Adapting crop species on grey Vertosols in North West NSW to compensate for high chloride levels in the subsoil.

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Abstract

High subsoil salinity and chloride concentrations are considered to be the main subsoil constraints restricting winter crop production in the northwest zone of NSW. The impact of subsoil salinity on productivity and profitability of a range of winter crop species and varieties was compared using paired sites. That is crop production was measured at two sites where the limitation was considered to be either unconstrained or constrained.

The order of decreasing impact of sub soil salinity was barley>bread wheat=durum wheat>oilseeds>grain legumes. Best returns at Bellata came from barley with an average yield of 5.24t/ha and a gross margin of $686/ha on the unconstrained site, which was 0.73t/ha and $124/ha more than at the nearby constrained soil. Bread wheat averaged 4.34t/ha with gross margins of $478/ha on the unconstrained site which was 0.59t/ha and $98/ha more than the constrained soil. Faba bean (only 2005 grown at Bellata) yields of 4.76t/ha declined to 3.27t/ha on constrained soil, but the gross margins of $469/ha were still $120/ha better than chickpea in the same year. Subsoil constraints reduced average chickpea yields from 3.07t/ha to 2.05t/ha and gross margins from $623/ha to $260/ha. Gross margins for canola were below both the cereals and pulse crops but were least affected by subsoil constraints and may offer other rotational benefits. Canola yields averaged 1.76t/ha. Production and profitability results from Garah showed similar trends between species on constrained and unconstrained sites as at Bellata.

This year's winter crop results will help to fine tune our recommendations for all the crops trialled.

Key Words

Subsoil constraint, farming system, chloride, cereal, pulse, oilseed

Introduction

Water is the most limiting resource in dryland farming systems of the northwest slopes and plains of New South Wales. Stored soil water is a critical component of crop water use and production in most winter seasons. Inherent physical, chemical or biological soil properties in the subsoil can constrain plant water uptake thus limiting productivity and profitability, particularly when in-crop rainfall is scarce. Once the specific or dominant constraint is identified, crop species choice can be based on knowledge of their relative performances under conditions of limited availability of stored water. In severe cases, an enterprise shift from cropping to extensive grazing, or a combination of the two may be warranted.

Vertosols make up the majority of irrigated and dryland cropping soils in north west NSW (Daniells *et al* 2002, Dang *et al* 2006). Several studies have identified significant chemical subsoil constraints, including high subsoil salinity, chloride toxicity, and sodicity as being important factors limiting crop production on the Vertosols of North West NSW (Daniells *et al* 2002; Dang *et al* 2006; Dalal *et al* 2002; Irvine and Doughton 2001). These soils create substantial challenges for developing and managing sustainable farming systems. The aim of this component of the project is to aid in the development of farming systems that minimise the risk of financial losses in moderately to highly constrained soils.

Methods

The productivity and profitability of a range of winter crop species and varieties was compared at paired unconstrained and constrained site trials at Bellata (near Narrabri) in 2004 and 2005 (on sites that were on different locations in 2004 and 2005 but on the same farm) and Garah (near Moree) in 2005. The trials were co-located on unconstrained and constrained soils on the same farm. Treatments in 2004 consisted of 7 winter crop species (and cultivars) barley (Binalong, Grout, Gairdner, Mackay and Fitzroy), bread wheat (Baxter, Lang, Strzelecki, Sunstate and Sunvale), durum wheat (Bellaroi and Wollaroi), canola (Ripper and Rivette), mustard (Mickey and Kaye), chickpea (Howzat and Jimbour) and field pea (Boreen and Yarrum). 2005 consisted of 11 winter crop species (barley, bread wheat, durum wheat, chickpea, field pea, faba bean, lentil, canola, mustard, linseed and safflower) and at least two cultivars were used for most species (barley cvs. Binalong, Grout, Gairdner, Mackay and Fitzroy; bread wheat cvs. Baxter, Lang, Strzelecki, Sunstate and Sunvale; durum wheat cvs. Bellaroi and Wollaroi; chickpea cvs. Flipper, Jimbour and ICCV; field pea cvs. Boreen and Yarrum; faba bean cvs. Cairo and Fiord; lentil cvs. Digger and CIPAL; canola cvs. Ripper and Rivette; mustard cvs. Mickey and Kaye; linseed cv. Glenelg; and safflower cvs. Gila and #555). Trials were sown in a randomised block design with three replicates. Plots were 12m long by 2m wide. Planting rates used were in line with district best practice and soil tests were used to calculate nutrient budgets and fertiliser application rates for each site. All crops were well managed with no significant weeds, pests, diseases or nutrient deficiencies experienced. However, some plots were damaged by emus prior to harvest and some oilseed plots suffered some shattering loses prior to harvest.

Plant available water-holding capacity (PAWC) was determined for each trial site as the difference between soil moisture contents measured under drip irrigation (drained upper limit) and rain exclusion tents set up on additional plots of wheat cv Baxter (crop lower limit) (Dalgleish and Foale 1998). Soil water use was monitored in each plot using a neutron moisture meter. Soil chemical characterisation of each site was done on composite samples taken across each trial site using standard laboratory methods for saline alkaline soils. Given that the soil profiles at both sites both contained naturally occurring gypsum, salinity is better represented as soil chloride than electrical conductivity (EC). Data analysis was carried out with the ASREML statistical program for varieties, species and trial sites.

Results

Soil Characterisation

Plant available water capacity (PAWC) of wheat cv. Baxter was 111 mm (to 90 cm) at Garah Bad, 201 mm (to 170 cm) at Garah Good, 97 mm (to 130 cm) at Bellata Bad and 171 mm (to 190 cm) at Bellata Good. The lower results from Bellata may reflect the extreme sodicity in the subsoil at this site (Figure 1a). Moisture extraction under the rain exclusion tent was similar to that in the uncovered plots at the bad sites, indicating that the crops grown in the plots were exploring the soil to the limit of their tolerance to the constraints.

Soil profile distribution of chloride concentration (Cl) for each of the sites is shown in Figure 1b. Chloride levels at Garah were up to 2940 mg/kg at 140cm depth in the constrained (bad) and 1560 mg/kg at 180cm depth in the unconstrained site. These numbers are much higher than seen at Bellata: 694 mg/kg in the unconstrained (good) and 947 mg/kg at the constrained (bad) site. Other workers on this project have determined a tentative threshold for soil chloride of 600 mg/kg, when root growth in some species is restricted (Yash Dang, *pers.comm*). This threshold was exceeded at Bellata constrained (bad) site at 70 to 90cm depth, and 150 to 190cm depth in the unconstrained (good) site, whereas the Garah constrained (bad) site exceeds the threshold at 30 to 50cm and the Garah unconstrained (good) site at 90 to 110cm depth.

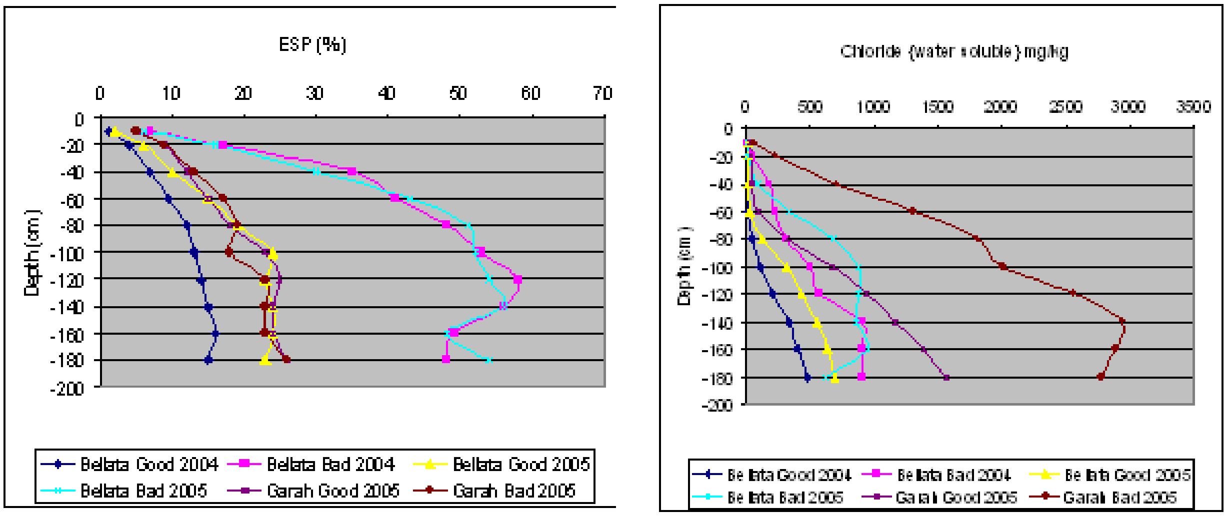

Figure 1. Soil profile distribution of (a) Exchangeable Sodium Percentage (ESP%), and (b) chloride at Bellata measured in 2004 and 2005 and Garah measured in 2005.

Production and Profitability

Yield results from Bellata (2004 and 2005) and Garah (2004) (Table 1) show that for the majority of species yield declined from the unconstrained to constrained site. Barley showed a yield reduction of 12-16% from the unconstrained to the constrained site. Bread wheat had a range of 11-16% yield decline at Bellata. At Garah, an apparent 29% yield increase was due to emu damage at the good site prior to harvest. The oilseeds suffered a lower yield penalty over the two seasons at Bellata and one season at Garah with ranges of 7-15% for canola and 5-18% for mustard. The legumes were most affected by the constraint with chickpea yields declining by 26-40%, field pea 33-41%, faba bean of 24-31% and lentil 55-83%.

Table 1. Average species yield at Bellata 2004 and 2005, and Garah 2005.

	Yield (t/ha)					
	2004		2005			
	Bellata		Bellata		Garah	
Species	unconstrained	constrained	unconstrained	constrained	unconstrained	constrained
Barley	5.98	5.07	4.50	3.95	4.17	3.48
Wheat Durum	2.58	2.09	4.45	3.29	3.21	2.67
Wheat Bread	4.45	3.96	4.23	3.55	2.22*	2.87

Chickpea	2.84	2.10	3.30	1.99	1.22#	0.86
Faba bean	*Not sown*	*Not sown*	4.75	3.27	2.21	1.67
Field pea	2.10	1.24	2.54	1.69	1.43	0.92
Lentil	*Not sown*	*Not sown*	0.97	0.44	1.62	0.26
Canola	2.20	2.02	1.46#	1.36#	1.33#	1.13
Mustard	2.06	1.95	1.48^	1.33^	1.19	0.98
Linseed	*Not sown*	*Not sown*	0.99	0.88	0.48@	0.71
Safflower	*Not sown*	*Not sown*	2.36	2.57	1.74	1.25

* Varieties Lang, Strzelecki and Flipper were damaged by emus prior to harvest
# One variety (Ripper) shattered prior to harvest
^ One variety (Kaye) lodged prior to harvest
@ Glyphosate drift on some plots

Looking at the percentage difference in gross margin of growing each crop on an unconstrained soil versus a constrained soil (Table 2), barley has a range of 15-21% profit decline. Durum wheat has a range of 24-37% penalty, and bread wheat when emu damage is excluded was 19-21%. When looking at productivity alone the yield decline of canola and mustard is minimal, however looking at gross margins the penalty for growing these crops on a constrained soil range was 17-111% and 22-47%, respectively. The grain legumes excluding faba beans suffered the greatest decline in gross margins; chickpea 46-201%, field pea 33-104% and lentil (one year only) 136-180%. Faba beans gross margins declined by 42-55% on the constrained soils.

Table 2. Average species gross margin in $/ha for Bellata 2004/05 and Garah 2005.

	Gross Margin $/ha					
	2004		2005			
	Bellata		Bellata		Garah	
Species	unconstrained	constrained	unconstrained	constrained	unconstrained	constrained
Barley	726	577	646	548	588	464
Wheat Durum	298	224	577	362	346	246

Wheat Bread	358	281	599	480	246[*]	360
Chickpea	503	270	744	250	38[#]	-38
Faba bean	*Not sown*	*Not sown*	812	469	227	101
Field pea	68	45	367	173	112	-5
Lentil	*Not sown*	*Not sown*	104	-84	450	-162
Canola	136	-15[#]	159	132[#]	122[#]	68
Mustard	351	200	240[^]	185[^]	146	77
Linseed	*Not sown*	*Not sown*	110	139	-88[@]	29
Safflower	*Not sown*	*Not sown*	525	593	334	182

* Some varieties (Lang, Strzelecki and Flipper) damaged by emus prior to harvest
# One variety (Ripper) shattered prior to harvest
^ One variety (Kaye) lodged prior to harvest
@ Glyphosate drift on some plots.

These results have important implications for farming systems on vertosols in north west NSW. Farmers and advisers need to look at underperforming paddocks, determine the existence of any subsoil constraint, and the nature and severity of the constraint. Growers and advisers then need to determine the level of reduced production potential that they can afford to accept on a constrained soil when compared to an unconstrained soil. Preliminary findings from this project are demonstrating that an opportunity farming system including barley, wheat (bread and durum), and sorghum on wide rows (Spencely *et al* 2005) may be the best option for highly constrained soil. Pulses are an important component of northern rotations. Despite the generally poor performance of pulses relative to other species, chickpeas remain profitable on the moderately constrained Bellata site. At Garah which has higher concentrations of chloride closer to the surface faba beans are still reasonably profitable. Pulses provide free nitrogen to the system and this should be accounted for in the gross margin when necessary. Planning a rotation in areas with a subsoil constraint also needs consideration of nematodes and especially crown rot disease management as constrained subsoils are more likely to be water stressed post anthesis unless there is good late season rainfall. Pulse and oilseed crops in rotation with cereals are an important part of the rotation, especially in reducing the amount of crown rot inoculum in the system (Simpfendorfer *et al* 2006). Opportunity cropping also becomes more important on soils with reduced “effective depth” since crops only dry the upper part of the profile which can refill with rainfall much faster than an unconstrained soil.

Conclusion

Economically viable cropping on soils where the subsoils constrain root exploration needs careful consideration of species selection. Our results have shown that while yields in constrained areas are less than in nearby unconstrained areas, many of these crops can still be profitable and may confer additional rotational benefits not quantified here. It is important for the farmer to identify areas with constraining subsoils and know the reduced “effective soil depth” and reduced production potential to properly appreciate the financial risks of cropping those areas. For example, knowing you have only 90 cm of potentially usable soil compared to 170 cm will influence fallow length and seasonal outlooks will have an even greater impact on crop choice than normal.

PAWC needs to be ascertained in paddocks with subsoil constraints to aid farmers and advisers develop a rotation suited to the paddock. The PAWC for Baxter wheat on the bad sites at Garah 111mm and Bellata 97mm gives an indication of production risk for wheat at these sites. For example if the profile is full and the seasonal outlook is for average to above average rainfall production risk is low, however if the profile is only half full and the seasonal outlook is for below average rainfall then production risk could be considered as high. Once a PAWC has been ascertained for a number of species growers will to be able to reduce production risk by matching crop choice with PAWC and seasonal outlook. It is important to know the amount of rainfall that is required to refill soil profiles of both constrained and unconstrained soils to determine fallow length.

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