Research Report:

Potassium responses observed in South Australian cereals

Research undertaken by the South Australian Research and Development Institute.

Potassium (K) deficiency is not currently recognised as a problem in the dryland cropping regions of South Australia. However, the National Land and Water Resources Audit published in 2001 reported that the region had a highly negative K balance (ie. much more K is exported off-farm in produce than is replaced in fertiliser). Recently it has become apparent that, on some soil types, poor growth of cereal crops may be attributable to K deficiency. In 2002 the South Australian Research and Development Institute (SARDI) established an experimental site on a farmer's field near Laura in the mid North region of South Australia. Severe K deficiency was confirmed in these trials, with wheat yields increasing from 500 kg/ha to more than 2500 kg/ha with the application of at least 50 kg K/ha of K fertilisers. Grain quality was also improved through a reduction in screenings, but extra N was required to maintain protein levels with the increased grain yields. Current critical diagnostic criteria for plant tests of 23-24,000 mg/kg in youngest fully emerged wheat blades appeared to be appropriate for South Australian conditions. Responses in wheat were recorded at soil test values (Bicarbonate extractable (Colwell) K) well above the 50-60 mg/kg required for normal wheat production on the sandy soils of Western Australia.

The experimental site was located on an undulating field with a duplex soil (sandy loam topsoil over a clay loam to clay, calcareous subsoil) and an average annual rainfall of 470mm. Three field trials were established on the site:

1. K rate response
2. NxPxK interaction, and
3. K application method.

There was variation in soil chemical properties across the whole experimental site, so soil samples were collected from each individual trial area and are presented in Table 1. Wheat was no-till sown on the site in June and harvested in December 2002. The 2002 season was particularly dry, with total rainfall being less than decile 2, however growth of wheat in the trials appeared quite vigorous in the high K treatments. The best treatment at the site yielded 2.78 t/ha, which was 102% of the yield potential as calculated using the French and Schultz model (French and Schultz, 1984).

Table 1. Soil chemical properties measured from each of the trial areas at the Laura experimental site.

Parameter	Rate Response Trial		Application Trial		NxPxK trial	
	0-10 cm	*10–20 cm*	*0-10 cm*	*10–20 cm*	*A horizon*	*B horizon*
Water pH	7.3	8.1	6.2	6.8	6.6	8.0
Colwell K (mg/kg)	45	46	121	53	42	69
Colwell P (mg/kg)	27	17	25	16	16	5
Nitrate N (kg/ha)	20	11	11	6	4	3
Sulphur (mg/kg)	12	11	14	7	6	23
Exchang Ca (meq/100 g)	5.8	8.5	4.9	5.8	4	11.6
Exchang Mg (meq/100 g)	0.5	0.5	0.4	0.7	0.4	1.7
Exchang Na (meq/100 g)	0.10	0.08	0.10	0.06	0.04	0.09
Exchang K (meq/100 g)	0.13	0.07	0.08	0.14	0.11	0.18
Walkley-Black organic carbon (%)	1.4	1.0	1.6	1.0	0.9	0.7

Rate Response Trial

This trial received basal applications of 56 kg/ha N, 20 kg/ha P, 15 kg/ha S and 1 kg/ha Zn. Eleven rates of K (between 0 and 150 kg/ha) were applied as muriate of potash (MOP) drilled under the seed row at planting.

Figure1. Wheat at tillering grown with 0 (left) and 100 kg/ha K.

Establishment was not affected by the rate of fertiliser K applied. Early growth was poor on plots without K fertiliser, with plants being paler, weaker and poorly tillered compared to those grown with a high rate of K fertiliser (Figure 1). Dry weight of shoots at tillering increased markedly with K. Without K, shoot dry weights were only 190 kg/ha but increased to more than700 kg/ha with high rates of K fertiliser. The K concentration of the youngest emerged leaf blades (YEB) at tillering also responded, with maximum dry weight of shoots not obtained until YEB K concentrations were approximately 2%, consistent with published critical values for wheat. The concentration of Cu, Zn, Mn and B in YEB were largely unaffected by rates of K, but the concentration of all other nutrients increased where plants were stunted by K deficiency. This was especially true for Ca, Mg and Na, for which concentrations increased by 0.8, 1.7 and 15 times respectively from the 150 kg/ha K to nil treatments.

Grain yield was severely affected by K deficiency in this trial. Plots without K yielded less than 500 kg/ha on average, while high rates of K increased yields to more than 2000 kg/ha (Figure 2). While high rates of K were necessary to maximise grain yield, even 5 kg/ha of applied K doubled yield compared to the nil treatment. A Mitscherlisch fit of grain yield against rates of applied K estimated that 33 kg/ha K (66 kg/ha MOP) were necessary to achieve 90% of maximum yield.

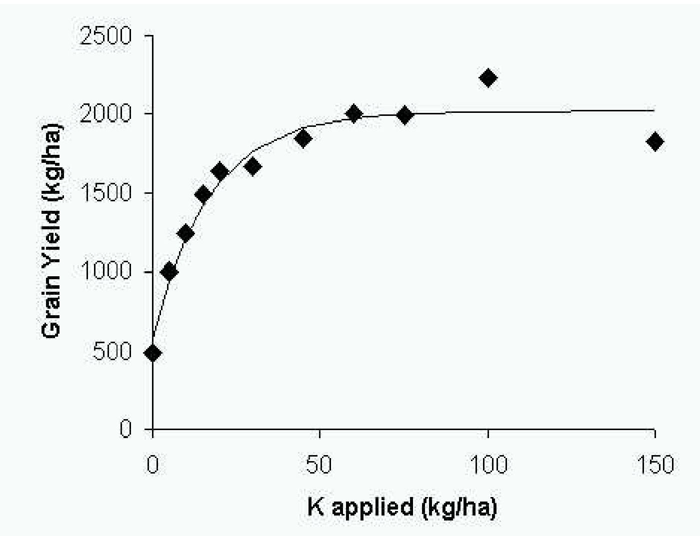

Figure 2. Grain yield in response to K application in the rate response trial.

The rate of K had little impact on grain protein and the average for this trial was 9.6%, suggesting that the 56 kg/ha N applied was barely sufficient for normal growth and yield of wheat.

The proportion of grain passing through a 2mm sieve (or screenings percentage) increased at K application rates that resulted in very low yields (less than 20 kg/ha K), which suggests that grain yield is more sensitive to K deficiency than grain size. Screenings with no added K averaged nearly 12%, but fell to less than7% where 20 kg/ha or more K was applied (Figure 3). Wheat delivered to the silo system in 2002 with more than 10% screenings would have been downgraded to feed grade, rather than the APW grade, which this variety normally qualifies as.

Application of K at seeding had no effect on the concentration of K in grain with an average of 0.45% across the trial.

Given on-farm wheat prices in 2002 of $210/t for APW grade grain, application of K fertiliser at $450/t would have been highly economical, even at rates above those required for 90% maximum yield. Assuming grain from all treatments had made APW grade, table 2 indicates the gross income from grain, the value of K fertiliser applied, the net income after K fertiliser costs and the return per K fertiliser dollar invested. In this year, net income per hectare was maximised at 100 kg/ha K.

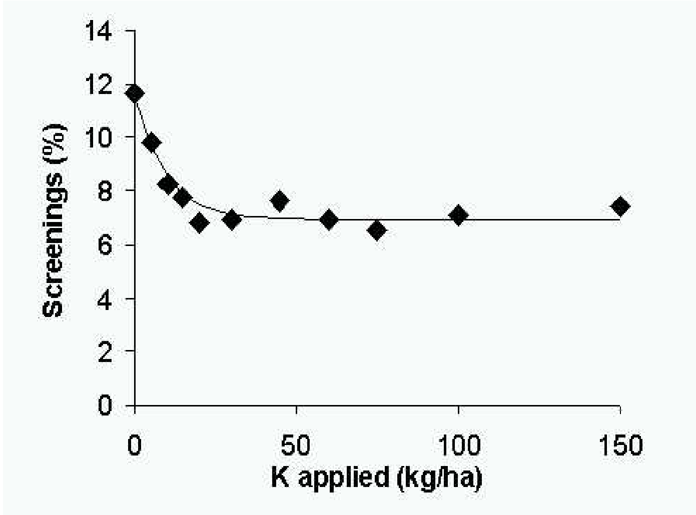

Figure 3. Grain screenings percentage in response to K application in the rate response trial.

Table 2. The economics of K application at the Laura site in 2002.

K Rate (kg/ha)	Gross Income ($/ha)	K Fertiliser Cost ($/ha)	Net Income after K Fertiliser ($/ha)	Return on K Fertiliser ($ gained/$ spent)
0	96	0	96	
5	214	5	209	25
10	269	9	260	18
15	314	14	300	15
20	351	18	333	13
30	352	27	325	8
45	396	41	355	6
60	429	54	375	5
75	422	68	354	4
100	468	90	378	3
150	387	135	252	1

NxPxK Interaction Trial

This was a split-plot trial with one of five N+P fertiliser combinations (15N + 10P, 15N + 20P, 56N + 10P, 56N + 20P and 112N + 20P) making up main plots and K applied to sub plots at 0, 50 or 100 kg/ha K as MOP drilled below the seed at planting. This trial also received basal S and Zn applications.

Shoot dry weight increased markedly with K fertiliser applied at 50 kg/ha, but doubling the rate of applied K caused no further increase in shoot weights. A similar response was measured for grain yield (Figure 4). Unfortunately, no plant data was available for K

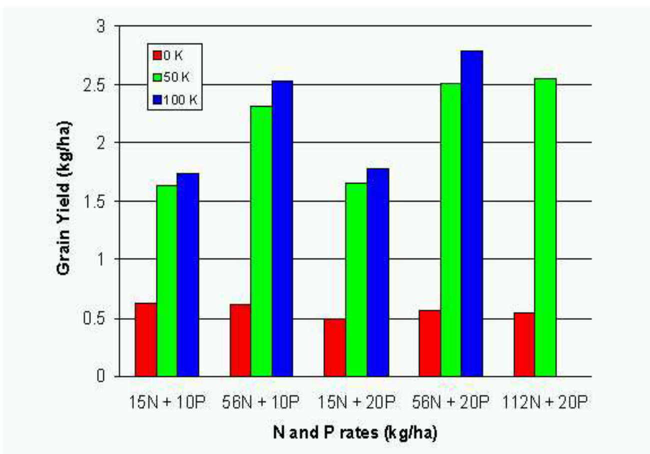

Figure 4. Grain yield response to the application of K at various N and P rates.

applied at 100 kg/ha with the highest rate of N application. Increasing rates of N or P did not improve shoot weights or grain yield unless K had also been applied.

The concentration of K in the YEB at tillering also responded to K application. Without added K, YEB concentrations were very low (1.2% or less). On the other hand, all plots receiving K had YEBs above 2%, except for those with the highest N application (1.9%). This may suggest that 50kg/ha were not sufficient K where N had been applied at the highest rate.

In this trial, grain protein decreased where K was applied, presumably due to a dilution of the available N over a larger grain yield. Increasing the rate of applied N resulted in higher protein content, and P application rate had no effect. The lowest grain protein in the trial (8.9%) occurred with low N low P and the highest K rate, whereas the highest grain protein (12.7%) occurred with the highest rates of N and P and 50 kg/ha of K.

Application Method Trial

This trial received the same basal nutrient applications as the rate response trial. Potassium was applied as MOP either drilled below the seed at planting (11 kg/ha K or 50 kg/ha K), broadcast prior to seeding (50 kg/ha K), broadcast at tillering (50 kg/ha K) or a split application drilled at seeding and broadcast at tillering (25 + 25 kg/ha K)

Establishment was not affected by any of the application techniques used. By tillering shoot dry weights and K concentration in the YEB were higher where K had previously been applied. Broadcast K at tillering was applied onto dry soil and little rain fell for the next 4 weeks, during which time MOP granules were still evident on the soil surface.

Banding 50 kg/ha of K below the seed at planting resulted in the highest grain yield of 2000 kg/ha. Banding produced 320 and 840 kg/ha more grain than the same rate of K either broadcast before seeding or at tillering, respectively (Figure 5). The split application was almost as effective as the same amount of product all banded at seeding. Grain yield was 1000 kg/ha where no K was applied, which was double the yield of plots without K in the other two trials, presumably due to the inherently higher soil K in this part of the experimental site.

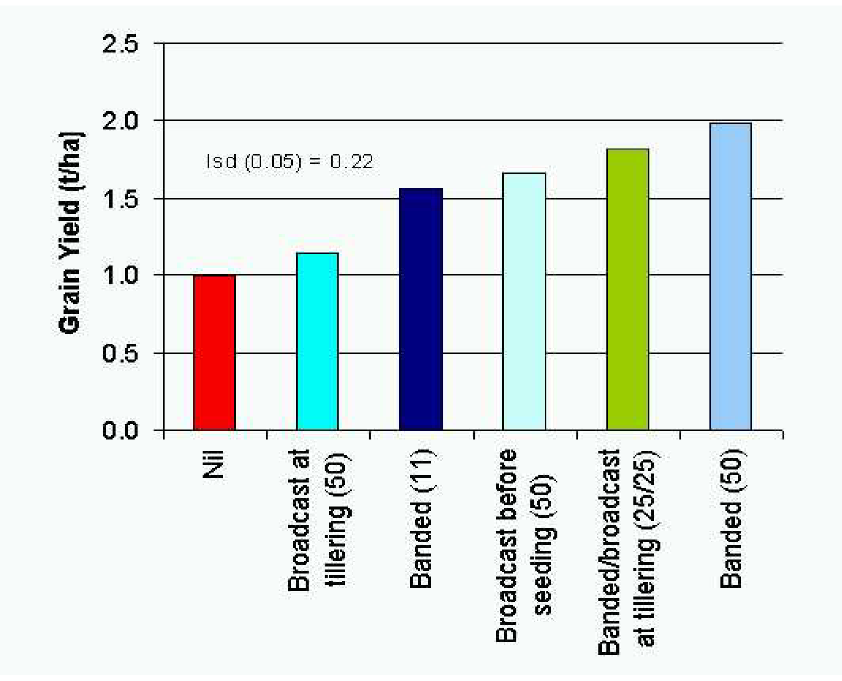

Figure 5. Grain yield in response to application technique.

Conclusions

Severe K deficiency was confirmed in these trials with yield and grain quality markedly improved by the application of K as MOP. Wheat grown without K had a sufficiently large percentage of small grains that the sample would have been downgraded to feed grade had it been delivered to the silo system.

In these trials, rates of at least 50 kg/ha of K were necessary to fully correct K deficiency and produce maximum grain yield of acceptable quality. However, the basal rate of N used (56 kg/ha) was insufficient to avoid N deficiency, as demonstrated by low grain protein, and so a higher rate of K may have been required if adequate N was supplied.

Tools for diagnosing K deficiencies include soil and plant analysis and identification of visible plant deficiency symptoms. In these trials, plants deficient in K were weak, pale, had few tillers and showed signs of chlorosis on the tips and margins of older leaves. In some ways, these symptoms could be confused with other conditions including N deficiency, root disease or sulfonylurea herbicide damage. Wheat in soils with levels of up to 120 mg/kg of Colwell K responded markedly to K application, suggesting that critical levels for K may need to be revisited. On the other hand, it appeared that published critical values for K concentration in the YEB at tillering were consistent with responses observed in this trial.

Banding K fertiliser below the seed row at planting was the most effective application method, while broadcasting at tillering was poorly effective, partly because of dry weather for a long period after application.

Results from these trials suggest that K deficiency is a distinct possibility in the grain cropping regions of South Australia, that deficiencies may go unrecognised for many years and that responses to applied K fertilisers can be highly economical.

Further Information

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