Developing a better understanding of determining potassium requirements in cereal cropping in the central wheatbelt of Western Australia.

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Abstract

The application of potassium fertiliser for cereal crops has come under increased scrutiny by growers in the central wheatbelt of Western Australia. Growers are becoming frustrated at not being able to have a clear diagnostic measure from the standard soil testing services on offer that give them certainty that applying K will show a yield response in cereal crops.

During the seasons of 2003 and 2004, the Kellerberrin Demonstration Group conducted a number of field trials to investigate potassium rate responses in wheat and barley crops. These initial investigations raised a series of questions about the adequacy of standard soil tests to indicate whether a crop response to K would be valid.

In 2005, a comprehensive series of trials were conducted to establish whether or not, and under what circumstances, wheat crops would respond to an application of potassium (drilled and/or top-dressed). Detailed soil sampling to 2-m depth was also conducted at a number of these sites. The results indicate that the effectiveness of applying K depends on the soil properties, moisture relations and rooting depth of the crop.

Key Words

Potassium, cereal crops, nutrition, soil moisture.

Introduction

Potassium is one of the four major nutrients required by plants (White, 2000). After many years of agriculture, soils of the central wheatbelt of Western Australia are beginning to indicate an insufficient supply of K to crops. This has become increasingly noticed as cropping has intensified over the last 10 to 15 years (Edwards, 1998). Traditional surface-soil testing often suggested that critical levels for K occurred at about 40 ppm and that there may be a link to increased cereal leaf disease incidence in marginal K conditions (Edwards, 2000). There is now some thought that this level may need to be higher.

The requirement for cereal crops to have potassium fertiliser has come under increased scrutiny by growers in the central wheatbelt of Western Australia. More intense cropping, greater yields and a higher incidence of leaf disease have meant an increased attention to the adequacy of K in cereal crops. However, grower's observations of the standard measure of marginal levels of K from using soil testing services were not delivering consistency in indicating responsiveness of soils to applied K that could be relied upon by growers. This gives mixed messages as to the value of applying K to crops in a climate of generally increasing costs of inputs such as fertiliser but declining monetary returns for product, and shrinking profits.

In 2003 and 2004, the Kellerberrin Farm Demonstration Group conducted a number of on farm research (OFR) activities to investigate potassium rate responses in cereal crops using farm scale machinery. These initial investigations raised a series of questions about the adequacy of standard soil tests to indicate whether a response to K would be valid. Soils indicating marginal K levels were not producing responses to applied K. Based on this work, the group members investigated in more detail in 2005 the reasons as to why responsiveness to applied K was not occurring where indicators were suggesting that there should be a response to applied K.

Methods

Initial investigations in 2003 and 2004

In 2003, a simple replicated 'strip' test of 6 rates of K (0, 5, 10, 12, 25 and 50 kg/ha) within a paddock indicating marginal K levels (36 ppm) was conducted. This was followed in 2004 in greater detail with eight trials being conducted (4 wheat and 4 barley). These trials were of a randomised block design of 4 rates of Muriate of Potash (MOP @ 0, 25, 50 and 100 kg/ha) top-dressed before or at seeding. Plot length was 100 m. In both years, some sites were selected based on soil tests while others were based on prior knowledge.

Detailed investigations 2005

In 2005, a suite of 4 detailed trials were conducted on wheat. Two had MOP topdressed as like in 2004. The other two sites had half rates of MOP drilled away from the seed at sowing. Treatments were replicated 3 times in a randomised block layout. Plots were 150 m in length. More detailed soil testing of the sites was conducted through the assistance of CSIRO working on a complementary project with the growers. This delivered detailed soil analysis at depth at 3 of the sites (Sites 1, 2 and 4) for soil K (Colwell) and estimates of plant available water content (PAWC) from gravimetric analysis of intact soil cores taken prior to and during the season in April and September respectively. Tissue test measurements of whole tops through a commercial analysis service (CSBP) were made during the season prior to booting.

In all years the centre of each plot was harvested and the grain measurements performed using a calibrated weigh trailer. Grain sample from each plot were taken to Cooperative Bulk Handling (CBH) for analysis at industry standards of receival. Regression analysis using Genstat v7 was conducted on the data.

Results

Initial investigations in 2003 and 2004

The 2003 investigation gave no clear response to applied K. While the greatest grain yield was from the highest rate of K applied, there was no clearly defined response of any significance ($p>0.05$) to be observed. Similarly, in 2004 all 8 sites indicated low to marginal levels of K at depth (topsoil: 0 – 10 and subsoil: 10 – 20 cm). While some trends indicative of increasing yield and quality were noticed at some sites, there seemed to be little clear evidence of significant ($p< 0.05$) responses to applied K as MOP from regression analysis of the results.

Detailed investigations 2005.

A brief description of the four sites is given in Table 1. All sites indicated low to marginal K levels in both the top and subsoil. Plant tissue tests show K levels not to have been critical at the nil or applied rates of K (Edwards, 1998) and indicate general responses expected with applied K. Site 3 had the lowest K levels in the nil-K treatment.

Table 1. Potassium status of the soils and plant test results taken in August for each K treatment in 2005.

	Soil Test K	Plant tissue test K (%K)

Site	(mg/kg)		Top-dressed K in kg/ha.			
	Topsoil (0 – 10 cm)	**Subsoil (10 – 20 cm)**	**0**	**25**	**50**	**100**
Site 1. Sand over clay loam	67 Marginal	63 Marginal	4.05	3.68	3.94	4.30
Site 2. Sand over sandy clay loam	60 – 65 Marginal	45 – 50 Low	2.96	2.64	3.96	4.27
			Drilled K in kg/ha.			
			0	**12.5**	**25**	**50**
Site 3. Sand	39 – 66 Low - marginal	43 – 66 Low - marginal	2.44	2.38	2.63	2.86
Site 4. Sand	38 Low	43 Low	2.53	2.73	2.89	2.70

Deep soil analysis beyond the depths of the initial soil testing shows that at Sites 1 and 2, K levels increase considerably with depth (Fig 1). Both these sites were duplex soils. In contrast, the more uniform sandy soil, site 4, had a consistently lower levels of K in the profile, and K levels decreased with depth at 0-80 cm.

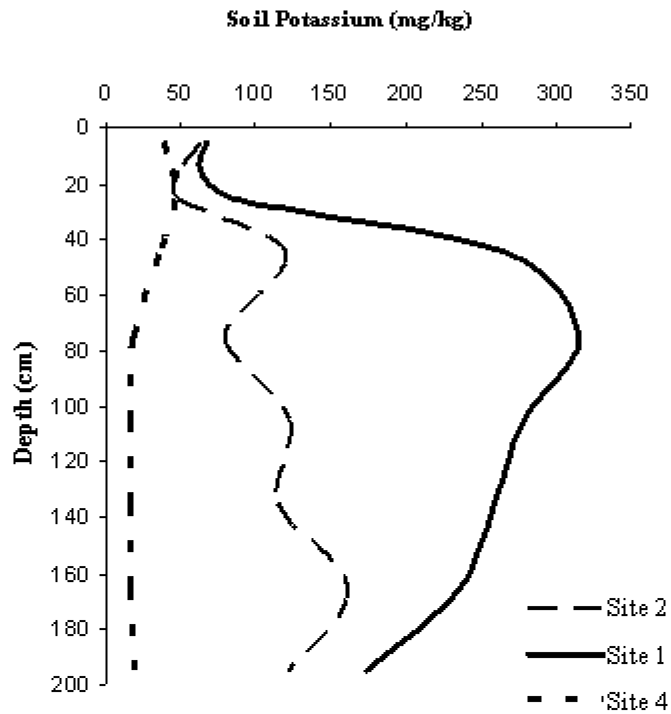

Figure 1. Potassium concentration in soil profiles for 3 of the 4 sites in 2005. Courtesy of CSIRO.

Harvest measurements for the sites are shown in Table 2 below. Only at one site (3) was there a positive yield response to applied K ($p<0.05$). Yield increases were seen at Sites 1 and 2 to some extent. It was also only at site 3 that differences in grain protein content responding to higher levels of applied K were found to be significant ($p< 0.05$). The level of grain screenings were found to increase significantly ($p<0.05$) with increased applied K at Site 1. This is not what a grower would prefer to find. Nevertheless, the levels of screenings are so low as to have any economic impact. While at Site 3 screenings reduced with applied K. Little else in conclusive responses to applied K can be detected in the data.

Table 2. Grain yield and grain quality of the 2005 wheat crop in response to applied potassium at the sites described in Table 1.

Site	**K rate** (kg/ha)	**Yield** (kg/ha)	**Protein** %	**Grain weight** (kg/hl)	**Screenings** %
1	**0**	3450	11.3	83.0	0.8
	25	3420	11.1	83.1	0.8
	50	3467	11.1	82.6	1.4
	100	3507	11.0	82.7	1.5

	l.s.d (5%)	257	0.3	0.6	0.4 *
2 (Frost affected)	**0**	652	12.1	82.9	2.2
	25	731	12.6	83.1	2.6
	50	751	12.5	83.8	2.2
	100	711	12.3	83.5	2.3
	l.s.d (5%)	174	0.2	0.5	0.5
3	**0**	2077	9.6	82.7	2.3
	12.5	2247	9.4	82.8	2.0
	25	2403	9.4	83.5	2.1
	50	2367	9.5	83.4	1.7
	l.s.d (5%)	70 *	0.1 *	0.4	0.5
4	**0**	3373	9.3	81.0	1.9
	12.5	3260	9.4	81.2	1.6
	50	3323	9.4	81.2	1.8
	100	3327	9.3	81.3	1.8
	l.s.d (5%)	256	0.2	0.4	0.3

* indicates $P \leq 0.05$ noted in regression analysis.

Soil moisture profiles at three sites were measured during 2005prior to seeding in April and during the season in September (Fig 2). Plant available water to 1.2-m depth has been calculated as 105, 72 and 52 mm for Sites 1, 2 and 4, respectively, and 155, 133 and 87 mm to 2.1-m depth, respectively.

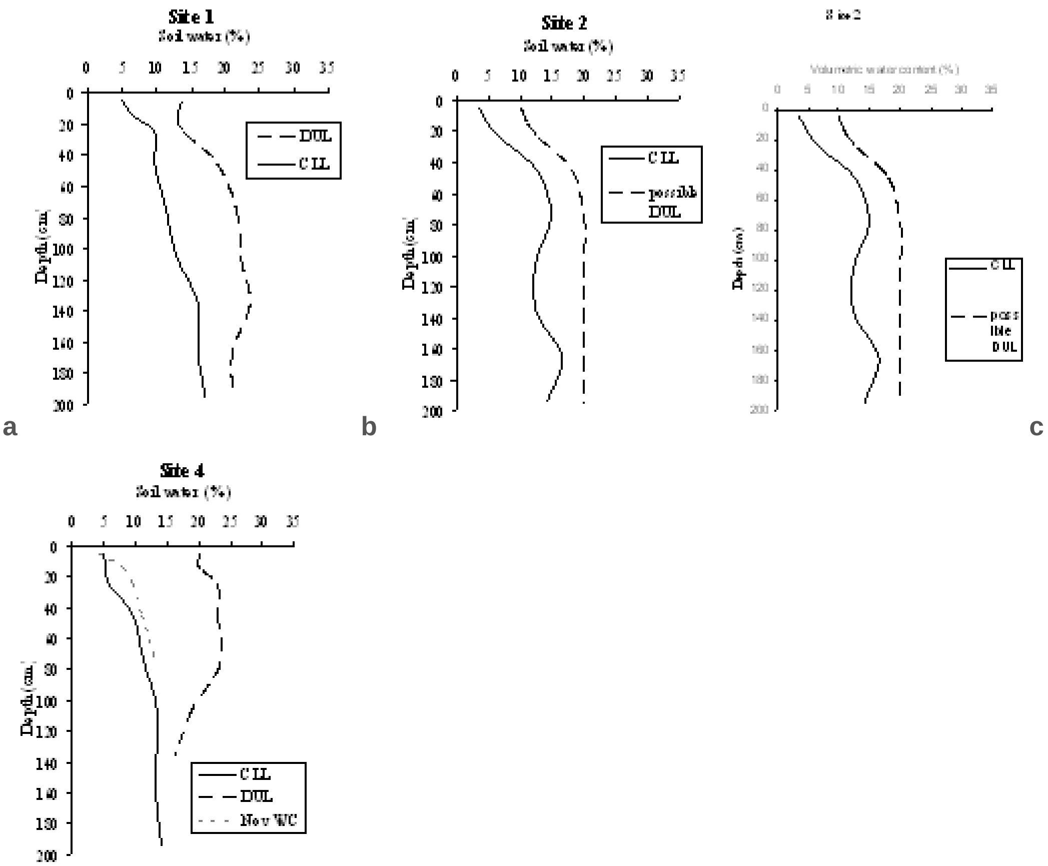

Figure 2. Soil moisture characteristics of three of the sites studied. Courtesy of CSIRO. DUL: Drained upper limit, CLL: Crop lower limit of extraction, WC: Water content

Conclusion

From a growers' perspective these results are disappointing as the 4 sites all indicated from the standard soil test results to be likely to respond to an application of K, yet only Site 3 displayed this to any degree. This is in keeping with the previous two years of observations. Defining K responsiveness through the use of current soil testing methods is not a reliable or consistent measure for growers.

There may be two factors that are confounding the interpretation of indicators for applying K. The first is that soil testing is often only to 20 cm and this may not be deep enough to give a clear diagnosis of the supply of K to the crop from the soil. The deep soil analysis (Fig 1) shows that at Sites 1 and 2 there existed large reserves of K at depth which the crop may have been able to access during the season. These were duplex soils and the ability to readily access K may also be impacted upon by other physical and chemical constraints. Crop roots have been able to access to this depth at Site 1 (Fig 2a) and this was probably the case at site 2. Hence with an adequate supply of K to the crop no clear response to applied K was forthcoming. It is most likely these sites will not be K responsive for a while as long as crop roots can penetrate into the subsoil with its increasing K status during the course of the season.

Sites 3 and 4 were sandy soils and as Figure 1 shows for Site 4, the already low levels of K continue to decline with depth. This type of profile may have also been in existence at Site 3. We do know that Site 4 was a deep sandy soil to depth and that in a season like 2005, adequate moisture can be made available to a reasonable depth. Given the kind season which had average to slightly above growing season rainfall, the crop may have been able to extract adequate K for its needs down through the depth of soil its roots were able to explore. This may not be the case in a drier season with a more limited depth of rooting for the crop.

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