Cotton Field Check

Fruit Loss Issues – Timing, Water, Weather and ?

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Boll and Square Shed in Pima and Acala Cotton. For most of the time growers and researchers have been closely observing the growth habit and structure of cotton plants, it has been recognized that: (1) the likelihood of retention of squares, flowers and young bolls is a variable controlled by multiple factors; and (2) that retention of at least some of that potential fruit is vital if fields are to produce adequate amounts of a saleable product. Particularly in California, there has been a considerable amount of research implicating plant bugs such as *Lygus hesperus* as having potential to reduce square or young boll survival and yield potential in cotton. However, as more efforts were directed also to close and careful plant observations, we have also observed that square and young fruit shed can be caused by reasons other than insect pests.

Particularly as the plant ages and squares become flowers and young bolls, there is a shift in how the cotton plant allocates its resources, and plant growth dynamics change. Many observations have been made over the years that implicate "physiologic shed" as a primary cause for fruit abscission following bloom in cotton. In this article, we will try to describe some of the primary issues related to physiological shed as well as attempt to clarify its relationship to plant type, water stress and heat stress during the key fruit setting period.

Setting Mid- and Late-Season Fruit. California growers and researchers have established that under some conditions, pre-bloom square losses and post-bloom square and young boll losses can be linked to insect population levels and most commonly to Lygus and in some situations other insects such as Stink Bugs. These insect-related losses are caused principally by damage associated with feeding on squares and smaller pre- and post-bloom fruit, most typically bolls the diameter of a dime or smaller. Because such a large portion of the harvest comes from the bottom 10 to 15 fruiting branches in Acala and even Pima cotton, the best yields are typically achieved when good fruit retention is maintained on these early set fruit, allowing the crop ample time to size and mature the fiber of the earlier-set fruit. Descriptions of relative success in achieving good early and mid-canopy fruit set have become important criteria in University of California approaches developed over the years for irrigation, nitrogen and plant growth regulator management practices Over the years considerable efforts have been made to understand these dynamics and make pest, irrigation, PGR and nutrient management decisions accordingly.

Many research trials in Acala and Pima cotton have shown that as plants enter the later part of the fruiting period (plants with >18 to 20 total nodes), the likelihood of continuing high fruit retention in upper canopy positions in general declines significantly, even without major insect pressure, heat, water or nutrient stresses. The concept of the 95 percent zone was thus established for California Acala cotton and later expanded to include California Pima cotton. This approach basically acknowledges and sets a number of fruiting branches that goes to make up 95 percent of the bolls produced. This concept was and continues to be useful as it helps establish a timing at which we want to terminate the crop and allows us to make economically-sensible decisions that balance the desire to continue to set fruit with the fact that a rapid decline in productivity of late-set fruit is expected and natural under most situations. Guidelines developed by UC Cooperative Extension have established approximate cutout values at about 4 to 5 nodes above the uppermost 1st fruiting position white flower for Acala and non-Acala Upland cotton and about 3 nodes above yellow flower for Pima cotton. Protecting the crop that is set on or before this date will help ensure yield and fiber quality will be maintained at high levels.

Physiological Fruit Losses – Potential for Water Stress Impacts. Fruit retention is not solely a function of levels of insect damage, so it is not unusual to find fields at certain times of the year that have significant square and boll shed when pest populations are considered too low to fully explain losses. Particularly as the plants move toward peak bloom, some fields experience significant and sometimes fairly severe fruit losses. The reasons for this shed are not completely understood, however there are some common themes and understanding as to why, and under what conditions post-bloom physiological shed occurs.

Recent results from furrow irrigation studies at UC's West Side Research and Extension Center help describe some issues that can effect mid- and late-season fruit loss. Observations in this irrigation management trial in a deep clay loam soil at this western Fresno County site allowed us to demonstrate some influences of water stress severity and timing, as well as cotton plant type on cotton fruit shed (Table 1). More than 3 weeks after first bloom we observed low levels of *Lygus* (average sweep counts between 1 and 2 per 50 sweeps) but still noticed some square and small boll shed beginning to occur in mid-July (data not shown). We found the Acala variety in the study to have significantly higher losses than the Pima cotton or hybrid in the higher water application irrigation treatments (T3 and T4), and higher average square plus fruit losses in the higher water application treatments than in the deficit irrigated treatments (T1 and T2) in both types of cotton.

Young boll and square shed increased over time to a greater degree across all Acala irrigation treatments when compared with Pima in all treatments (Table 1). Similar to observations earlier in July, higher late-July square and smaller boll losses were observed in treatments receiving more irrigation water and therefore having less water stress. Increasing crop water stress did not increase physiological shed at the water stress levels imposed in this study. However, this should not be interpreted as implying that reduced water applications don't impact overall plant growth. The height of plants, leaf area and total # of fruiting sites (fruiting positions) are reduced with moderate to more severe water stress. Late-July leaf water potentials in the lower water application treatments ranged from about -17 to -20 bars, while mid-afternoon leaf water potentials averaged -14 to -16 bars in the high irrigation water application treatments.

Regardless of water stress levels (Table 1) or time of sampling (data not shown), the Pima variety exhibited lower levels of young boll and square shed when compared to the Acala. This observation is consistent with some prior observations of fruiting patterns under water stress we have made in Pima cotton. Reasons for this difference are not clear. Pima cotton bolls are approximately one-third the size of typical Acala cotton bolls. One possibility might be that smaller Pima bolls could result in much lower carbohydrate demand by each individual fruiting structure, impacting the plants ability to meet boll demands during development. However, the relative impact of higher total boll number in typical Pima plants may bring total carbohydrate and nutrient demand per unit leaf area back into a range similar to Acala types. Similar trends have been observed in recent weeks in some of our field trials, with lower average fruit losses observed in the Pima cotton when compared to Acala cotton.

Table 1. Comparison of aborted small bolls (less than ½ inch diameter), mid-size older bolls (½ to ¾ inch diameter), and squares on July 23rd in Acala (Phy-72), Pima (DP-340) and Pima-Acala hybrid (HA-195) entries in 2009 irrigation trial at the University of California West Side Research and Extension Center.

Variety	Irrigation Treatment # and Pre-fruit loss measurement irrigation history	Aborted small bolls / 15 feet of row	Aborted mid-size bolls / 15 feet of row	Aborted Squares / 15 feet of row
DP-340	1 (one irrigation prior to measurements, on 7/14)	0.0	0.0	0.0
(Pima)	2 (one irrigation, on 7/02)	0.0	0.7	0.3
	3 (two irrigations, 6/19, 7/14)	0.0	0.0	1.3
	4 (two irrigations, 6/03, 7/02)	0.7	0.0	1.0
Phy-72	1 (as above)	13.0	1.3	3.0
(Acala)	2 "	9.3	1.3	3.0
	3 "	15.0	2.7	7.3
	4 "	16.3	2.3	4.7
HA-195	1 "	7.7	1.0	2.3
(hybrid)	2 "	4.3	1.3	1.3
	3 "	9.3	0.3	7.0
	4 "	11.3	2.0	5.3

Physiological Fruit Losses – Potential for High Temperature and Related Stress Impacts. Although the weather has moderated greatly within the past ten days or so, the issue of whether the persistent heat of a few weeks back, including high nighttime temperatures, impacted fruit losses in the San Joaquin Valley is an issue of discussion. Based on a variety of research trials in California and other states, the temperatures we experienced back in mid to late-July (daytime temperatures generally less than 110F and nighttime temperatures below 85F after midnight) are generally not considered to be high enough to cause pollen sterility problems. Peak temperatures of about 110 to 112F and above, and nighttime temperatures of relatively short duration (several hours) that reach about 82 to 85F have been associated with loss of pollen viability in controlled research done in greenhouse or growth chambers, and there also have been good correlations with field fruit loss in some, but not all situations. When temperatures are high enough to damage pollen, the direct heat damage is done mostly when flower buds are small, and is not seen right away. Typically, damage is seen as aborted positions about 2 ½ weeks or so after the first high temperature events.

However …. life in the fields for plants is never quite as simple to explain as results from greenhouse or growth chamber research. Plants in the field are exposed to more complex combinations of multiple stresses. In addition, we have multiple types of cotton grown here in the SJV, each with potentially different characteristics affecting relative heat tolerance:

- non-Acala Uplands with origins outside of CA (likely more heat-tolerant)
- Acala varieties with SJV origins (generally considered more heat-sensitive, but little new work has been done to compare newly-introduced Acalas in recent years)
- Pima (generally considered more heat-tolerant, improved tolerance likely associated with screening and variety development work in Arizona – heat tolerance less known for more recently-developed varieties)

High daytime temperatures not only impact leaf net photosynthetic rates but also plant respiration rates and utilization of stored carbohydrates. High night-time temperatures that contribute to high respiration rates also have potential negative impacts, and these combination effects are typically most detrimental to plants that have a relatively large fruit load to support relative to the size of the photosynthetic leaf area and root system (smaller, lower leaf area plants with a big fruit load). For plants fitting this type of description, the developing fruit require carbohydrates and nutrient uptake to fully develop, and these requirements represent direct competition for the same materials needed to support continued shoot and root growth and maintenance.

Most years in the SJV we are lucky enough to have either a limited number of these periods of temperatures high enough (over 110 to 112 F) to cause these direct injuries or to experience them late in fruiting when most of the boll load is set. In prior years with incidents of prolonged high temperatures (such as late-July, 2006), some of the worst-affected plants observed have been where a combination of high air temperatures occur in conjunction with aeration/anoxia stress brought about with irrigation / standing water on low intake rate soils. This combination can result in near closure of the stomata during the worst of the aeration stress, causing elevated plant canopy temperatures and more stress on transpiring and non-transpiring plant tissues. Withholding irrigation water under these conditions would reduce aeration stresses, but for long-lasting hot spells would eventually lead to more direct water stress. If lighter irrigations are possible in order to reduce the duration of the aeration stress during hot spells, that might help.

At any location, however, indirect effects of long-lasting hot spells on plants can be similar to what long term high temperature exposure does to people around here – a cumulative stress associated with hot daytime temperatures combined with nighttime temperatures that in some cases remained at 85 to 90F well toward midnight. Day and night temperatures reaching the high temperature ranges mentioned above are generally less conducive to good, high photosynthetic rates, and favor higher daytime and nighttime respiration rates in plants. This reduces available carbohydrates needed for maintenance of developing fruit and continued growth. If this continues for long, without relief, it certainly represents another stress for beleaguered plants already dealing with fruit losses and perhaps water or aeration stresses. With this in mind, when you see fruit loss in years with very high temperature periods lasting a few days or more during fruiting, keep in mind that some fruit losses can be heat-related or limited by available nutrients or carbohydrates rather than just pest-related – so, identify the presence of pests prior to deciding on fruit loss causes and making control decisions.