Research into Early Senescence Syndrome in Cotton

By Philip Wright

A nutritional disorder resembling the so-called premature senescence syndrome (which has affected cotton in the U.S.) has become quite common to Australia in recent years. The disorder is thought to be related to many factors that influence the supply and distribution of potassium (K) in the plant. Recent efforts by Australian researchers are providing new insights and management options.

Cotton field in eastern Australia shows premature senescence symptoms. Leaves near the top of the canopy turned red during early boll filling. Note how the edge row is unaffected.

Typical symptoms of premature senescence...area between veins turning red.

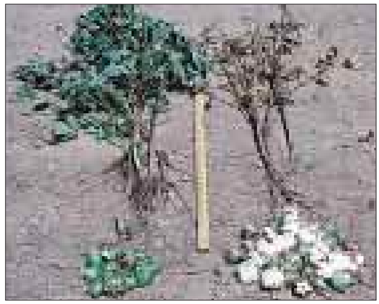
Cotton is grown on about 400,000 ha (one million acres) in Australia, mainly in New South Wales (NSW) and Queensland. While there has been some development of dryland production, the major portion of cotton is grown under flood irrigation within the latitudes of 24 to 32 degrees south. Crop yields are among the highest in the world, averaging over 6 bales/ha (3 bales/A). Individual fields have exceeded 12 bales/ha (4.5 bales/A).

The majority of Australian cotton is grown on highly fertile soils, classified as Vertisols, with very high levels of available K...more than 400 parts per million (ppm) K to depths of over one meter. Yet the disorder occurs in crops growing on these soils as well as on crops growing on low K soils. The "classical" symptoms of K deficiency usually occur first on the older leaves of the cotton plant. However, in the case of this problem, the younger leaves are the first to exhibit symptoms. The K levels in young leaves of affected plants are below the critical level of 0.9 to 1.2 percent K, and are often as low as 0.2 percent K. In some seasons the symptoms can be so severe that eventually the whole plant is defoliated.

This article discusses causes of this problem as related to the interaction of high boll loads and to K distribution in the plant.

Plants with or without symptoms of premature senescence within the same commercial field were compared for nutrient concentrations and plant growth. At each site at least five plants were sampled with or without the symptoms. Five different fields were used, all with available K levels in the soil greater than 200 ppm (ammonium acetate extract).

A cultivar with a reputation for high susceptibility (Siokra 1-4) was compared with a cultivar with reputed low susceptibility (Sicala V-2) at the Australian Cotton Research Institute near Narrabri NSW. A random-



Plants with premature senescence have much higher boll loads than other plants without premature senescence in the same field.

ized complete block design was used with four replicates. Dry matter was determined regularly (about two-week intervals) and the plants partitioned into different plant parts. These were analysed for K concentration using atomic absorption spectrophotometry, and uptake curves were derived for individual organs and the crop.

The effect of soil applied K was examined in a series of six experiments. Potassium (as KCl) was applied prior to sowing at 100 kg K/ha offset 5 cm from the plant line and at 20 cm depth. In a further series of experiments foliar applications were examined. Potassium (as KNO_3) was applied at 4 kg K/ha on four occasions, starting 7 to 10 days after first flower and then every 7 to 14 days. Each experiment was a randomised complete block with at least four replicates of each treatment.

It was found that the leaves of plants showing symptoms had about half the concentration of K and three-quarters the concentration of nitrogen (N) compared with the leaves of plants in the same field which did not show the symptoms, as shown in **Table 1**.

Table 1. Leaf N and K concentrations were dramatically lower in affected plants compared to healthy plants.

Leaves	Dry matter K content, %	Dry matter N content, %
Healthy plants	0.90	4.66
Affected plants	0.38	3.53
Significance	P<0.001	P<0.05

Plants which showed the symptoms had a far greater fruit load than plants that did not show any symptoms, even though there were only very small differences in the amount of leaf and stem tissue in each case (**Figure 1a**). Equally dramatic differences occurred in boll numbers with affected plants having about twice the boll numbers of unaffected plants (**Figure 1b**).

These large differences in boll load mean that the source/sink relationships of the plants in **Figure 1** are substantially altered. For example the ratio of boll mass to leaf mass in healthy plants was 2.7, while in affected plants it was much greater at 6.1. A further observation which highlights the importance of boll load in the early senescence syndrome is that the transgenic varieties carrying the Bt gene seem to be more susceptible to the problem. These varieties suffer less insect damage in their early stages, and so may be able to retain a greater percentage of their early fruit. Therefore, Bt varieties would carry a much higher early boll load than conventional varieties.

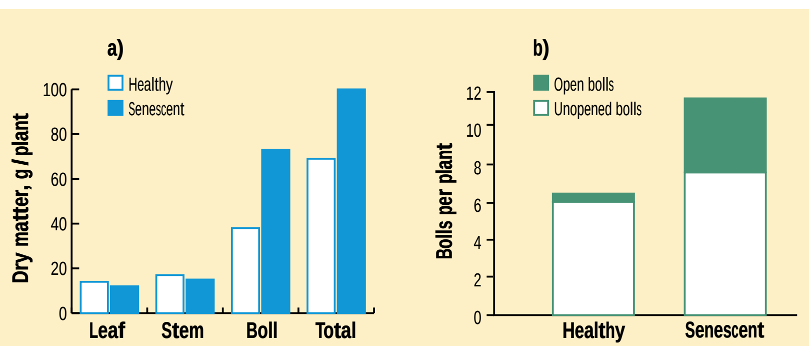


Figure 1. Dry matter a) and boll numbers b) were greater in plants with premature senescence than in plants without symptoms when compared in the same field.

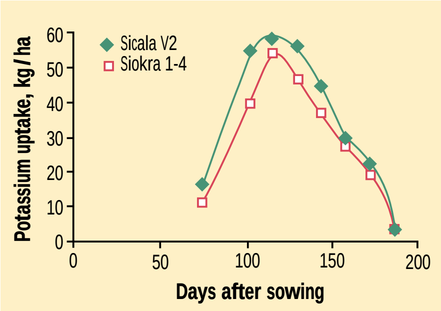


Figure 2. A non-susceptible cultivar (Sicala V2) stored more K in its leaves than a cultivar susceptible to premature senescence (Siokra 1-4).

Although there was little difference in the total amount of K taken up by non-susceptible and susceptible cultivars, there were quite significant differences in the way that they partitioned K.

The varieties compared were Sicala V-2, a non-susceptible variety, and Siokra 1-4, a susceptible variety. Both varieties took up similar amounts of K (207 and 202 kg K/ha respectively), at similar maximum rates of uptake (3.8 and 3.6 kg K/ha/day, respectively). However, Siokra 1-4 stored considerably less K in its leaves throughout the growing season than did Sicala V-2 (**Figure 2**).

Soil applied K fertilizer increased yield in only one out of six trials, and foliar applied K fertilizer increased yield in only one out of four trials, although there was a weak indication of increased yield in one other trial. In these trials, K application had little effect on fibre quality.

Conclusions

Premature senescence is becoming of widespread importance in the Australian cotton industry. While it appears to be connected with the supply of K, the reasons for it are not simple, and it can occur on soils with high or low K levels. Factors such as boll load, weather conditions, supply of phosphorus (P) and other nutrients, variety, and other conditions seem to be implicated. Transgenic varieties which carry the Bt gene seem to be more susceptible than the conventional varieties because of their higher retention of early fruit.

In some conditions, soil applied K fertilizer has led to increased yields. In other situations, foliar applied K has increased yields.

At this stage, good agronomy and choice of variety seem to be the most important management options available to growers to reduce the incidence of premature senescence. Thus, good irrigation scheduling and good field layout, both of which reduce waterlogging, will as a consequence also reduce premature senescence. Minimising soil compaction by carrying out tillage operations at appropriate moisture contents will have the added benefit of reducing premature senescence. The importance of K fertilizer, whether soil or foliar applied, is also likely to increase, especially as more transgenic varieties are planted, yields continue to rise, and the removal of K from the soil increases. BCI

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