1965 Comparing pima and upland cotton growth, development and fruit retention in california's San Joaquin Valley

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Plant growth monitoring derived from experimental trials conducted at a university research center were developed and used to compare growth differences and boll retention of commonly grown commercial varieties of Pima (Gossypium barbedense) and Acala (Gossypium hirsutum) cotton. The plant monitoring data sets were developed over a 9 year period from successfully managed fields having a range of production levels with Pima and Acala plots planted simultaneously. Early season plant mapping results show Pima and Acala cotton having similar, but not identical early growth and development characteristics. The number of vegetative nodes before the first sympodial branch and plant growth rates were not always consistently though there was a general trend for more vegetative nodes on Pima type cotton that can result in a 1 to 4 day delay in first flower date. More consistent plant development differences were observed late in the flowering period including contrasting fruit retention on all fruiting positions as well as the vertical retention on fruit branches. The proportion of yield coming from second and third fruiting positions out from the main-stem, was consistently higher in Pima cottons in all cases as was an increased number of fruiting branches that make up the yield. Plant mapping comparisons were useful in detailing plant type differences in boll loading periods, maturity differences, and help support management actions useful in correcting problem fields or seasonal periods in which plant performance is limited.

Introduction

Due largely to economic reasons, Pima cotton production is playing an increasingly important role in maintaining a viable San Joaquin cotton industry. The production of Pima, or ELS (extra long staple) cotton, is now at acreage levels similar to traditionally grown Acala plant types. More widely known differences between these two plant species include Pima's delayed maturity for most commercially available cultivars, Pima cotton's exceptional fiber quality, Pima's relatively small boll size and Pima's reduced lint production level. The San Joaquin Valley Quality Cotton district formally expanded it's variety offerings in 1991 by allowing growers to commercially produce approved Pima cotton varieties in the valley thereby expanding it's offerings of very high quality cotton's while also establishing an industry standard variety. Since that time, Pima acreage has continued to steadily increase while Acala and total plantings have decreased.

Growers and agronomic managers are looking into better ways to manage each of the major cotton types, and have adopted plant monitoring programs during the most active periods of the growing season to assist with irrigation, fertility and pest management decisions. Because of Pima cotton's plant architectural difference, evaluating plant mapping data sets generated by the two most common UC programs is challenging. Growers and researchers alike are hoping to use information such as plant height, node number, growth rate, and fruit retention to assistance them in making management decisions. Understanding and proper interpretation of the data can result in improved timing and application of plant growth regulators, irrigation events, insecticides and fertilizers.

Materials and Methods

Research data and field observations were made on irrigation and variety field trials conducted at the University of California's West Side Research and Extension Center Station near Five Points, California in Fresno County. Trials were established each year between 1997 and 2006 using the dominant Pima and Acala cotton cultivar approved for growing in the San Joaquin Valley Quality Cotton District. Following uncharacteristically cool spring and early summer weather accompanied by very heavy pest pressures, we decide to abandon reduce our data collection efforts in 1998 and we did not include this data in the analysis. Approximately 100,000 to 125,000 plants per ha were established on beds spaced 1.0 m apart each spring prior to April 20th, a date considered optimum for ensuring full season growth and yield potential. Best management practices established by University of California production guidelines (reference prod manual) were used to ensure timely pest protection, adequate irrigation timing and optimum fertility. Data presented were collected on 0.8 to 1.6 ha fields using optimum management treatments on irrigation and variety trials conducted on the 320 acre farm site. Plant, yield and quality data were derived from 4 row plots replicated 4 times in a randomized complete block experimental design having irrigation treatment or variety as the main affect on 80 m long plots. Trial locations varied each year on the research and extension center and dominated by Panoche clay loam soils (fine-loamy, mixed superactive, thermic Typic Haplocambids).

Early and mid-season plant mapping data collection was initiated following first square with 3 to 5 evenly spaced mappings occurring between early square and plant cutout with data input to the California Crop Manager computer program (reference UC California Crop Manager). Measurements of plant height, node number, vegetative branches before the first sympodial branch and square absence or presence were collected in the pre-flower stages with the flowering node number and nodes above white flower added to flowering cotton. A more comprehensive final plant map was developed prior to defoliation using the Cotton Plant Manager computer program (reference) that identifies final growth parameters as well as harvestable boll location and number. Each program was developed specifically for cotton agronomists, growers and researchers. Whole plants were evaluated from random locations within the plot sampling 5 consecutive plants in each of the four replicates for a total of 20 plants. Treatment yields were obtained by averaging seed cotton yield weight for the four plots with gin turnout developed from the average of 3 kg sub-samples obtained for each or the four plots. The degree day calculation uses the single triangulation method with a 15.5 C minimum temperature threshold and no upper threshold (reference UCIPM program).

Results and Discussion

Lint production levels varied widely during the 10 years of activity and generally followed the ups and downs of statewide production statistics. Acala lint yield ranged from 1345 to 2123 lbs. per acre while Pima lint yields ranged from 1394 to 2106 lbs. per acre, table 1. No consist relationship between Pima and Acala yield was observed from season to season, but overall, Pima types outperformed Acala types at this site by 104 lbs. per acre. Consistent plant densities, adequate fertility and effective pest control measures assisted in providing plot data that was representative for the area in any particular year, providing a good opportunity to compare fruiting habits of the Acala and Pima plant types.

Early season comparisons of Pima and Acala cotton show only subtle differences in the timing of emergence with some growers reporting slightly faster emergence with Acala plant types on some years. However we found no consistent data that demonstrated one plant type had more rapid emergence over another. Similarly, early season node development and plant height were found to be relatively consistent throughout the pre-bloom period with typical heat unit accumulations of 50 degree days (F) per node. Field observations showed us that standard Acala varieties had fewer vegetative nodes before the first sympodial branch than was the case of the Pima varieties by one node, though there was considerable variation from year to year. First sypodial branches developed between 275 and 325 degree days following planting and a very strong relationship was observed early and mid season between the number of fruiting nodes present and post plant cumulative degree days for both plant types, figure 1.

Plant height is often used as an indicator of plant vegetative productivity and while we found a strong relationship between plant height and cumulative degree days, the close relationship broke down earlier than node production relationship as we observed a less predictable relationship in plant height following first flower, figure 2. Similarly, more clear and recognizable differences in plant growth between the two plant types began to appear during the effective bloom period. Though we did find variations in the number of nodes to the first fruiting branch, it is clear that node production for these two very different plant types in fact respond similarly to the primary growth limiting factor early season, which is clearly temperature driven. Pima and Acala cottons tested respond similarly to temperature stresses which may also be an indicator of our limited ability to modify production potential at these early stages. This may in part explain why changing potential early season stressors including, fertility, water stress and plant population, has shown little effect on the productivity of these cotton types, (reference).

First bloom dates for Acala cottons were either identical to or slightly earlier than the Pima cotton plantings. We often found Pima cotton first flower date to be 1 to 4 days later as calculated by mapping plants having their first position flowers on the second and third main-stem node and back calculating average node production level (3.25 days per node) to arrive at our best estimate, table 2. The 1 to 4 day delay in first flower date corresponds closely to the time required to produce the additional vegetative node that Pima types have prior to producing the first sympodial branch. First flower was estimated to occur at an average of 793 degree days for the Acala types while Pima types required an average of 830 degree days (f) before first flower. Early and midseason vegetative branch production was similar between plant types and years As the plant progresses into the effective bloom period, we made an increasing number of observations that Pima and Acala plant morphology and plant carbohydrate distribution are fundamentally different.

Though bloom was slightly later for the Pima type cottons, we found a greater number of nodes above the yellow flower (NAYF) at early bloom and a less rapid decline in the NAYF value over time. The slower decline in NAYF is noteworthy because it indicates that ample carbohydrates are available for continued vegetative growth as the bloom period progresses. This allows the plant to continue to produce fruit over a longer period of time which from a production stand point, has both positive and negative connotations. Crop stressors including physiological as well as pest related problems during the critical bloom period may impact a smaller proportion of total yield and responsive stress relief though appropriate management changes could reduce yield loss impacts in Pima cotton. Alternatively, costly crop inputs including water and pest management protection period may need to be extended if the effective flower period is increased.

One of the critical issues in cotton production management is related to the retention of fruiting bodies on the plant. As we improve our ability to improve boll retention, there is generally a corresponding increase in the productivity at that site. Pest control advisors and agronomists understand this and expend considerable energy and resources in retaining bolls and fruiting bodies at all early stages of growth. As young bolls exteriors expand beyond 1.5 centimeters in diameter, retention and harvest of these bolls in nearly guaranteed providing there are ample heat units and water to finish the development of these bolls. The timing and degree of square and young boll shed can be useful in identifying the causes of yield loss in cotton and provides an opportunity to improve production efficiencies.

Plant mapping from early squaring to through the end of the critical bloom period was conducted with particular attention focused on the top five and bottom five sympodial branches. Top five fruit retention showed a strong negative correlation between accumulated degree days and the square retention on both Pima and Acala cotton. There was particularly high retention early season with top plant squares retained at or above the 85 percent level. Retention of the top five fruiting branches did not dip below 85 percent in the Acala types until 10 to 14 days following first bloom, while top 5 square retention was maintained at high levels on pima cotton for an additional 10 days. A more rapid decline in top five retention level was also observed for the Acala cotton types which may be linked to the more rapid decrease in available carbohydrate resources as larger lower bolls are being filled. Further analysis of the change in top fruiting bodies retained finds that early season decreases in retention are often smaller than late season declines in the retention of newly produced fruiting sites, Figure 4. Toward the end of the effective fruiting cycle, retention of top five fruit was commonly reduced by 10 to 30 percent when compared to the previous mapping while minimal decreases in retention were observed early in the fruiting period.

The relationship between the retention of bottom five fruit during the season is less clear and not as predictable as with the top five fruit, particularly with Acala cotton types, figure 5. While Pima cotton types generally maintained bottom retention levels above 80 percent, there was a tendency for Acala cotton types to have early season retention levels of 75 percent or lower with late season retention dipping below 50 percent in some cases. Causes for mid-season boll loss include physiological shed and mechanical damage and are not normally associated with insect pests. Average bottom five fruiting branch retention was above seventy percent late season.

The distribution of bolls monitored from a final plant map conducted after most all bolls have reached maturity can also be helpful useful in identifying the timing and the degree with which crop stressors played a role in the final crop yield. Our analysis shows a very different pattern of boll retention and effective bloom period for Acala and Pima types. Though node production continues through the peak bloom periods, Pima cotton continues to produce a considerable number of additional harvestable bolls after beyond the 15th fruiting branch and in some cases will produce harvestable bolls beyond the 20th sympodial branch position, figure 6. The large proportion of bolls that contribute to Acala cotton yield are found on the first sympodial branch through the 12th or 13th branch. The rapid decline in boll retention typically seen above the 11th or 12th fruiting branch also demonstrates the more defined period of plant cutout and a cessation of new fruiting bodies produced.

Distinguishing fruit produced on outer sympodial branch sites gives us additional insight as to when the harvested fruit were produced and can improve our understanding of the effective bloom period. Bolls produced on Acala cotton are dominantly 1st position fruit and commonly makeup 70 to 85 percent of the boll quantity produced on the plant and represent an even higher proportion of the yield, figure 7. On high yielding San Joaquin Valley cotton fields, very few bolls are produced on third and fourth position fruit out from the mainstem with second position sympodial positions contributing significantly on fruiting branch 2 through 9. Comparatively, more than 60 percent of the yield harvested from Pima cotton fields comes from fruiting positions other than the first position on the sympodia. Fruiting bodies making up the 3rd 4th, and occasionally the fifth position contribute significantly to harvestable yield as well as the axial position fruit that occupy the position where sympodial branches and the mainstem are joined. Very few (<3%) of the final bolls harvested came from monopodia and there was no effect on the type of cotton evaluated. This is generally typically of plantings with moderate to high plant populations for these soils and region.

References: (To be completed)

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Table 1

	Pima lbs. lint/acre	Acala lbs. lint/acre
1997	1913	1974
1999	2106	2010
2000	2051	1761
2001	1963	1810
2002	1675	2035
2003	1394	1489
2004	2095	2131
2005	1901	1268
2006	1660	1345

Table 2

	HU and Date to 1st Flower		Vegetative Nodes to 1st Fruting Branch	
	Pima	Acala	Pima	Acala
1997	833.6 (6/16)	801.9 (6/14)	6.1	5.6
1999	715.7 (6/26)	688.6 (6/24)	5.6	4.3
2000	783.3 (6/17)	691.3 (6/13)	6.4	4.5
2001	951.4 (6/17)	862.1 (6/12)	6.4	5.8
2002	766.3 (6/21)	766.3 (6/21)	5.6	5.6
2003	895.1 (7/11)	876.1 (7/10)	6.5	6.9
2004	911.1 (7/3)	867.0 (6/30)	5.8	6.3
2005	779.8 (7/4)	745.9 (7/2)	7.2	7.2
2006	844.9 (6/30)	844.9 (6/30)	6.7	6.4

Figure 1

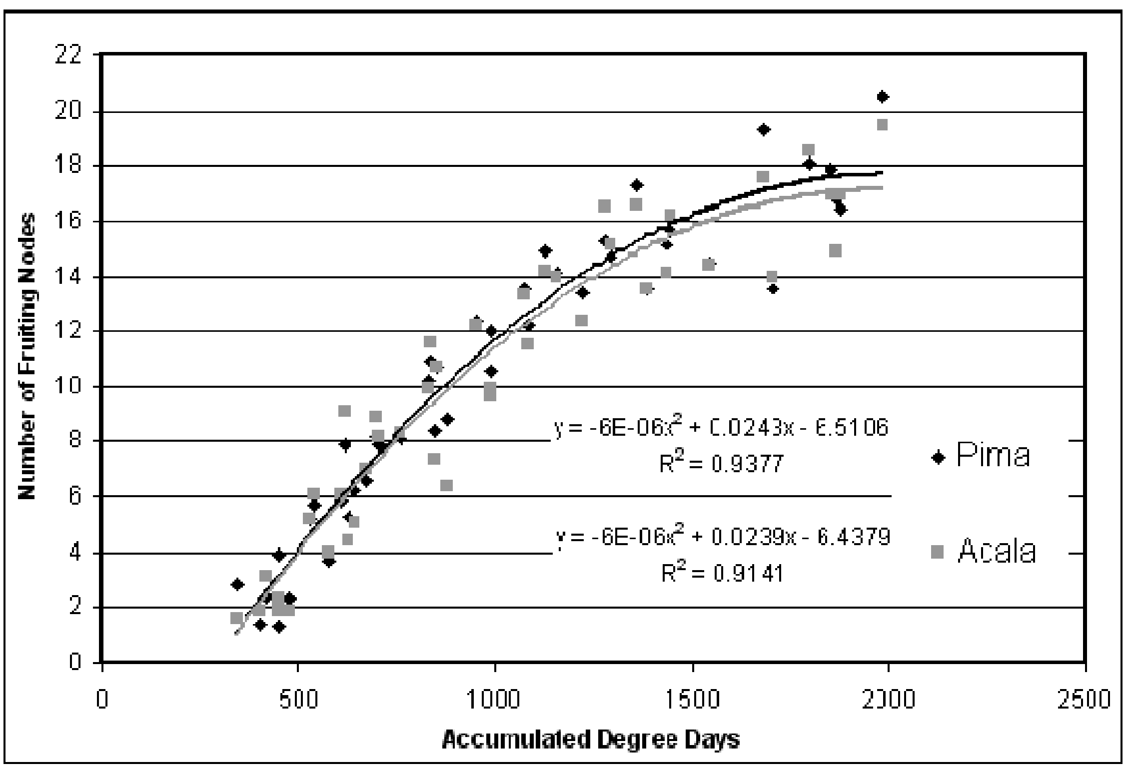

Figure 2

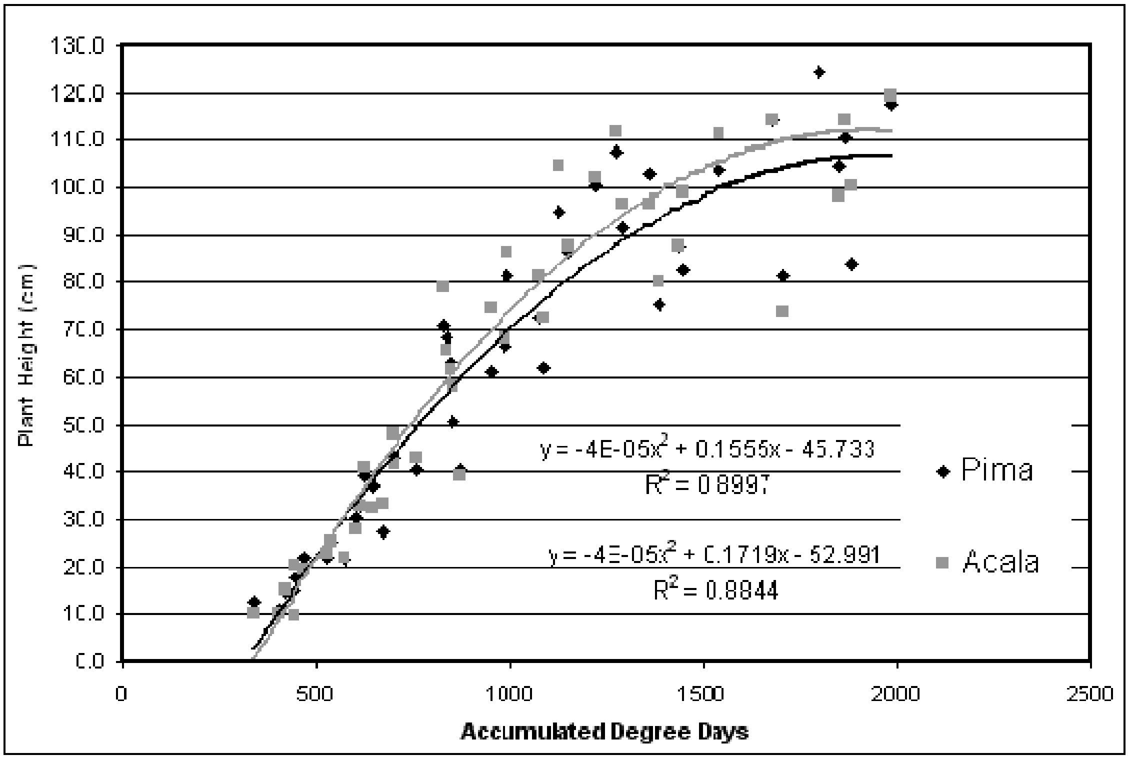

Figure 3

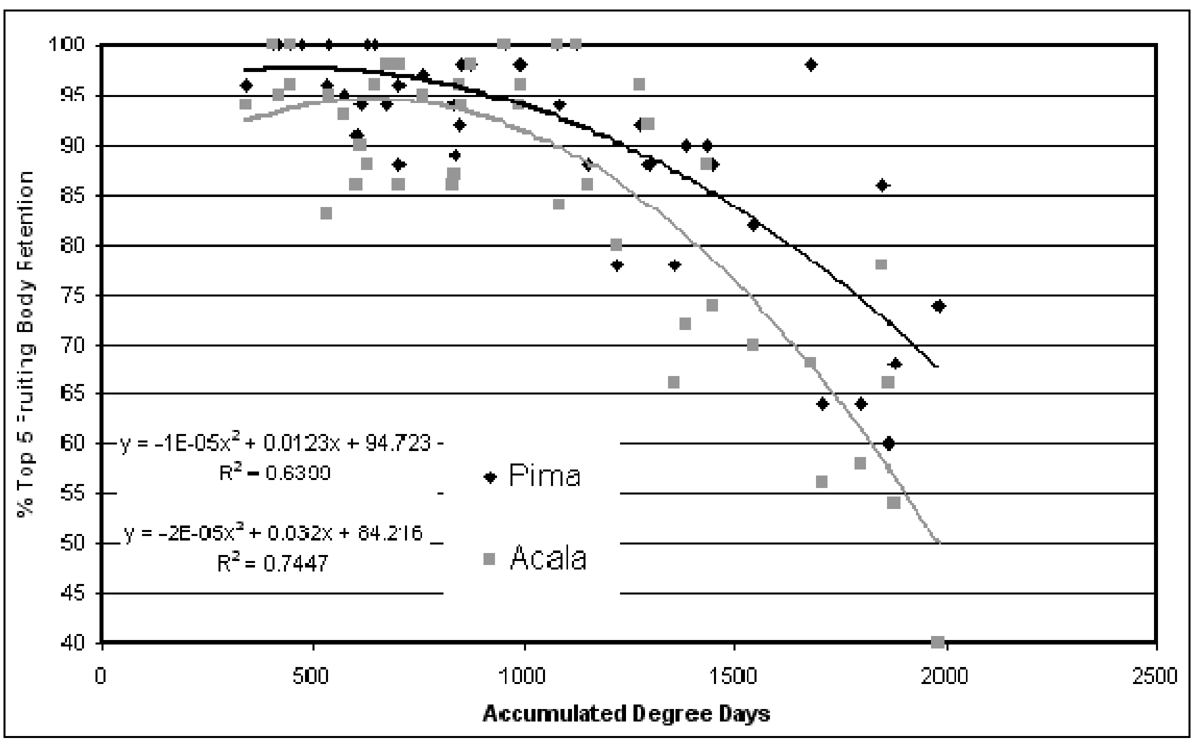

Figure 4

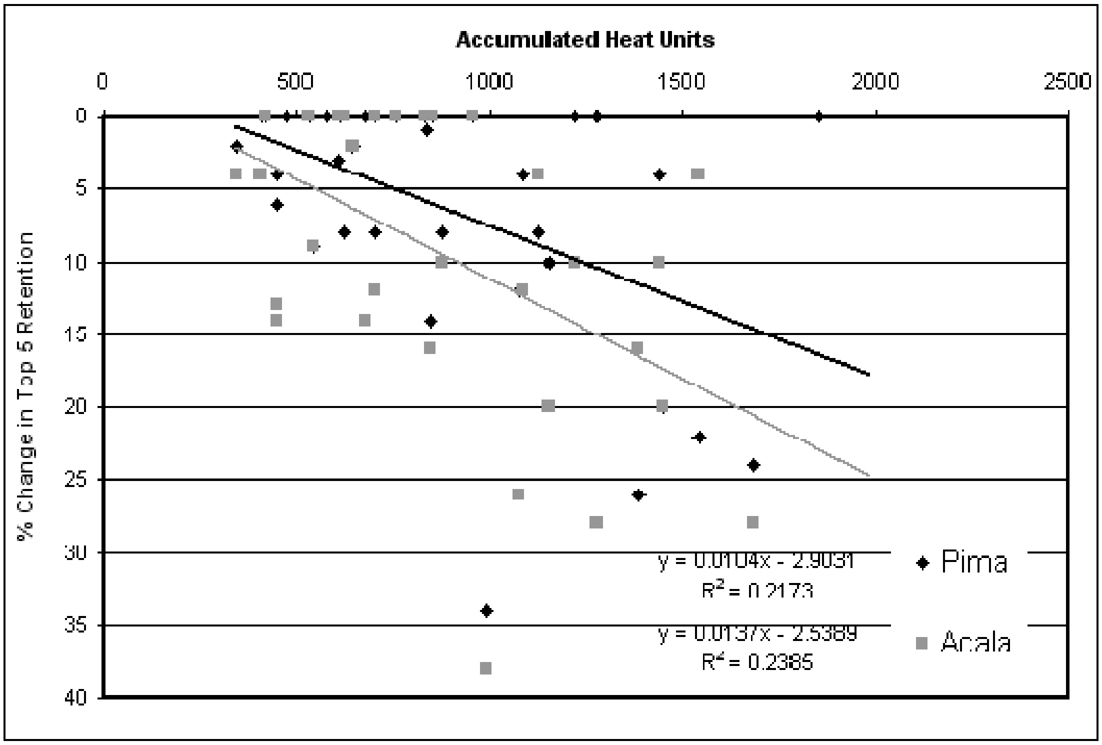

Figure 5

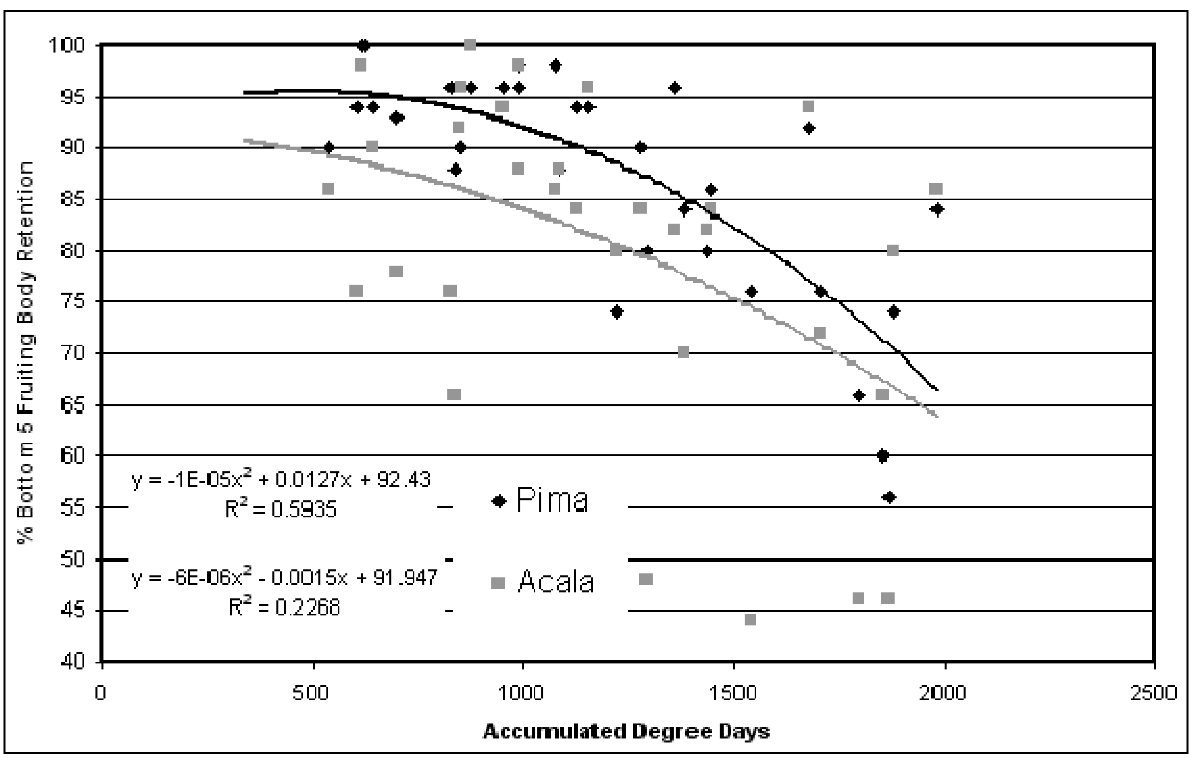

Figure 6

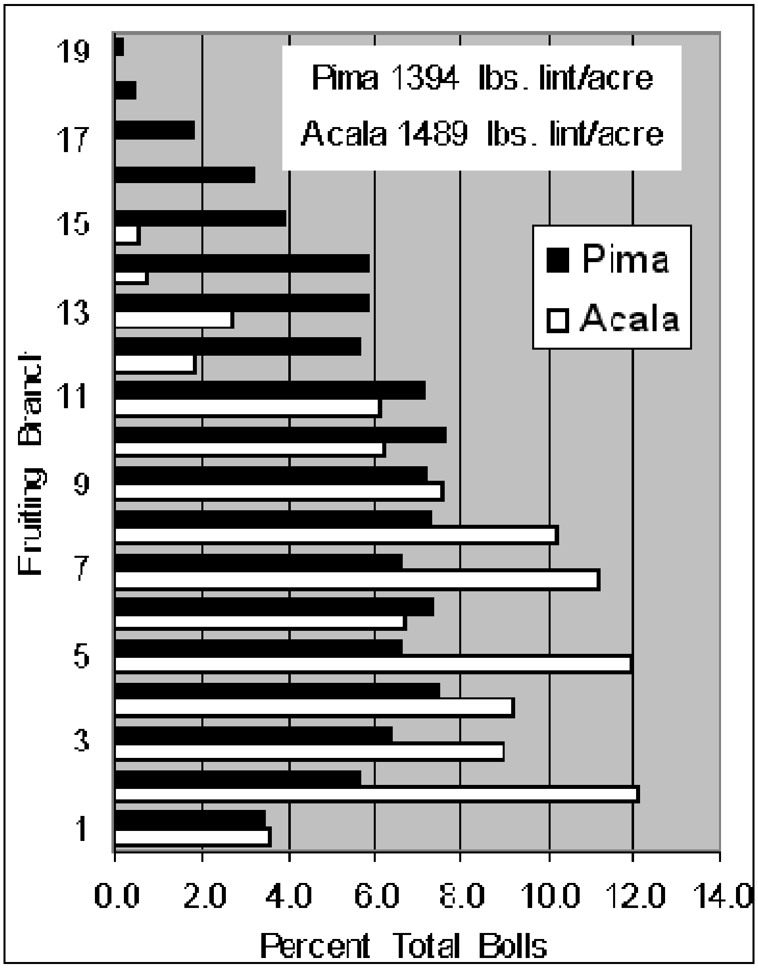

Figure 7