Tillage and gypsum to address a surface soil constraint

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Abstract
Soil sodicity, acidity and formation of hardpans have been identified as constraints to productivity on the western plains, NSW. Information is available on the identification, cost of the constraint and potential management strategies. Surface crusting was identified as a constraint limiting the infiltration of rainfall reducing the opportunity to store water during the fallow. A field experiment was established near Nyngan to examine the effect of current farm practice and surface applied gypsum (2.5 t/ha) along with deep tillage +/- gypsum on profile water storage during a fallow period and two crop cycles. Water storage in the 120-cm profile was the same for current practice and the gypsum treatment and significantly lower for the tillage (20 cm) +/- gypsum throughout the two cropping seasons (Chickpea followed by wheat): 127, 123, 75 and 111 mm of water for the control, surface gypsum, tillage and tillage + gypsum, respectively. There were no significant differences in yield, water use or crop water-use efficiency between treatments for both crops. Gross margin analysis showed a loss for all treatments in the first season and a small profit for the second season. The benefit of the treatments need to be assessed over several seasons due to variability between growing seasons.

Keywords
Wheat, chickpea, profile water, gross margin.

Introduction
The Central West Farming Systems group (Evans and Fettell, no date) highlighted the major subsoil constraints of the region and potential management strategies, however the advice provided has not been widely adopted. Dear et al. (2005) reported strategies for managing heavy sodic clay soils of the Bland region where not all soils responded to gypsum application, response only occurred where exchangeable sodium was greater than 6 % in the surface soil and while deep ripping (40 cm) removed a compacted layer the layer reformed rapidly under grazing and traffic. Information to manage soil acidity of NSW soils has been provided by Upjohn et al. (2005), however little information on the extent of acid soils in western NSW is available. Land and soil capability classes have been developed by the Central West Catchment Management Authority (2008a) to aid growers in determining best management practices, where land classes are rated from 1 to 8 (these are largely based on position in the landscape, ranging from flat ground to steep slopes). Each class is rated for degree of limitations for cropping or pastoral productivity; such as salinity, sodicity which can be managed using current accepted practice. Sodic soil management practices have also been provided to growers (Central West Catchment Management Authority 2008b). A constraint not identified in previous studies is surface crusting limiting the infiltration of rainfall reducing the opportunity to store water during the fallow.

This study assessed the hypothesis that surface applied gypsum, deep tillage +/- gypsum would improve rainfall infiltration and increase, in the short and long-term, stored profile water for the subsequent crop.

Methods
A field experiment was established near Nyngan after collecting soil samples for chemical analysis from 10, 30, 60, 90 and 120 cm to determine whether subsoil constraints were present. A soil dispersion test indicated that the soil readily slaked and dispersed. A randomised block design with three replicates of each treatments was laid out. Plots were 24 m wide by 200 m long to accommodate the growers equipment. This enabled two or three passes of a spreader to apply gypsum at 2.5 t/ha, a chisel with narrow tines to deep rip to 30 cm and to incorporate surface applied gypsum with the control being current farm practice of stubble retention and direct drill planting. Multi-depth soil moisture sensors and loggers were installed after treatment application. These recorded soil moisture (mm) at 10, 30, 50, 70 and 90 cm every three hours. A tipping bucket rain gauge was also installed on site. The chickpea variety Hatrik and wheat variety Gregory were planted in 2014/15 and 2015/16, respectively. Crop yield was recorded using the header yield monitor.

Results were analysed by ANOVA with a significance level *P* < *0.05* using Genstat v16, 2013.

Results

Soil analyses at the initial sampling indicated no subsoil constraints (Table 1). The profile water storage differed between the treatments with the control ~ gypsum > gypsum + tillage > tillage during the chickpea and fallow, and with the control > gypsum/gypsum + tillage > tillage during the wheat phase (Figure 1). Gaps in the data were due to logger damage by sheep and time taken to get replacements.

Table 1. Soil chemical properties at the initial sampling in Nyngan. Units are mg/kg unless specified.

Depth cm	pH CaCl	Ec dS/m	Cl	NO_3	NH_4	P	Ca	K	Mg	Na	CEC	OC %	ESP %
0-10	6.3	0.1	9.0	9.0	28.0	25.0	7.7	1.1	1.1	0.1	10.0	0.8	1.0
10-30	6.4	0.1	9.0	5.6	18.3	9.0	8.7	1.0	1.1	0.1	10.9	0.5	0.7
30-60	6.9	0.1	9.0	2.3	7.8	6.3	9.3	1.0	2.0	0.1	12.4	0.3	0.6
60-90	7.3	0.1	9.0	3.4	7.1	6.0	9.5	1.4	3.4	0.2	14.5	0.2	1.4
90-120	5.9	0.1	10.0	0.5	2.2	6.0	6.3	1.0	4.9	0.7	12.9	0.1	5.5

Table 2. Agronomy for each crop and season at Nyngan.

	Chickpea/Hatrick	Wheat/Gregory
Plant date	10/5/2015	3/5/2016
Plant rate (kg/ha)	60	30
Germination (%)	90	95
Depth (mm)	75	30
Row spacing (mm)	300	300
Fertiliser (kg/ha)	35 (MAP)	70 (MAP)

Table 3. Crop establishment (plants/m^2, yield (t/ha), water use efficiency (WUE) (kg/ha/mm) and gross margin ($/ha) for various treatments at Nyngan (ns, not significant).

	Establishment		Chickpea		Wheat		Gross Margin			
	Chickpea	Wheat	Yield	WUE	Yield	WUE	Chickpea	Diff	Wheat	Diff
Control	9.4	21	1.10	9.0	2.92	8.3	513		255	
Gypsum	9.3	19.7	1.14	9.9	2.90	7.4	507	-6	272	+17
Tillage	11.0	21	1.03	7.8	2.97	7.5	462	-51	272	+17
Gypsum+Tillage	10.6	19	1.14	9.9	3.06	8.2	468	-45	287	+32
LSD (*P<0.05*)	1.1	ns	ns	ns	ns	ns				

The agronomy for each crop and season used by the grower is shown in Table 2. There was a significant difference in chickpea establishment with the tillage treatments being higher than the control and gypsum alone (Table 3), this however did not result in a yield or water-use efficiency benefit (Table 3). No significant differences were found between the treatments for the following wheat crop (Table 3). Gross margin analysis indicated a loss in the first season due to the extra cost in applying the treatments, however in the following season a small benefit occurred (Table 3). The extent of the benefit depends largely on the price for the commodity grown. Also, the two seasons were quite different with little in-crop rain for the first and considerably more during the second season (Figure 1).

Tillage significantly reduced profile water storage, both alone and in combination with gypsum; it was speculated that the induced surface roughness might provide increased infiltration and that the gypsum might stabilise the soil against slaking thereby also allowing better infiltration.

Conclusion

In the short-term tillage would not be a recommended strategy to improve surface infiltration. However, there may be a benefit in controlling resistant weeds and thereby indirectly improving profile water storage. Surface applied gypsum did not differ from current practice with respect to profile water storage although a benefit may accrue in the longer term. The application rate was economically acceptable to the grower under the current seasonal conditions, a greater benefit may result from higher application rates. A longer term study is required to accommodate seasonal differences.

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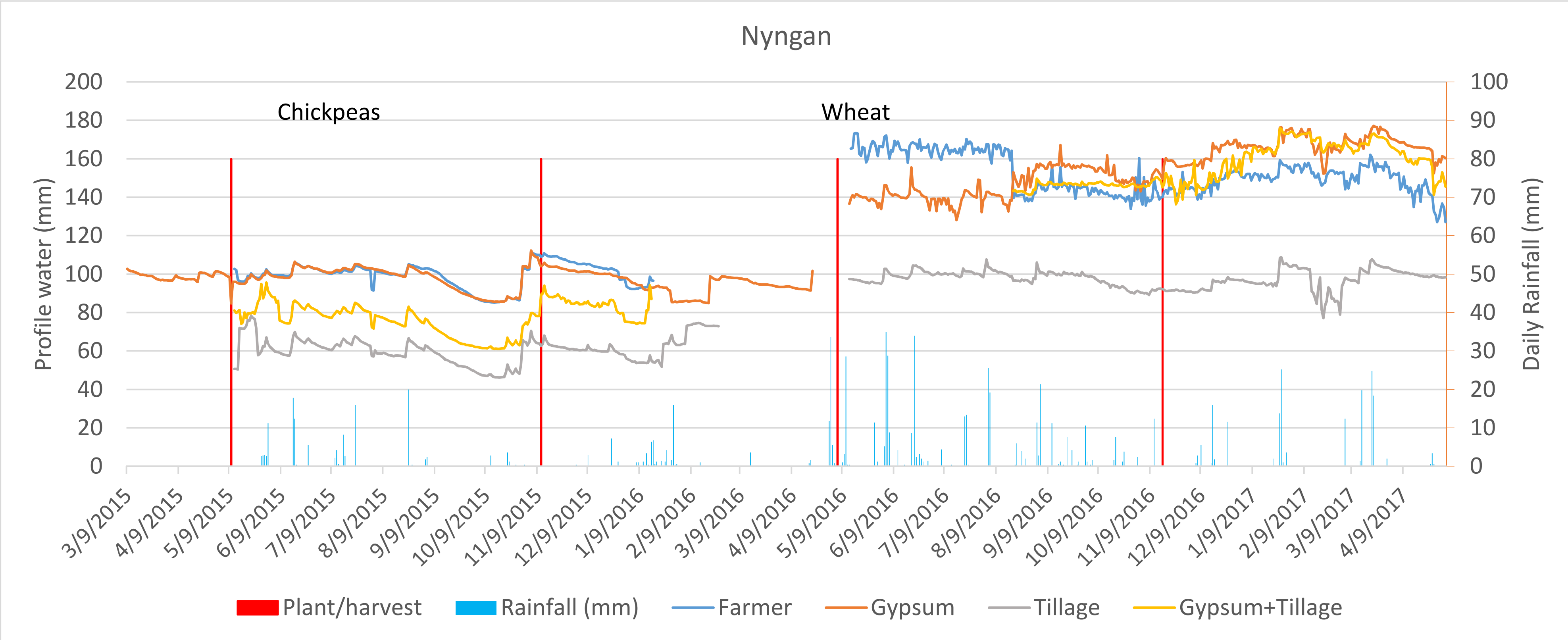

Figure 1. Water storage (mm) in 120-cm soil profile for fallow and two cropping cycles (2014/15, 2015/16) at Nyngan.