GROWTH AND DEVELOPMENTAL RESPONSE OF COTTON CULTIVARS TO DIFFERENT LEVELS OF *LYGUS* INFESTATION

S. C. Carroll
R. B. Shrestha
W. O. McSpadden
A. Bastola
M. N. Parajulee
Texas A&M AgriLife Research & Extension Center
Lubbock, TX

Abstract

A 3-yr Texas High Plains study (2009-2011) was conducted to quantify the lint yield compensatory ability of two commercially available cotton cultivars, DP 104 B2RF (early maturity) and DP 161 B2RF (long-season), following pre-bloom cotton fruit loss resulting from either insect-induced fruit loss or artificial (manual) cotton square removal. Different levels of pre-flower square loss were achieved by augmenting natural populations of *Lygus hesperus* (Knight), western tarnished plant bugs (WTPB), with laboratory-reared nymphs released three times at weekly intervals or via manual fruit removal during the first three weeks of squaring. Treatments included: 1) augmentation of 2-3 bugs per plant (Low), 2) augmentation of 4-6 bugs per plant (High), 3) 0 bugs augmented (untreated control, UC), 4) 0 bugs achieved through spray applications (spray control, SC), 5) artificial (manual) removal of pre-bloom first position squares (ASC_{1st}), and 6) artificial manual pre-bloom removal of all fruits (ASC_{all}). At the end of the fourth week of squaring, all treatment plots were sprayed with insecticide to eliminate further insect-related fruit losses and the plots were kept generally pest-free until crop harvest. The test was deployed in a 2 (cultivar) x 4 (insect-augmented and control treatments) x 4 (replications) factorial arrangement with a randomized complete block design (32 total plots). The two manual removal treatments (ASC_{1st}, ASC_{all}) were merged into small areas within the eight SC control plots (2 cultivars x 4 reps). In all three study years, *Lygus* augmentation in pre-flowering cotton consistently resulted in significantly higher fruit loss percentages in both cotton cultivars versus corresponding cultivar controls (UC and SC). Regarding final lint yields, both insect-induced (Low and High) and manual fruit removal (ASC_{1st} and ASC_{all}) significantly reduced lint yield contributed by first fruiting positions. Averaged across both years and cultivars, SC, UC, Low, High, ASC_{1st}, and ASC_{all} produced 916, 928, 745, 779, 480, and 476 lbs/A first position lint yields, respectively. Conversely, both insect-augmentation and manual fruit removal resulted in significantly higher lint yield contributions by lateral fruiting positions. Averaged over three years, SC, UC, Low, High, ASC_{1st}, and ASC_{all} produced 298, 275, 385, 423, 768, and 631 lbs/A lateral position lint yields, respectively. Regardless of the manner of fruit removal, the cotton plants were able to fully compensate, in terms of final lint yield, for early-season fruit loss, largely via significant overcompensation by lateral fruiting positions. It should be noted that the level of lint yield compensation realized is dependent upon the availability of adequate input resources (e.g., water, plant nutrients, heat units) following early-season fruit losses.

Introduction

A three-year study evaluating the fruit loss compensation capacity of cotton grown in the Texas High Plains (THP), using pre-bloom artificial (manual) square removal treatments ranging from 0-100%, indicated that irrigated cotton could withstand 100% first-position square removal during the pre-bloom period with no subsequent observed yield loss (Leser et al. 2004). Dryland cotton was observed to withstand 50% removal with no significant yield impact. Maturity was impacted under the most severe treatments. Nevertheless, while 100% square removal prior to blooming failed to impact yield, a substantial maturation delay was incurred. Leser et al. (2004) concluded that irrigated cotton could tolerate a 40% loss with no impact whatsoever. However, these data were generated based on manual pinhead square removal. Previous researchers have indicated that plants exhibit differential reactions to insect-induced fruit loss, likely due to insect feeding behavior, for example, as a result of insect secretion of enzymes and other chemicals in the process of feeding (Sadras 1995). Using *Lygus hesperus* (Knight) nymphs, Barman et al. (2007) and Parajulee et al. (2008) demonstrated the likelihood that cotton is incapable of compensating for more than 25-30% of insect-induced fruit loss under a more limited input/limited irrigation production system. In addition, plant compensatory capacity for insect-induced fruit loss has correlated strongly with soil moisture and overall plant vigor. Our research has shown that cotton may compensate for up to 30% of insect-induced fruit loss if plants are not water-stressed, which is generally not the case under a limited-irrigation production system.

In the THP region, water management is probably the most important input management issue, but production technology has advanced to give THP producers opportunities to utilize high-input resources to maximize production yields and profitability. Current research at the Helms Farm near Plainview, Texas has demonstrated tremendous opportunities for THP growers to utilize high-input resources such as high-yielding cultivars, near-100% irrigation efficiency (particularly subsurface drip irrigation systems), aggressive insect management regimes, and proper nutrient management. Our research has also suggested that cultivars differ in their ability to support plant bug infestations. This phenomenon is true for both *Lygus* bugs and cotton fleahoppers. It is also expected that some cultivars may differ in susceptibility to plant bug injury and subsequent square loss. There is a need to identify these potential differences as they pertain to the development of fruit loss-based plant bug economic thresholds.

The objective of this study was to quantify the yield-compensatory potential of selected cotton cultivars (early-maturing versus full-season) following exposure to different levels of insect-induced fruit loss in order to allow for further evaluation and refinement of current economic thresholds. Improved and refined economic thresholds are expected to reduce the necessity for insecticide applications and, consequently, mitigate problems due to secondary pests.

Materials and Methods

This 3-yr study was conducted at the Texas A&M AgriLife Research & Extension Center research farm located in Lubbock County near New Deal, Texas. A 5-acre subsurface drip-irrigated field was selected for this experiment. Two cultivars, DP 104 B2RF (early maturing or short season) and DP 161 B2RF (full season), were evaluated. Test plots were planted on May 18, May 25 and May 11 in 2009, 2010 and 2011, respectively. Experimental plots were 12 rows wide and 75 ft long with 5-ft alleys separating the plots. Four central rows were selected in each plot for plant bug treatment deployment and plant mapping. Pre-flower *Lygus* bug-induced square loss treatment levels were achieved by augmenting any naturally occurring plant bug populations with laboratory-reared 3rd-instar *L. hesperus* nymphs weekly during the first three weeks of squaring. Treatments included: 1) augmentation of 2-3 bugs per plant (Low), 2) augmentation of 4-6 bugs per plant (High), 3) 0 bugs augmented (untreated control, UC), 4) 0 bugs achieved through spray application (spray control, SC), 5) pre-bloom artificial (manual) removal of all first-position squares and spray control (ASC_{1st}), and 6) pre-bloom manual removal of all fruits and spray control (ASC_{all}). In explanation for the stated ranges of bug augmentation (Low and High), it should be noted that following the 2009 season, the treatment release numbers were increased to the tops of the stated ranges in 2010 and 2011 to encourage greater early-season fruit loss, facilitating a more complete evaluation of each cultivar's lint yield compensatory ability. The test was deployed in a 2 (cultivars) x 4 (treatments; High, Low, UC and SC) x 4 (replications) factorial arrangement with a randomized complete block design for a total of 32 experimental plots. The two manual removal treatments (ASC_{1st}, ASC_{all}) were overlaid into small areas within the eight SC control plots (2 cultivars x 4 reps). These treatments allowed for good comparisons of cotton plant responses to early-season insect-induced fruit loss to artificial manual fruit removal.

Insect augmentation began upon initial pinhead-sized square observation in all bug-augmentation treatment plots and consisted of 3 consecutive weekly releases of *L. hesperus* nymphs in the designated plots (Fig. 1). Plant bugs were aspirated from a laboratory colony (3rd instar) into 0.75-inch X 1.5-inch plastic vials. The bugs were carefully deposited on the mainstem terminal of each plant. The releases were conducted on July 2, 7, and 13 during 2009; July 1, 8 and 15 in 2010; and June 30, July 7, and 13 in 2011.

Immediately prior to each release date, fruit-set monitoring was conducted using the SQUAREMAN component of the COTMAN^{TM} program in order to follow any differing plant growth or fruiting responses resulting from the variable levels of early-season fruit removal (Fig. 1). Pre-flower SQUAREMAN data were collected on July 1, 6 and 13 in 2009; June 30, July 7, and July 14 in 2010; and June 29, July 7 and 13 in 2011. Complete in-season plant mapping was conducted in all plots one week after the final *Lygus* release per study year, on July 21, July 26, and July 20 during 2009, 2010, and 2011, respectively. Immediately following, insecticides (Orthene, 2009; Carbine/Holster tank mix, 2010; Orthene, 2011) were applied to all treatment plots to minimize further fruit loss. Season-long monitoring followed in order to keep the plots generally pest-free until harvest.

COTMAN-SQUAREMAN plant mapping continued until physiological cutout [Nodes Above White Flower (NAWF) =5], after which heat unit accumulations were monitored to aid decisions regarding harvest-aid application timing. Final complete plant mapping was conducted each study year immediately prior to harvesting (Fig. 1).

Harvest-aid chemicals were applied based on heat unit accumulations and percent open bolls for each cultivar. FirstPick® and DEF® 6 (boll opener/defoliation) were applied during 2009 in early- (DP 104 B2RF) and late-maturing (DP 161 B2RF) cultivars on September 30 and October 14, respectively. One week after boll opener/defoliant application in each cultivar, Gramoxone® was applied to finish crop preparation for harvest. Harvest dates for 2009 were October 15 (DP 104 B2RF) and 27 (DP 161 B2RF). For 2010, both cultivars were sprayed with a tank-mixture of Finish® plus DEF 6® on October 16, followed by an application of Gramoxone® on October 21. Both cultivars were harvested on October 27, 2010. In 2011, a tank-mix of Finish® 6 Pro and DEF® 6 was applied on September 21 and 29 on the DP 104 B2RF and DP 161 B2RF, respectively. A final treatment of Gramoxone® was then applied September 27 and October 7 on DP 104 B2RF and DP 161 B2RF, respectively. In 2011, the two cultivars were harvested separately on September 30th (early maturity DP 104 B2RF) and October 11th (full season DP 161 B2RF).

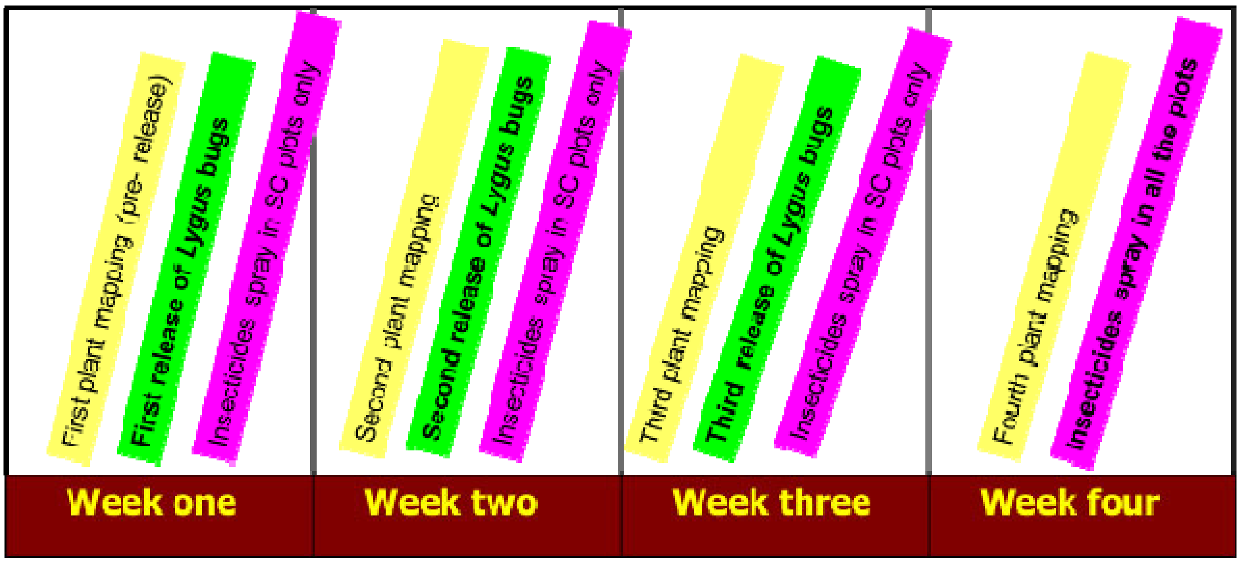

Figure 1. Experimental activity sequence related to the release of *Lygus* bugs and cotton fruit loss monitoring. Week one corresponds to first week of the pin-head squaring stage in each study year.

Results and Discussion

COTMAN™ Target Development Curve (TDC) and Fruiting

Figure 2 illustrates yearly cotton development and squaring initiation, which generally adhered to or preceded the COTMAN™ target development curve (TDC; black line), but peak fruiting was lower than the TDC in all years, particularly in control plots (blue and purple lines). Observed SQUAREMAN curves peaked 7-10 days later in DP 161 B2RF than in DP 104 B2RF, indicating cotton reproductive profile and crop maturity varietal differences. The crop maturity profiles of both cultivars varied among years. In 2009 and 2011, DP 104 B2RF reached cut-out (NAWF = 5) approximately 1 week earlier than DP 161 B2RF, whereas in 2010, both cultivars exhibited similar crop maturity timing. In 2009, *Lygus* augmentation treatments did not significantly affect the cotton crop maturity profile in either cultivar, whereas in 2010 and 2011, the *Lygus* augmentation treatments clearly caused significant delays in peak squaring and crop cut-out (NAWF = 5). In 2011, *Lygus* infestation delayed crop cut-out by approximately 3 weeks. Despite cotton's capability to compensate for damage caused by early-season *Lygus* infestations, the crop may also mature later, potentially resulting in lint quality discounts. Possible lint quality penalties due to early-season cotton fruit loss will be discussed when lint quality data are available for all three study years.

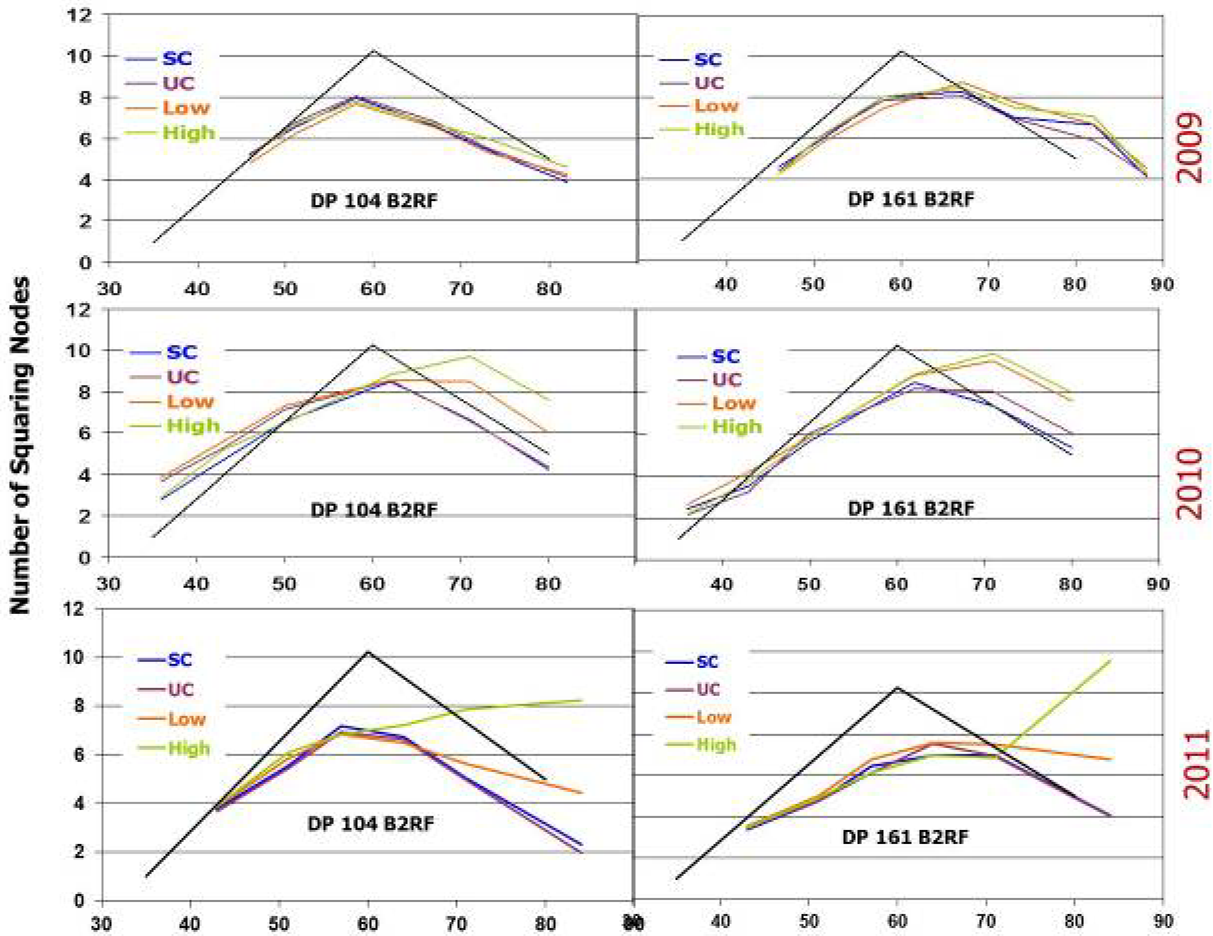

Figure 2. COTMAN™ software cotton fruiting profiles as influenced by *Lygus*-induced fruit loss, and target development curves (black lines). For each year, two cultivars, DP 104 B2RF and DP 161 B2RF, were monitored, Lubbock, TX, 2009-2011.

Percent Fruit Loss

In all three study years, pre-flower *Lygus* augmentations in cotton consistently resulted in significantly higher fruit loss percentages in both cultivars versus corresponding cultivar controls (UC and SC) (Fig. 3). At four weeks into cotton squaring, the highest percent fruit losses were observed in *Lygus*-augmented treatments in 2011 (34-73%), followed by 2010 (45-58%) and 2009 (20-26%). *Lygus* augmentation in Low and High treatments was increased in 2010 and 2011 to achieve higher early-season fruit loss percentages for better evaluation of the maximum crop compensation capacity in each cultivar.

Final Lint Yields

In all years, both cultivars compensated for *Lygus*-induced fruit loss (Fig. 4). Also in all years, although some numerical differences were observed in percent fruit loss values, both cultivars produced similar lint yields (Figs. 3 and 4). By determining the fruiting position-based lint yield contributions, it was revealed that insect-induced (Low and High) fruit removal treatments and manual fruit removal treatments (ASC_{1st} and ASC_{all}) significantly reduced the first-position lint yield contribution. Averaged across both years and cultivars, SC, UC, Low, High, ASC_{1st}, and ASC_{all} produced 916, 928, 745, 779, 480, and 476 lbs/A first-position lint yields, respectively. Conversely, both insect-augmented and manual removal treatments significantly increased lateral-position lint yield contributions. Treatments SC, UC, Low, High, ASC_{1st}, and ASC_{all} produced 298, 275, 385, 423, 768, and 631 lbs/A lateral-position lint yields, respectively. Interestingly, regardless of the manner of fruit removal, plants were able to fully compensate, in terms of final lint yield, for early-season fruit loss, largely by way of significant lateral fruiting overcompensation. Again, it is important to note that the level of lint yield compensation realized is directly dependent upon the availability of adequate input resources (e.g., water, plant nutrients, and heat units) following early-season fruit losses. Pending analyses of fiber properties will elucidate potential fiber quality penalties due to delayed crop maturities observed in the insect-induced and manual fruit removal treatments.

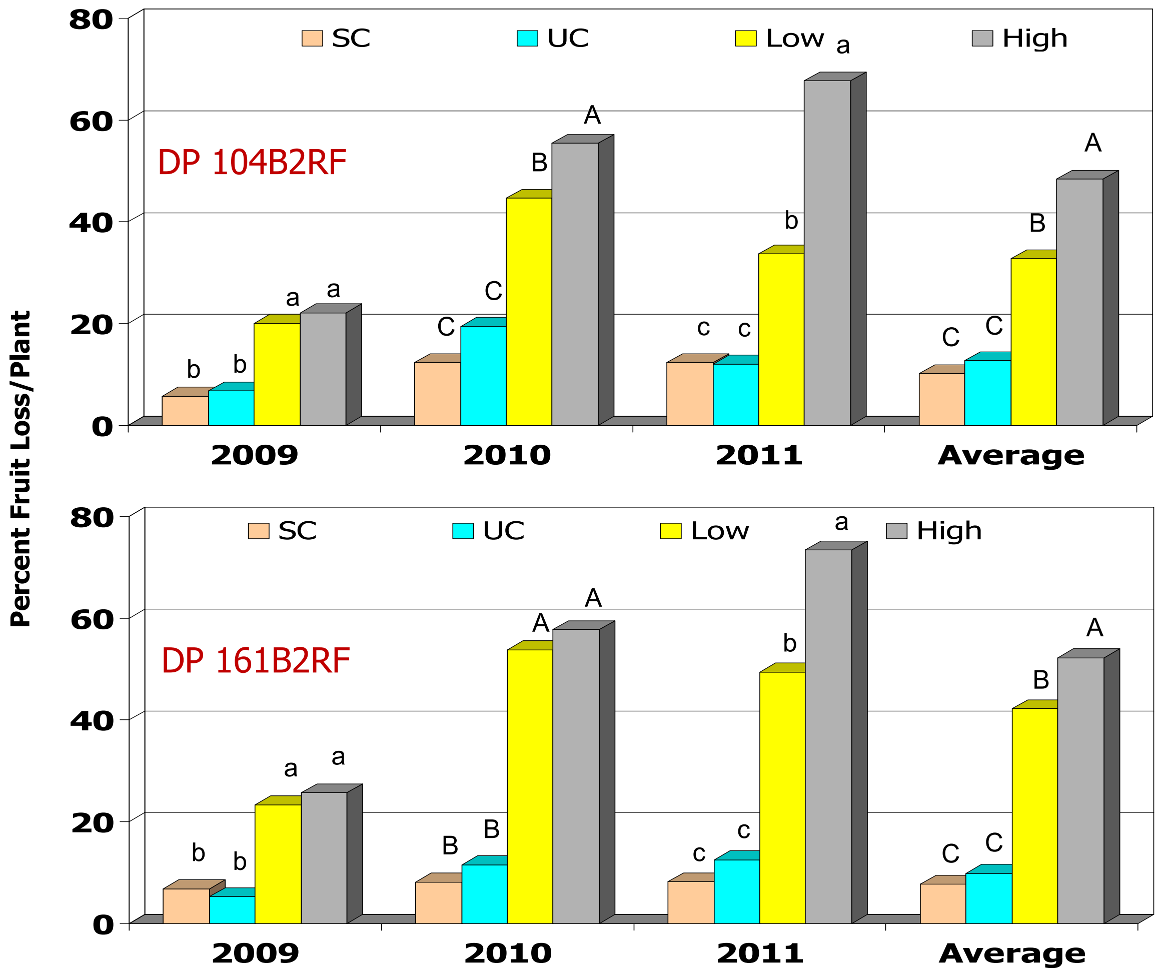

Figure 3. Observed percent cotton fruit loss one week after final *Lygus* release in DP 104 B2RF and DP 161 B2RF cotton cultivars, Lubbock, TX, 2009-2011. Within a single cultivar and year (or 3-yr average), treatment means with differing letters are significantly different at P = 0.10.

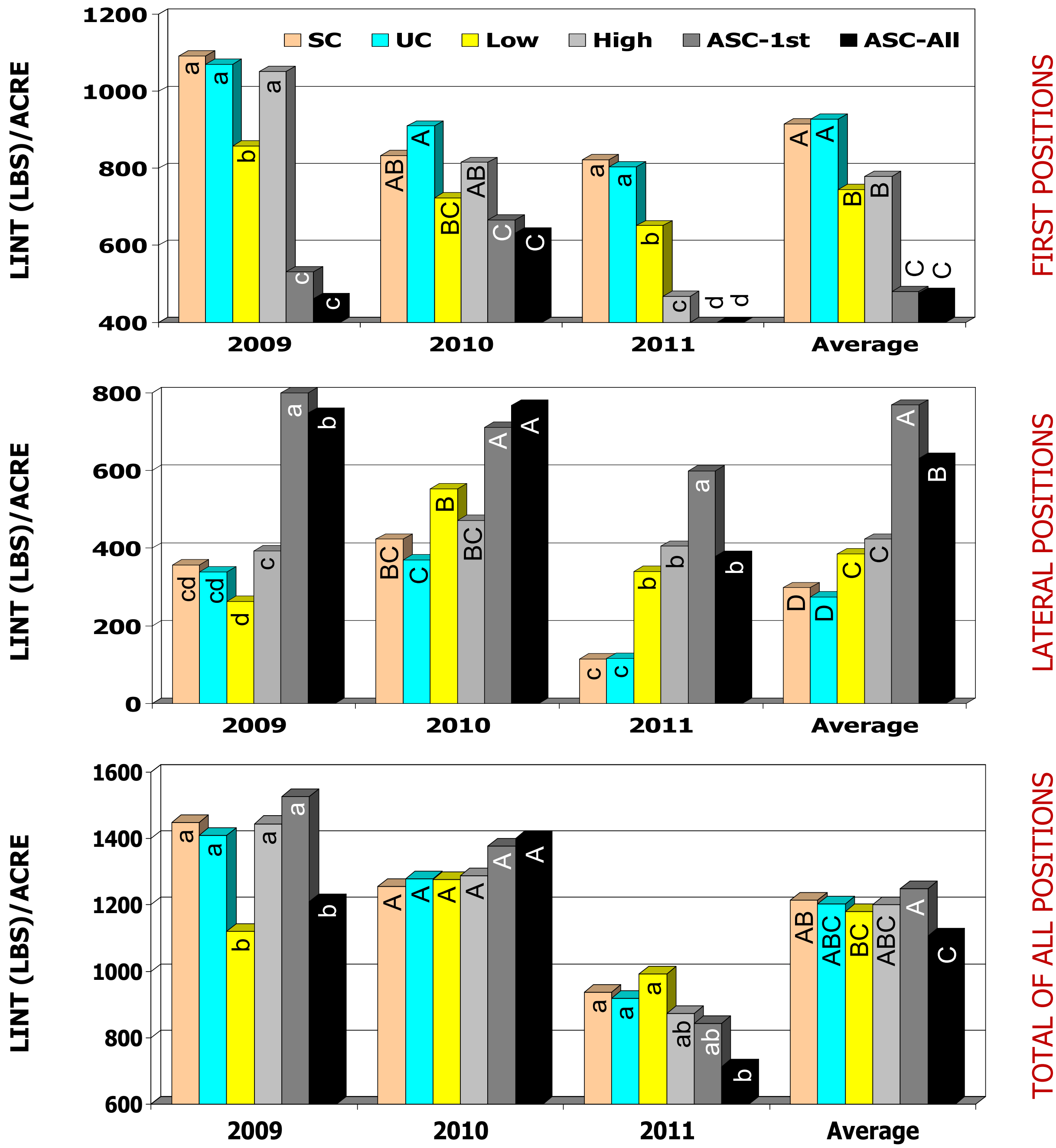

Figure 4. Yearly and 3-yr averaged lint yields (across two cultivars) from cotton plots receiving: 1) varied levels of *Lygus* augmentations (Low, High), 2) artificial (manual) square removal (ASC_{1st}, ASC_{all}), or 3) controls (UC, SC). Yields were separated by fruiting positions (1^{st}, lateral, combined). Within types of fruiting position and year (or 3-yr average), treatment means with differing letters are significantly different at P = 0.10. Lubbock, TX, 2009-2011.

Acknowledgements

We thank our funding agencies including Cotton Incorporated Core Program and Plains Cotton Growers, Inc. The authors also are indebted to Kamala Adhikari, Diwash Neupane, Bo Kesey, Swagat Parajulee, Poma GT, Michele Fekete, Andrew Stevens, and the late Anabel Reid, whose technical assistance in the field was invaluable.

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