Causes of fruit loss from cotton: 1991/92 season.

Gary P. Fitt, Colin Tann and Debbie Richardson
CSIRO Cotton Research Unit
Narrabri

Cotton plants normally produce an excess of fruiting structures, many of which are lost early in development (Constable 1991). It is estimated that less than half the squares initiated can ever be matured; many of these are shed when very small. There are two major causes of square and boll loss: physiological shedding and various types of insect damage.

Physiological shedding occurs when the plant has insufficient nutrients to support the energetic demands of maintenance and development of all fruits. These energetic constraints mean that only a proportion of the squares initiated can ever develop to produce a mature boll. When nutritional demands from maturing fruits become limiting, young fruit will be shed. Hearn and Constable (1984) give an excellent account of the processes underlying physiological shedding.

Damage from insect pests is the other major cause of fruit loss. Cotton is susceptible to a range of insect pests and developing fruiting structures are particularly sensitive to damage. Fruits need not be totally eaten to be lost as components of yield. Squares need only be nibbled by a *Heliothis* larvae to flare and shed. Similarly a small feeding hole in the side of a boll can cause incomplete opening and loss of yield. Mirid bugs also cause fruit loss, particularly in areas of Queensland. Mirids pierce small fruits and suck the contents causing the whole fruit to be shed. They can be particularly damaging to pinhead squares, which blacken and fall. This type of damage can often go unnoticed.

The two processes of physiological shedding and insect damage are of course not independent. Insect feeding by reducing numbers of fruit can result in greater availability of photosynthate to others and increase their chances of maturing as bolls. Fruits removed by insect feeding may in fact have been shed anyway had they not been damaged. In this case insect feeding may have no significant impact on yield. Indeed in some situations insect grazing of fruits, particularly early in the season, may even be beneficial in stimulating overcompensation, resulting in higher yields than might have been possible without damage. Prolific fruit production is the basis of cotton's ability to compensate for damage, a process which has been central to pest management systems such as SIRATAC, and which has been extensively researched (Brook et al 1992). Despite this, there have been few studies in Australia which accurately identify the causes of fruit loss from cotton. In the 1991/92 season we started observations in both sprayed and unsprayed plots of different cotton varieties to record the numbers of fruit lost during the season and to identify the causes of shedding. The first years results are presented here.

Methods.

Experiments. Observations were made in two experiments at Myall Vale during 1991/92. Experiment 1 was a large scale trial where we imposed three levels of insect management on four cotton varieties in large replicated blocks. The management treatments were imposed using the entomoLOGIC package by modifying thresholds for *Heliothis*. Treatments were (1) standard thresholds (2 larvae/m), (2) half thresholds (1 larva/m) + Temic at sowing and (3) 4 x normal thresholds (8 larvae/m). Each treatment was replicated 4 times. Each experimental plot was 48 rows wide with a 60 row unsprayed buffer between treatments. Within each treatment plot there were sub-plots of four varieties (12 rows of each): Siokra L22, DP 90, Sicala 34 and N74-199B (an okra leaf/glabrous breeding line). Data was recorded only for Siokra L22 and DP 90.

Experiment 2 involved unsprayed small plots of 16 genotypes of cotton used in studies of insect pest resistance (see Fitt et al 1992). There were 4 replicates of each genotype (64 plots in all). Observations we made in 2 replicates of each genotype.

Collection of Squares. In Experiment 1 we marked a 10 metre length of row in each plot of Siokra L22 and DP 90; 24 x 10m rows in all (3 treatments x 4 replicates x 2 varieties). In Experiment 2 we marked a 10 length of row in each plot; 32 x 10 m rows in all (16 genotypes x 2 replicates). All freshly fallen fruits above 1 cm in size were then collected from the ground in the marked length of row at approximately weekly intervals between late December and late February.

As far as possible collections of fallen fruits were done immediately before irrigations to avoid fallen fruits being washed away. Note we did not collect **all** fallen fruits, only those which were freshly fallen, probably in the previous 1-2 days. Thus our data do not reflect total fruit loss over the season, but do show the seasonal pattern of loss.

Identifying Causes of Shedding. Each fallen fruit was examined for signs of damage and allocated to one of 3 categories: (A) - *Heliothis* damaged, (B) - mirid damaged or (C) - physiological shedding. Squares or bolls with visible feeding damage from *Heliothis* were allocated to category A. All remaining fruit were dissected to examine the state of anther tissues. Mirid feeding on squares produces a characteristic discolouration of the anther tissue. There may also be a darkened spot of the surface made by the mirid's proboscis as it penetrates the surface. Any fruits with no visible anther damage was allocated to category C, physiological shedding.

In practice we found very few fruits damaged by mirids (less than 5%) in the early samples of fallen fruits. In some cases this was because fruit contents were uniformly discoloured making it difficult to ascertain the cause of shedding. In addition we were unable to record the numbers of fallen pinhead squares which may have been damaged by *Heliothis* or mirids. In later samples we abandoned dissection of fruits and allocated any fruits without visible signs of *Heliothis* damage to physiological sheds. Hence in this paper we omit mirid damage as a category, but acknowledge that mirids may be a significant source of fruit loss in some situations and that we have undoubtedly underestimated their effects in these observations.

Results and Discussion.

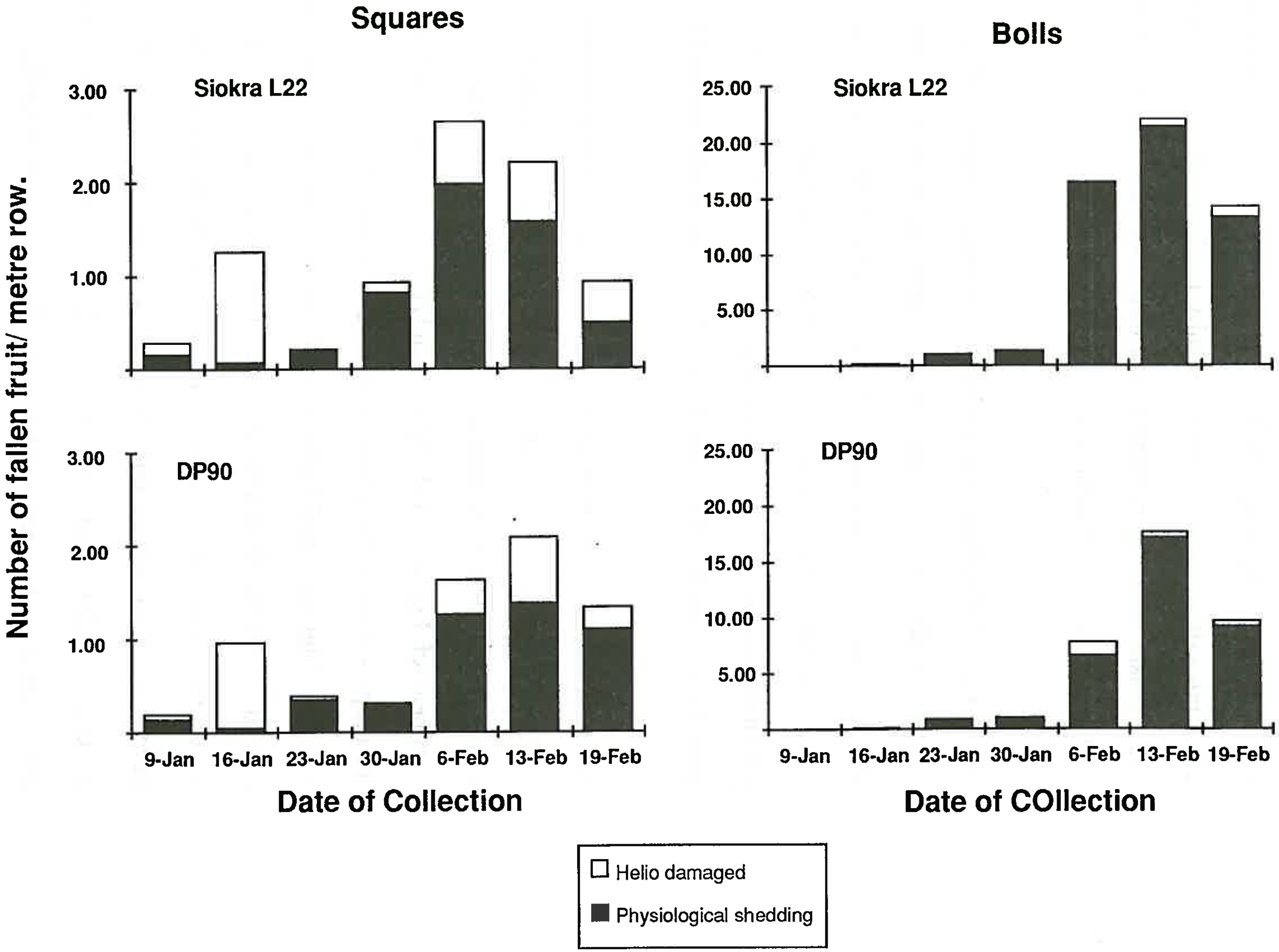
Experiment 1. Figure 1 shows the numbers of fallen fruit at each collection for Siokra L22 and DP 90 in the large scale experiment. Square loss peaked in early February and boll loss about a week later. Most fruit was lost as "bolls", peaking at 15-20 bolls/ metre row in mid-February, and most of these were lost either as "pink" flowers or small bolls less than 3 cm diameter. The majority of fallen fruits were undamaged. Overall the percentage of fallen squares damaged by *Heliothis* was 38.7% and 34.8% for Siokra and DP 90 respectively. For bolls the figures were 4.3% and 7.2% respectively.

Heliothis had damaged a significant proportion of fallen squares in mid-January (96% for both varieties) when a peak of egg-laying produced a significant peak of larvae which were not controlled adequately. During February, square damage ranged from 20% to 48% (these data are averaged over the three spray treatments). Further analysis will be necessary to unravel treatment differences. Average yields across treatments for the two varieties were 8.12 and 7.39 bales/ha for Siokra L22 and DP 90 respectively.

Experiment 2. Figures 2 and 3 show square and boll loss respectively for 7 selected genotypes grown under unsprayed conditions at Myall Vale which represent the major characteristics among those being examined. The selected seven are: Siokra 1-4, DP 90, OGF (an okra leaf, glabrous, frego bract breeding line), Glandless (a DP16 lacking terpenoid glands), HT smooth (a glabrous high tannin line), MHR11 (a multiple pest resistant line from Mississippi) and HG660 (a high gossypol line).

In this experiment, which was totally unsprayed, square loss was substantially higher than in the sprayed experiment, but boll loss reached similar levels. *Heliothis* damage to

Figure 1. Numbers of fallen fruit/ metre and the cause of shedding of squares and bolls for Siokra L22 and DP90 in large scale sprayed experiments, Myall Vale 1991/92.



fruits was also substantially higher (Figure 2 and 3). Table 1 shows the overall proportion of squares and bolls damaged by *Heliothis* and the total numbers of fallen fruits/m collected for all 16 genotypes (yield data for these genotypes is given in Fitt et al 1992). There was considerable variation between genotypes. Of the fallen squares the proportion damaged by *Heliothis* ranged between 35% (OGF) and 68% (HG063), while for bolls the range was 9% (HG065, OGF, N74) to 23% (Glandless). The level of pest resistance shown by OGF, N74, and some of the high gossypol and high tannin lines using this criteria is discussed more fully in Fitt et al (1992). Siokra 1-4 showed its characteristic heavy fruiting ability and shed more fruit than any other genotype, yet had the highest yield (11 bales/hectare, Fitt et al 1992).

These types of observations are valuable, but must be interpreted carefully. For example, we did not collect all fallen fruit, so it is impossible to say how many fruits in total were shed from each plot. Secondly, we could not adequately record fallen pinhead squares which may have revealed the true extent of mirid damage. Thirdly, many larger bolls in the unsprayed experiment were damaged to varying degrees by *Heliothis*, but were not shed. These bolls may have shown incomplete opening or been lost totally to boll rots.

Nevertheless our observations demonstrate the abilitiy of cotton varieties to tolerate insect damage. Despite the loss of many fruits several of these genotypes achieved accepatable yields (Fitt et al 1992). Although many more squares were shed in the unsprayed treatment (cf. Figure 1a and Figure 2) and *Heliothis* damaged 2-3 times as many bolls in the unsprayed as in the sprayed experiment (Siokra: 20.4% vs 4.3%, DP 90 14.7% vs 7.2%, cf. Figures 1 and 3) the total numbers of shed bolls were similar. Shed bolls peaked in both experiments in the week of February 13 at 12-20 bolls shed/metre. While we acknowledge that yields in small plots may be biased upwards and that there may have been some drift onto our unsprayed block these results clearly demonstrate that the genotypes suffered considerable fruit damage and are consistent with hypotheses of cottons ability to compensate for damage (Brook and Hearn 1992).

Table 1. Overall percentage of collected fallen squares and bolls which had been damaged by *Heliothis* larvae plus the total numbers of shed fruit collected for all genotypes under unsprayed conditions.

Genotype	Squares %	Bolls %	Total number of shed fruit collected/m
MHR 10	65.66	16.69	58.00
DP 90	63.85	14.67	60.95
HT - hirsute	54.25	12.82	64.10
MHR 17	58.20	18.24	72.75
MHR 11	64.23	18.37	74.70
HT 35	46.05	17.09	82.10
HG 660	50.27	11.36	85.40
OGF	34.85	9.33	89.65
HG 065	45.51	9.08	91.27
N74	60.28	9.93	92.15
Glandless	65.38	23.28	95.70
Sicala	65.65	17.86	96.55
HG 063	68.03	11.99	98.30
CS 8310	46.83	13.61	112.25
HT - smooth	37.18	10.86	116.90
Siokra 1-4	64.57	20.39	123.70

References.

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Figure 2. Levels of square loss and the major causes of loss for seven cotton genotypes during three periods of fruiting. Myall Vale 1991/92. Genotypes ranked by fruit loss. Note different axes for each period.

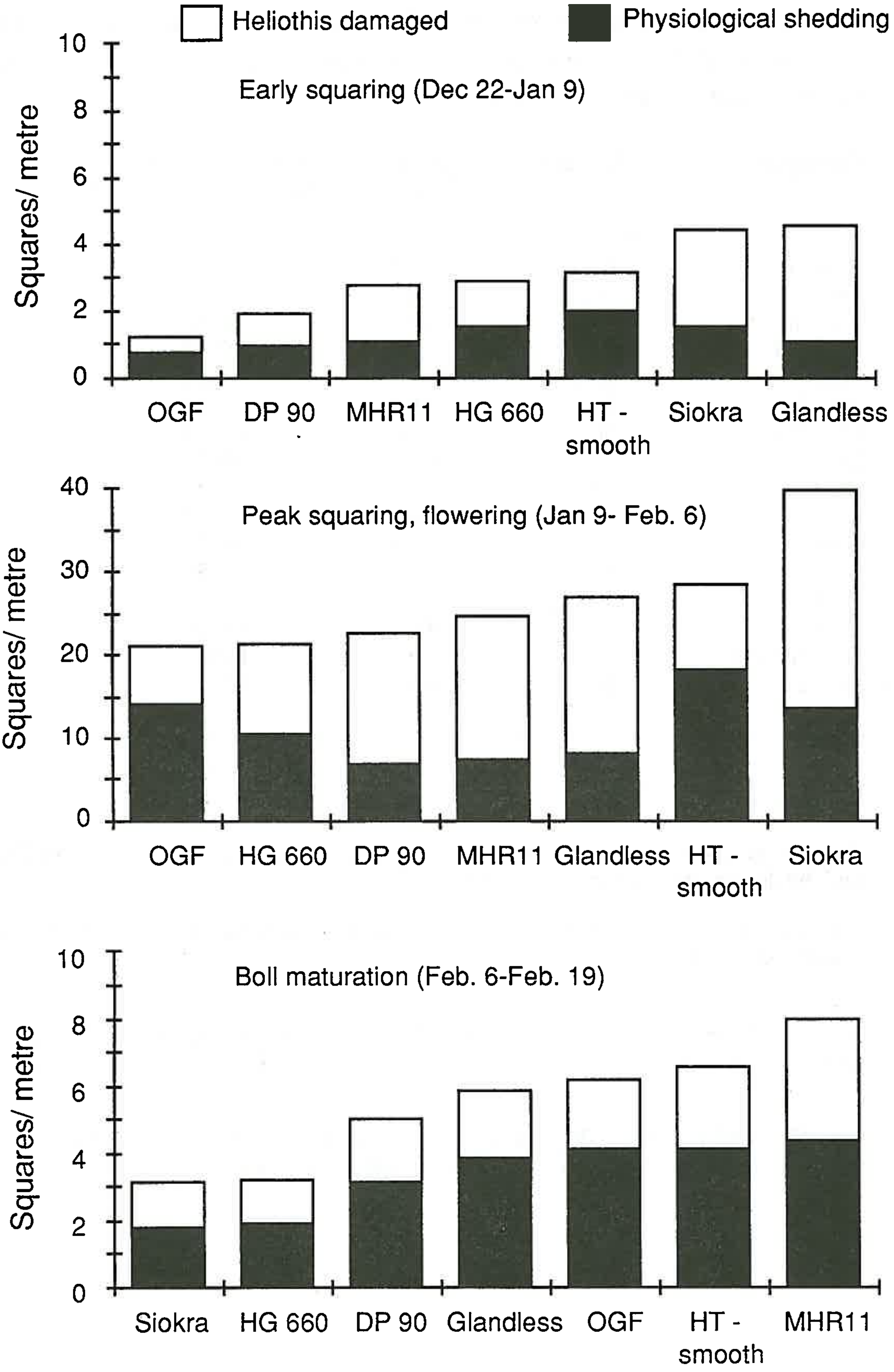

Figure 3. Levels of boll loss and the major causes of loss for seven cotton genotypes during three periods of fruiting. Myall Vale 1991/92. Genotypes ranked by fruit loss. Note different axes .