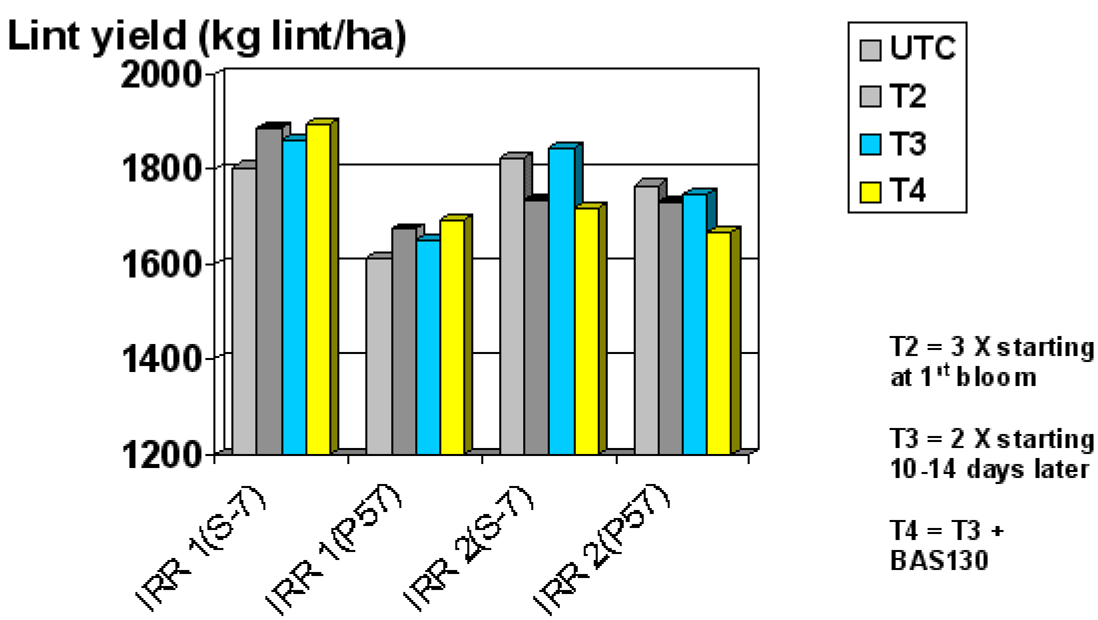
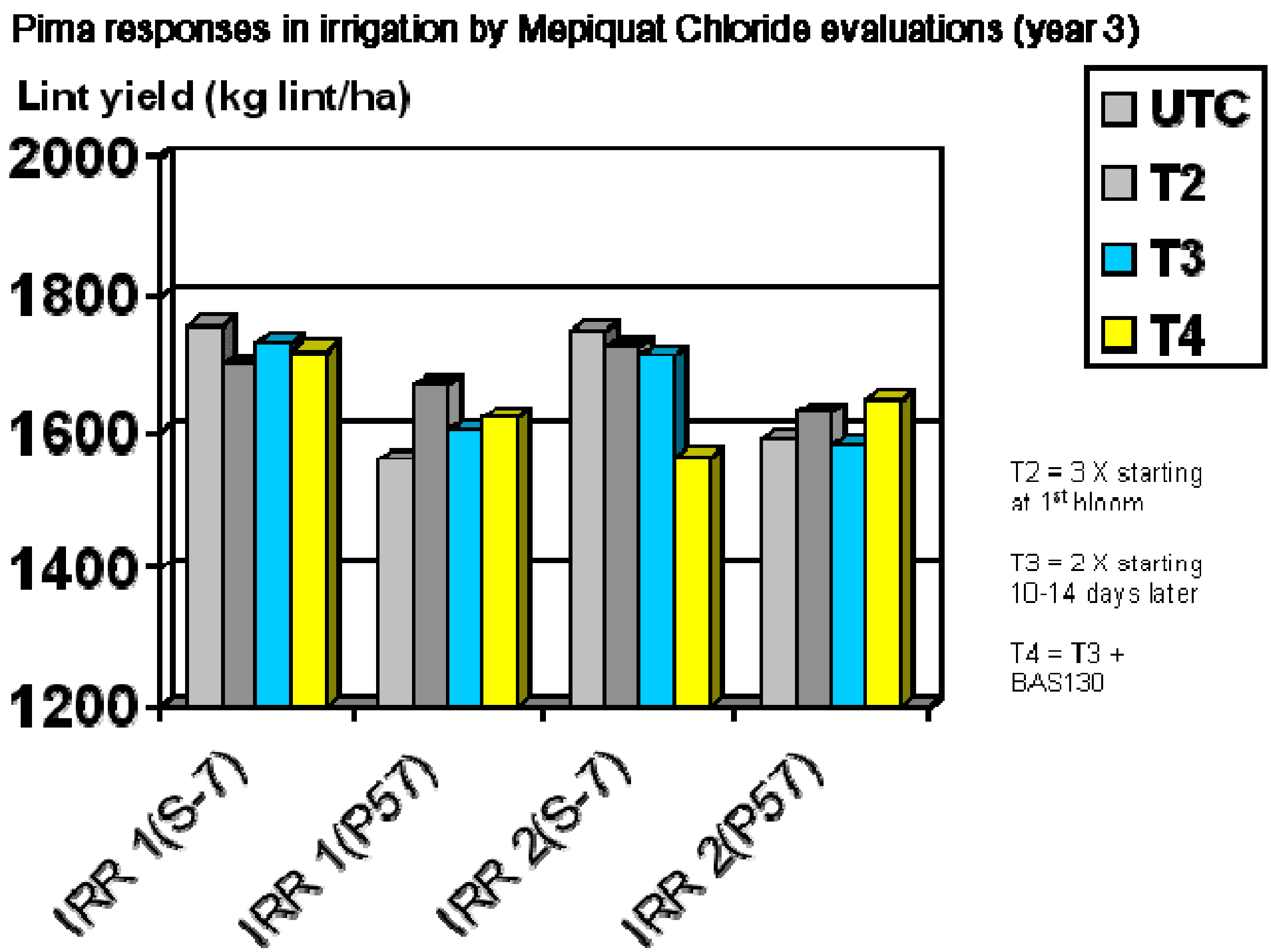


Figure 3.



Pima responses in irrigation by Mepiquat Chloride evaluations (year 3)
Lint yield (kg lint/ha)
2000
1800
1600
1400
1200
IRR 1(S-7)
IRR 1(P57)
IRR 2(S-7)
IRR 2(P57)
UTC
T2
T3
T4
T2 = 3 X starting at 1st bloom
T3 = 2 X starting 10-14 days later
T4 = T3 + BAS130

Figure 4.

Pima responses in irrigation by Mepiquat Chloride evaluations (year 3)

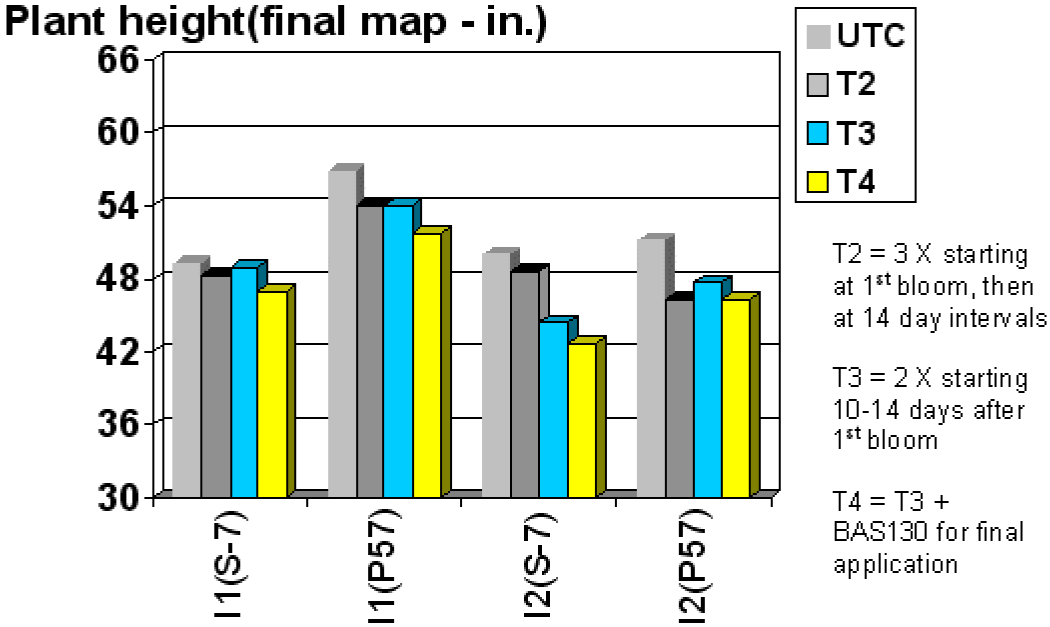


Figure 5.