Impact of early season retention on yield potential in high-yielding Bollgard® 3 cotton

Irrigation Research & Extension Committee

2021-22 season report

Summary

THE 2020-21 season (being cool, and in certain districts very wet) was quite different to previous seasons however results continued to demonstrate that high yielding Bollgard® 3 varieties can compensate for extensive pre-flowering square loss (FB 1-5) across a range of environments without compromising lint quality and time to maturity or requiring additional management inputs to enable compensation.

Maturity delays (to reach 80% bolls open) for the FB1-5 treatment ranged from 0-6 days with the pattern of opening over time altered as had been observed in previous years. The opening of the final bolls in both the control and damaged plots occurred at the same time with no delay to picking date. Lint quality was within base grade for all damage treatments across all locations in 2021/22.

Materials and methods

The experiments were located within commercial irrigated fields at 2 locations (see Table 1). The NSW DPI Leeton field station was a full research site with multi-row plots that allowed for biomass sampling. At Whitton (IREC field station), only the early square removal treatment (FB1-5) was enacted together with controls (replicated four times) across four different cultivars. Plots were located within a uniform area of each field. Care was taken avoid the overlap of plots with wheel tracks for spraying and cultivating operations.

Table 1. Trial site details. (R) denotes the larger research sites.

Location	Sowing Date	Cultivar	Field Configuration	Picking Date
Whitton	10/10/2021	Sicot 714, 746, 606 & 748B3F	Solid	11/5/2022
Leeton (R)	12/10/2021	Sicot 714, 746 & 606B3F	Solid	10/5/2022

The three primary damage treatments entailed the removal of all squares (except very small pin squares) on all plants from:

1. the first five bottom fruiting branches (sympodia 1-5) one week prior to flowering
2. fruiting branches 6-10 (leaving sympodia 1-5 intact) one week after first flower
3. fruiting branches 1-10 (with damage implemented on the occasions above); compensatory squares initiated on the first five sympodia were left intact during the second damage event.

Photo 1. Pliers used to 'pinch' the buds within the squares.

Damage was implemented manually with small spring-loaded bent nose pliers to 'pinch' the square bud (Photo 1), resulting in square abscission 2-3 days later. Using this method avoided damage to the underlying sympodia. Squares that were not protruding from the growing points were left intact, so that developing plant tissues were not compromised.

Mirids (*Creontiades spp*.) were managed as per the commercial practices implemented within the larger field area.

Crop maturity was determined by counting and hand harvesting open bolls and weighing corresponding seed cotton from 2 metres of row within each plot every 6-8 days from early boll opening to the last pickable boll. The term 'pickable' described bolls with the lint unfurled and available for machine spindle picking.

The contribution of different boll cohorts to overall yield was measured using a segmented picking technique at the majority of sites just prior to machine picking. Fruiting branches of each plant within 1m of row of each plot were numbered from the base towards the terminal and grouped into subsets of 5 nodes resulting in fruiting branches (FB) cohorts of 1-5, 6-10, 11-15 and all FB ≥16. Within these FB groups, the number of bolls on each plant were counted and handpicked from the first fruiting site position (P1), followed by all remaining distal FB fruiting site positions (≥P2). The bolls on vegetative (monopodial) branches (MB) were also counted and handpicked as one cohort per plant. All handpicked seed cotton samples were stored in paper bags in an air-conditioned laboratory for at least 10 days to allow seed cotton moisture to equalise before being weighed. Segmented picking enabled boll number, size, and contribution to overall yield to be calculated for each canopy section.

Seed cotton was hand harvested from 6m of row not used for other destructive plot assessments at the majority of sites. At Goondiwindi and Leeton a 10m row not used for other assessments was machine picked. Handpicked yields were reduced by 3% to account for estimated losses that would be associated with machine picking. Lint yield was calculated by ginning a 400g sub-sample with a 10 saw laboratory mini-gin, and the results adjusted down by 4-5%, to account for lower turnouts achieved from commercial scale gins. The adjusted results were commensurate with commercial ginning results (where available) from the surrounding field areas.

The experiment plots at each site were subject to the standard operations (cultivation, irrigation, nutrition, defoliation) conducted on the host field area (i.e. the experiments were not managed to encourage compensation).

Weather conditions were monitored by nearby automated weather stations that recorded temperature and rainfall.

Measurements taken at plot level at each site (fruit number, final biomass, lint yield & lint quality parameters) were analysed using a combined trials ANOVA and least significant differences (lsd) calculated. The significance was set at 5% for all testing. All analyses were conducted in Genstat (19th Edition) (VSN International, 2017).

Results

Early square removal from FB1-5 caused no significant yield loss but increased (*P*<0.05) yield at Wee Waa (14%) and Goondiwindi (11%) (Figure 1). Removal of squares just after first flower from FB 6-10 negatively impacted yield (*P*<0.05) at Cecil Plains, Leeton & Wee Waa by 10, 6 & 12% respectively (Figure 1). Each of these sites were planted to Sicot 606B3F. The FB 1-10 treatment reduced yield significantly at 5 sites (Cecil Plains, Goondiwindi, Leeton, Moree and Wee Waa) by 11-23% (Figure 1). The increase in yield for FB1-5 and decrease for FB6-10 were largely due to weathering losses reducing the pickable boll counts on the first 5 fruiting branches. For the FB1-5 treatments, compensatory bolls above the lower canopy avoided these losses whilst underlying bolls lost from the FB6-10 damaged treatments compounded the loss.

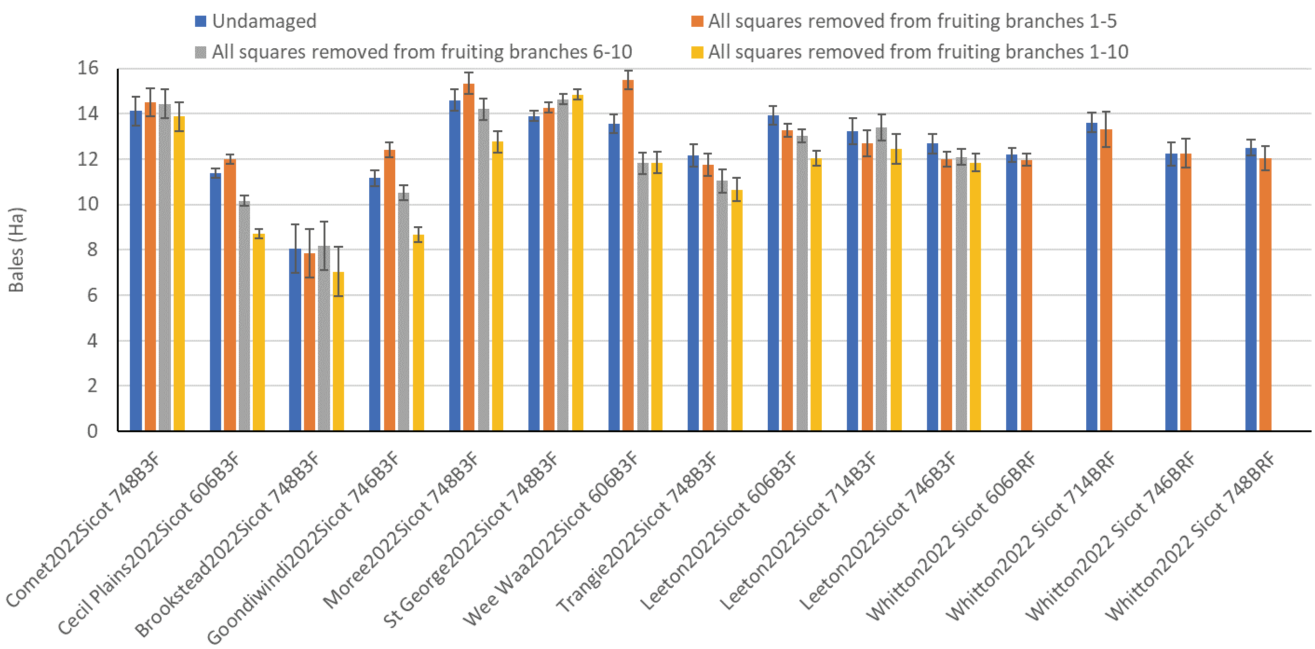

Figure 1. Lint yield (bales/ha) picked from each of the experiment sites. Leeton and Goondiwindi were machined picked whilst the remaining sites were hand-picked. Bars denote standard error. Treatments are undamaged (Control), and squares removed from fruiting branches (FB) 1-5, 6-10 and 1-10.

Significant differences were detected for some lint quality parameters at some sites (Table 2). However, the magnitude of differences was very minor regardless of treatment or location, falling well within the Australian basis for micronaire, strength and length parameters.

Final boll number was largely unaffected by the damage treatments except for a significant reduction (*P*<0.05) of final boll counts for the FB6-10 and FB1-10 treatments at Cecil Plains and Leeton where Sicot 606B3F was grown (Table 2). Final boll weight for the FB1-10 treatments was also significantly reduced compared to the other damage treatments and control at these two sites. No significant differences occurred at Leeton for boll number or size where Sicot 746 and 714B3F were sown. (Table 2).

Table 2. Final boll number and boll size (calculated from maturity picks) and fibre quality parameters for Southern NSW sites. Despite some minor significant differences for various lint quality parameters, all parameters remained well within the Australian basis for quality.

Location & Treatment	Final boll number	Mean boll size	Micronaire	Length	Strength
Leeton					
Sicot 714B3F					
Undamaged	140.3	5.8	4.7	1.22	31.0
FB 1-5	146.6	5.5	4.7	1.23	30.4
FB 6-10	141.8	5.6	4.6	1.24	30.7
FB 1-10	134.2	5.6	4.4	1.24	29.3
Sicot 606B3F					
Undamaged	147.9a	5.4a	4.7a	1.27	32.1
FB 1-5	149.1a	5.2a	4.5b	1.26	32.8
FB 6-10	138.6ab	5.3a	4.4bc	1.26	32.3
FB 1-10	130.8b	5.0b	4.2c	1.26	31.7
Sicot 746B3F					
Undamaged	153.8	5.1	4.4	1.26	30.7
FB 1-5	146.0	5.2	4.5	1.23	30.2
FB 6-10	148.8	5.2	4.3	1.25	30.9
FB 1-10	158.4	5.1	4.2	1.24	30.7
Whitton (IREC)					
Sicot 746B3F					
Undamaged	132.5	4.9	4.1	1.28	34.6
FB 1-5	131.0	5.1	3.9	1.26	33.7
Sicot 714B3F					
Undamaged	148.2	4.6	4.3	1.27	33.9
FB 1-5	148.0	4.7	4.1	1.27	33.6
Sicot 748B3F					
Control	122.0	5.2	4.4	1.31	34.2
FB 1-5	117.7	4.8	4.4	1.26	34.4
Sicot 606B3F					
(Control)	132.0	4.8	4.7	1.27	36.1
FB 1-5	132.2	4.8	4.5	1.25	34.9

Letters denote significant differences ($P<0.05$)

Similar to previous years, segmented canopy picking showed that compensation occurred via the production of more distal bolls on the fruiting branches (second or third position bolls) and increased retention of first position bolls on fruiting branches 11-15 (Figures 2a and 2b). Limited compensation occurred via bolls retained on fruiting branches 16 and above (Figure 2b). Figure 2b also shows the number of bolls borne by vegetative branches typically increased. Compensation was primarily a function of additional bolls being retained in these positions.

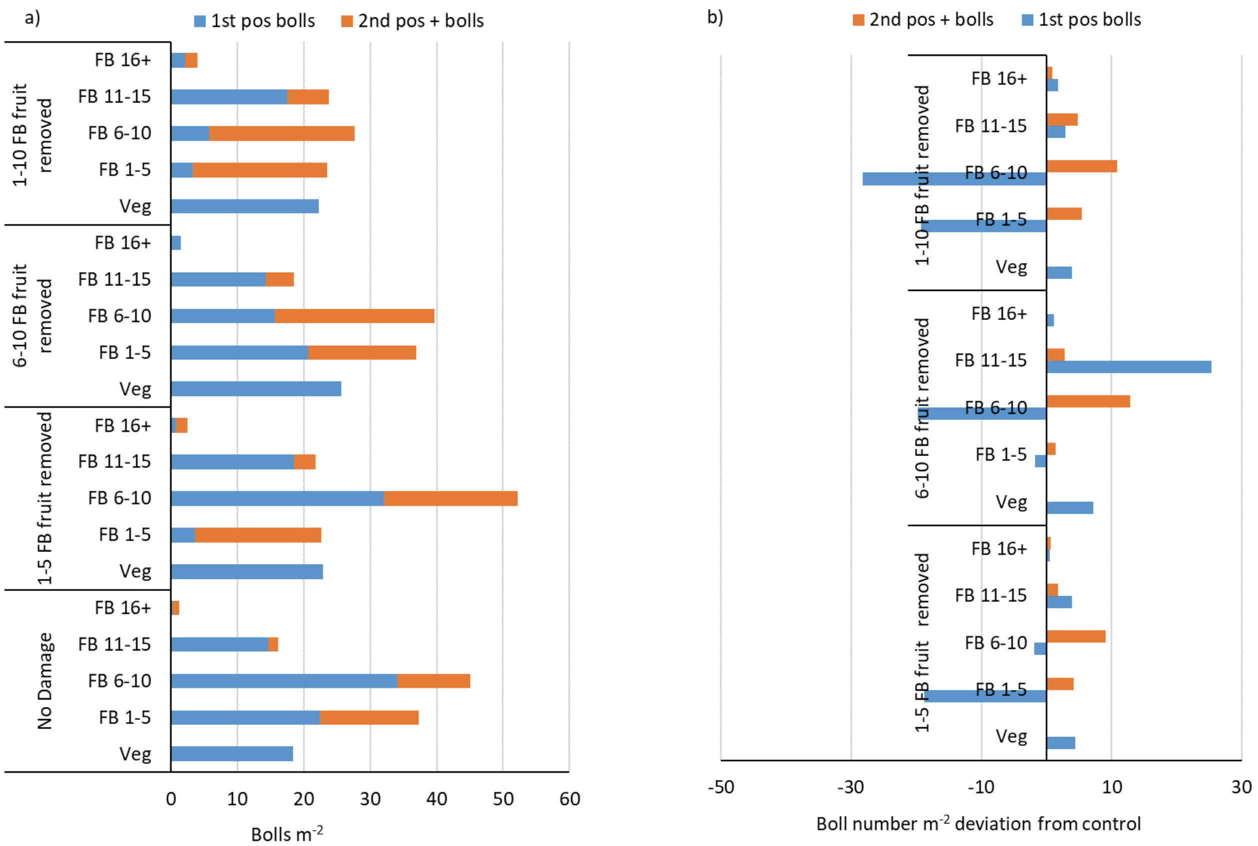

Figure 2. Segmented picking data showing first position (P1) and outer fruiting branch position bolls (P2+) for the fruiting branches (FB) 1-5, 6-10, 10-15 and >16 and vegetative branches (Veg) (a) and change in boll number (b). Data presented is the mean of all replicates across segment picked locations and locations. Treatments are undamaged (Control), and squares removed from fruiting branches (FB) 1-5, 6-10 and 1-10.

Hand picking indicated that final crop maturity was not delayed but the pattern of boll opening was altered, particularly when more extensive damage and compensation had taken place for the FB 1-10 treatment. A higher number of compensatory bolls were borne on more distal fruiting branch positions (Figures 2a and 2b) resulting in a slower boll opening rate initially, followed by a rapid increase during the final stages of opening. Compared to the control, the FB 1-5 and FB 6-10 treatments reached 60% of bolls open 2-11 days later whilst the FB 1-10 treatments spanned 6-16 days (Table 3). These differences diminished during later opening with the FB1-5 and 6-10 treatments reaching 80% of bolls open 0-6 days after the controls. The last bolls in these treatments were open and unfurled no later than the last pickable bolls in the controls and surrounding field area indicating that there would be no picking delays for these treatments despite the delayed rate of opening earlier on during defoliation. The exception was some of the FB 1-10 treatments in cooler areas that remained 2-4 days behind at picking.

Table 3. The number of days after sowing (DAS) that treatments reached 60 & 80% of bolls open for Southern NSW sites calculated from regressions fitted for each treatment at each site. Delay in days relative to the undamaged control (calculated via regression) is given in brackets. Maturity data is unavailable for Goondiwindi due to site access difficulties with flooding during the boll opening period.

Location and treatment	DAS 60% bolls open	DAS 80% bolls open	Location and treatment	DAS 60% bolls open	DAS 80% bolls open
Leeton (Sicot 746B3F)			**Leeton (Sicot 606B3F)**		
Undamaged	199	210	Undamaged	193	211
FB 1-5	201(2)	211(1)	FB 1-5	201(8)	211(0)
FB 6-10	203(4)	212(2)	FB 6-10	204(11)	214(3)
FB 1-10	205(6)	214(4)	FB 1-10	209(16)	217(6)
Whitton (IREC)			**Whitton (IREC)**		
Sicot 746B3F Undamaged	178	188	Sicot 748B3F Undamaged	175	186
FB 1-5	188(10)	193(5)	FB 1-5	184(9)	192(6)
Sicot 714B3F Undamaged	181	191	Sicot 606B3F Undamaged	180	190
FB 1-5	187(6)	196(5)	FB 1-5	188 (8)	196(6)

Discussion

Yield

Wet weather during boll opening led to boll losses from the lower branches, and a number of the FB6-10 treatments and controls were negatively affected due to tight locking of these lower bolls. The removal of early squares (treatment FB1-5) did not significantly reduce yield at any site this season, and actually increased it in some locations, as the majority of compensatory bolls were located higher in the canopy thus avoiding tight locking. Compared to the control and FB6-10 treatments, the FB1-5 treatment did not expend energy filling bolls at the very bottom of the canopy only to be subsequently lost to boll rots. The FB1-10 treatment caused yield loss at a number of sites, largely reflecting cooler seasonal conditions associated with the 2021/22 La Niña that reduced the length of favourable conditions for full compensation. The performance of the FB1-5 treatment (despite the cooler than average conditions) demonstrates that compensatory response following early square loss is robust (Figure 1).

Lint quality

Lint quality was virtually unaffected by the damage treatments except for relatively minor but statistically significant differences at two sites. This was mostly in response to the more severe damage treatments that also induced yield loss. The lack of differences for the FB1-5 treatment demonstrates that compensatory process following early square loss did not materially shift the maturity profile of the crops bolls in a way that might induce treatment differences, and reflects compensatory positions being developed well ahead of crop cut-out.

Retention

Measurements of fruit development and retention over time were only conducted for the DAF research sites during the final year of the study. As expected, square removal drastically altered early fruit retention to levels well below accepted industry standards (60-80%) prior to flowering. However, compensation was rapid with the FB1-5 treatment being commensurate with the control by mid flowering, which largely explains why this treatment has no impact on subsequent yield and lint quality.

Segmented picking

Similar to previous seasons, segmented picking data show that the majority of compensatory bolls were retained throughout the canopy at sites distally adjacent to where squares had been removed, as indicated by the increased proportion of ≥P2 bolls on the damaged branches and P1 bolls on fruiting branches immediately above the damaged canopy zones (Figures 2a and 2b). Likewise, vegetative branches produced more bolls in the damage treatments, a likely consequence of surplus assimilate during early flowering enabling greater vegetative branch expansion. The compensatory bolls produced on either branch type were initiated prior to cut-out, which explains why the rate of boll opening is altered but final maturity with the opening of final bolls remaining unaffected (Figure 2).

Crop maturity

Final crop maturity was largely unaffected by the damage treatments. However, the rate of opening was altered during the first weeks of boll opening. Fruit removal from the lower branches (FB1-5) delayed the onset of boll opening but these treatments rapidly caught up with the control.

60% of bolls being open is a traditional measure of physiological maturity and the point at which defoliation can commence with the objective of attaining complete leaf drop as the last bolls open. Defoliation decisions made at each trial site were based on the surrounding field (indicative of the control). For the majority of sites no negative impacts were observed for what would usually be considered an earlier than optimal application of defoliant for the damage treatments, suggesting that the changed boll age distribution was not overly different from the control. Despite a lower number of bolls open in the damaged (FB1-5 & FB6-10) treatments when defoliation commenced, the maturity profile of the remaining green bolls was very similar to the control. For the research sites, traditional maturity assessments based on nodes above cracked boll suggested a very similar defoliation commencement timing particularly for the FB1-5 & 6-10 treatments. The FB1-10 treatment had delayed maturity (being 5-6 NACB when field defoliation commenced), reflecting the additional 1-2 extra fruiting branches generated in response to extreme damage. The last green bolls in the control and FB1-5 treatments opened at the same time during the latter stages of defoliation indicating no delays for harvest maturity.

Conclusions

The 2021-22 season data continued to show that compensation is rapid, with compensatory fruiting sites (excess to requirements) produced prior to the undamaged controls attaining cut-out. This largely explains why yield, lint quality and final maturity were mostly unaffected, particularly for the FB 1-5 treatment, which is indicative of pre-flowering square loss. Importantly, across every trial conducted since 2019, yield compensation has been attained without any alteration to agronomic management (as each trial site was managed as per the whole field, which was effectively represented by the control). The damage implemented at many sites was in addition to any insect damage that may have occurred.

Overall, the research has demonstrated that Bollgard® 3 varieties are well placed to achieve timely and effective compensation particularly following the loss of squares from the early branches (FB1-5). The complete square removal from these branches was extreme compared to the typical management target of 60-70% retention for this crop stage. Insecticide intervention for managing retention would therefore be best targeted towards the late square stage onwards as opposed to the early squaring period.

Acknowledgements

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