PREMATURE SENESCENCE, POTASSIUM AND COTTON GROWTH

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Introduction

Premature senescence of cotton is a broad term describing defoliation and or physiological cut-out of the plant prior to the development of a desired yield. In truth there are as many causes of this as there are factors that can limit the growth of cotton plants, such as disease, soil compaction, nutritional deficiency etc. The term *premature senescence* is at present most often used to describe the symptoms occurring during potassium deficiency. As crops approach maturity, the upper leaves yellow between the veins, developing a thick felty texture and later, a bronze sheen, in severe cases upper bolls may become spongy. The leaves become very susceptible to the *Alternaria* leaf spot fungus and when cool moist conditions lead to infection widespread defoliation can occur. Most importantly, even before these symptoms become visible, bolls in the process of filling are deprived of potassium and yield is reduced along with quality characteristics such as length and uniformity. (Harden, 1992)

Premature senescence caused by potassium deficiency has been most severe on soils that are considered deficient or marginal in potassium for cotton growth ie. having a soil test result less than 0.4 meq K/100g (Kirby and Adams, 1985). There are other factors which can induce potassium deficiency in plant tissues such as heavy fruit load on small plants and plant uptake that is impaired for various reasons. These are the subject of current research by CRDC funded projects and will be discussed in other papers at this conference. This paper will focus on the question of soil deficiency.

Confusing symptoms

Two other conditions are commonly confused with potassium deficiency, Verticillium wilt, caused by the fungus *Verticillium dahliae,* and nitrogen deficiency. Both these conditions lead to a reddening and shedding of the upper leaves, verticillium however, is easily determined by splitting a stem which will reveal dark brown flecks in the vascular tissue. Late season nitrogen deficiency, leads to a more even yellow and red discolouration of leaves without leaving the veins green or developing a bronze sheen. In the USA (Ashworth et al.1982), have used high levels of potassium , (up to1000 kg K/Ha) to reduce the infection rate of Verticillium wilt in cotton, suggesting that this disease induces potassium deficiency. Its difficult to evaluate this under Australian conditions as our strain of verticillium is quite different to that in the US. and infection often appears without the symptoms of potassium deficiency. Researchers in the US cotton industry such as Tom Kirby have more recently downplayed the connection, commenting that the soils on which fertilising reduces infection are often potassium deficient to start with.

Potassium deficiency on low potassium soils

In the Emerald Irrigation Area there are a significant number of soils below the 0.4 meq K/100g threshold, and some scattered examples occur in other districts also. Experiments have been conducted over the last three seasons to determine if the critical level of this soil test is still relevant to our current high yields, varieties and practices, and at what level potassium fertiliser should be added to rectify deficiency.

Seven rates of pre-season banded potassium chloride (KCl) from 0 kg K/Ha to 500 kg K/Ha were compared in replicated plots at chosen sites of either adequate or apparently deficient soil potassium. The results of these trials are typical of those illustrated in

Figure 1. Yield response of CS50 cotton to bed applied potassium (KCl) on medium grey cracking clay, Emerald 1993/94

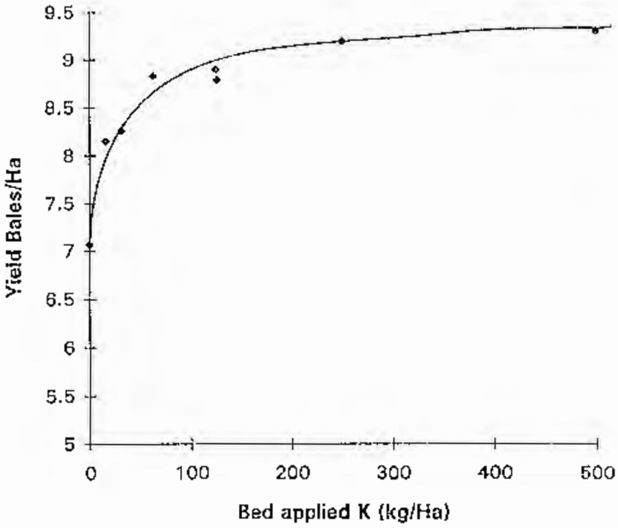


Figure 2. Yield response of DP90 cotton to bed applied potassium (KCl) on heavy black cracking clay, Emerald 1991/92

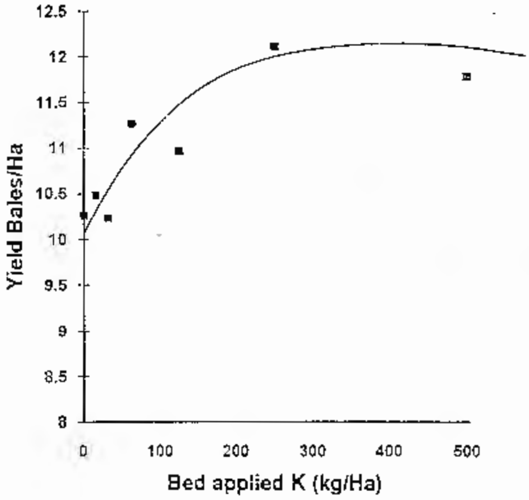
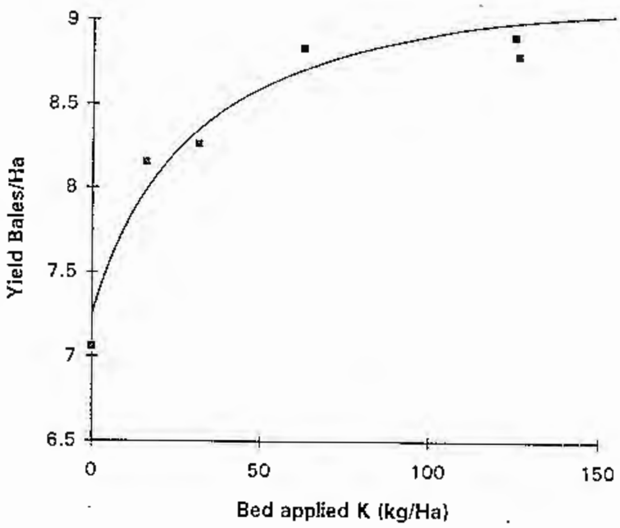


Figure 3. Change in soil test at first flower after potassium application (KCl) to heavy hlack cracking clay, Emerald 1992



figures 1 and 2 where two soil types with potassium deficiency are represented, the first a medium textured alluvial grey cracking clay (21 meq/100g cation exchange capacity with 0.12 meq K/100g), the other a heavy black cracking downs soil (45 meq/100g CEC with 0.22 meq K/100g). In both cases, untreated crops exhibited deficiency symptoms which were greatly reduced by the point where fertiliser application reached "critical level", where 90% of potential maximum yield was achieved. This rate of application was approximately 44 kg K/Ha (88 kg KCl) for the lighter soil (fig 1.) and 71 kg K/Ha (142 kg KCl) for the heavier soil (fig. 2). In figure 3 where soil tests from the side of bed are compared, this level of addition to the heavy soil gave a result of 0.28 meq/100g. This is close to the established critical level, but as fertiliser was applied in a band, soil test results are not as representative as might be found if soil were mixed thoroughly. While I have a small project under way that aims at doing this, Ivan McLeod of the University of New England, is currently involved in PhD studies which should provide information on K fertiliser reaction for the major cotton growing soils. Growers armed with such information will be able to add potassium to these soils and aim at raising K levels to a known point.

Banding or broadcast?

Work in the USA has suggested that there are no significant differences in plant uptake or use of the different forms of potassium fertiliser eg.chloride, nitrate, sulphate and so most work in Australia has centred on the cheapest alternative, KCl. For our heavy black/grey cracking clays this should be banded under the bed for greatest efficiency. Potassium is not highly mobile in clay soils and if dropped on the soil surface will be away from most of the roots capable of absorbing it which are between 10 and 30 cm deep (Brouder and Cassman, 1990). This is illustrated in table 1, where at the same heavy clay site as figure 2, 500 kg/Ha of potassium was spread across the surface of several plots and sampled at various depths. There has been some increase in potassium at depth but most fertiliser remains in the top five to ten centimetres.

Table 1. Potassium levels after broadcasting 500 kg K/Ha over scrub soil (0.22 meq K/100g, CEC 45 meq/100g) and rolling cultivation. First Flower, Emerald 1992.

Sample location	Depth	Exchange K(meq/100g)
Furrow	0-10	1.43
Side of Bed	0-5	1.31
	5-20	0.67
Centre of Bed	0-5	0.76
	5-20	0.45
	20-35	0.47

It' also worth noting that cotton roots do not grow toward areas of potassium concentration as they do for nitrogen and phosphorus, (Brouder and Cassman, 1993) therefore potassium will be more readily taken up if applied with or near N and P fertilisers.

Maintaining nutrient levels

Significant amounts of potassium are removed in lint at harvest, increasing along with yield. The amounts in table 2, are typical of international estimates and more precise information on losses in Australian growing areas is currently being collected by Phillip Wright from NSW Dept. of Ag. at Narrabri.

Table 2. **Removal of potassium in lint and seed**

Lint yield (bales/Ha)	K removed (kg/Ha)
7.3	35
10.2	42
10.7	58
11.1	58
12.1	65

That this nutrient export leads to reductions in soil potassium can be demonstrated. Several sites in the Emerald Irrigation Area have been monitored since the late 1970's (table 3.) and run down is evident in levels of both exchangeable K (most easily available for plant uptake) and non-exchangeable K (less available reserve). These sites have all had ten cotton crops between 1978 and 1990, during which no potassium fertiliser was added. The implications are that soil levels of potassium *will* drop in the long term and are worth monitoring. Once test levels fall below 0.3-0.4 meq/100g of exchangeable K, a fertiliser program which replaces harvest losses will be required.

Table 3. Long term change in potassium levels 0-10cm at Emerald 1978 - 1990

Site	Year	CEC	Non-exc K (meq/100g)	Exch. K
M1	1978	65	0.83	1.16
	1990		0.60	0.79
M2	1978	41	n/a	0.56
	1990		0.39	0.47
M3	1978	35	0.71	0.64
	1990		0.45	0.48

Future Directions

Foliar spraying and water run fertiliser are being evaluated as alternative potassium sources in cooperation with INCITEC. Results from two sites at Emerald suggest that foliar potassium nitrate may increase yields by up to 0.25 bale/Ha on top of an 8-9 bale/Ha crop even when soil levels are adequate.

As there also appears to be significant difference between the potassium uptake of different varieties, during the next twelve months I will be looking at the variation in root growth and temperature sensitivity of currently sown cottons.

Acknowledgments

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