Non-cracking clay amendment of yellow acid sand to improve soil physical and chemical properties

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Key messages

- Improved soil physical-chemical properties were evident in a light -textured acid sand mixed with a heavy-textured soil. Growers need cost-effective ways to amend acid sands affected by aluminium toxicity and it may be possible to do this by adding clay to sands.
- Amendment of light-textured soil with heavy-textured soil reduced soil aluminium toxicity and increased soil organic matter, pH and total cation exchange capacity.
- Amelioration of acid sandy soils with alkaline clay, in combination with appropriate management regimes, may potentially minimise the soil constraints and increase soil productivity.

Aims

Subsoil constraints cost Western Australian growers more than $600 million per year in lost production. Acidity is on the major subsoil constraints to grain production on light-textured soils due to aluminium (Al) toxicity and nutrient disorders. These reduce root depth and function to the extent that water and nutrient levels can be insufficient to sustain production, particularly in areas with low rainfall. Often it is difficult for growers to confidently identify and manage constraints within a limited farm budget. One approach for the improvement of constrained soils that is gaining popularity is to use locally available soils of contrasting characteristics as ameliorants. For example, alkaline clays might be used to ameliorate sands affected by acidity and Al toxicity.

The aim of this study was to evaluate the effects of different soil mixtures to improve knowledge of soil properties and develop better ways of managing subsoil constraints.

Method

In May 2015, two soils were collected from the Central Wheatbelt of Western Australia. These were an acid yellow sand (Wodjil sand) collected from a site (Lat. -31.502649˚; Long. 118.647482˚), approximately 50 km south-east of Merredin, and a grey non-cracking clay (Heavy soil) collected from a site (Lat. -31.505045˚; Long. 118.212590˚) at Merredin Research Station (Paddock 3c). After collection, the soils were air dried for 5 days, passed through a 2mm sieve, and stored at room temperature before use. Soil physical and chemical properties were analysed by the CSBP laboratory in Perth.

A glasshouse experiment was conducted to test the effects of a range of mixtures of acid yellow sand and grey non-cracking clay on the growth of wheat (Emu Rock). The experiment was grown in a controlled environment (~20°C) without additional nutrient supply. A series of pots were used to evaluate the effects of different mixtures on soil properties and plant growth. Soil water content was measured at different stages using a hand-held TDR probe. The wheat shoots were harvested 42 days after seeding, oven dried at 70°C and their dry biomass was recorded. In all procedures, 3 replicates were used.

Results

There was considerable variation in particle size distribution between the two soils. The acid sand was comprised primarily of coarse sand particles, and the non-cracking clay was comprised primarily of clay particles (Table 1).

Table1: Particle size distributions of soil samples used in this study.

Particle size distribution	Acid yellow sand	Grey non-cracking clay
Coarse sand (2.0-0.2mm)	81	31
Fine sand (0.2-0.02mm)	6	14
Silt (0.02-0.002mm)	1	15
Clay (< 0.002mm)	11	40

Clay-textured substrates can hold more water than coarse-textured substrates (Pathan *et al.* 2003). Incorporation of clay into the sand therefore increased soil water-holding capacity (Figure 1). For example, addition of 10% (w/w) non-cracking clay to the sandy soil increased the volumetric water content by 18% measured 3 days after saturation.

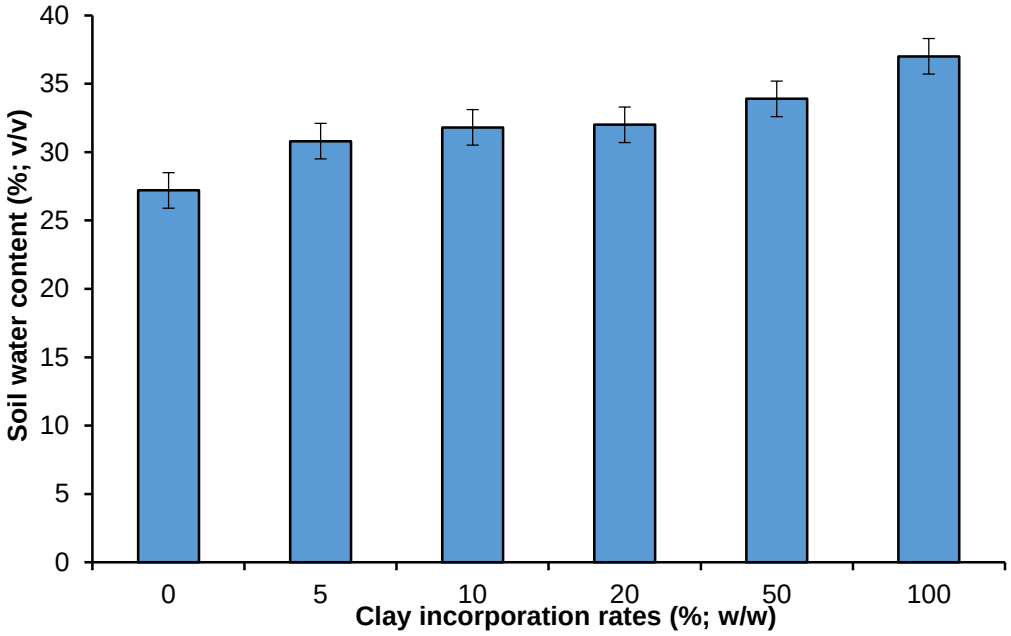

Figure 1: Effect of incorporation of grey non-cracking clay on soil water content (%, w/w) in the acid yellow sand measured 3 days after saturation. Values are the mean of 3 replicates and error bars are the SEM.

Table 2 shows the variation in a range of measured soil parameters in the acid sand, the clay, and sands amended with 5 to 50% clay. These analyses suggest that the greatest challenge to plant growth in the sand would have been the high concentrations of toxic Al in the soil, although the sand also had low concentrations of the major macronutrients (N, P and K). By contrast, the clay was only mildly acidic, had low Al and higher concentrations of nutrients (Table 2). Not surprisingly, addition of clay to the sand decreased toxic Al and increased the soils nutritional status. With incorporation of 10% clay, the Al concentration in the resulting mixture was ~10% of the concentration in sand alone, and the concentrations of P and K were about 4- and 11-fold higher than in the sand alone (Table 2).

Table 2: Selected chemical properties of soils used this study (acid yellow sand and grey non-cracking clay), and effects of incorporation of grey non-cracking clay (5 to 50%) to the acid yellow sand.

Chemical properties	Acid yellow sand	Grey non-cracking clay incorporation rates (%, w/w)				Grey non-cracking clay
		5	10	20	50	
pH1:5 (H_2O)	4.6	4.9	5.2	5.7	5.8	6.6
pH1:5 ($CaCl_2$)	4.0	4.1	4.3	4.7	4.8	5.8
EC1:5 (mS/m)	3.9	4.4	5.1	5.6	5.8	7.7
OC (%)	0.18	0.22	0.27	0.46	0.49	0.86
CEC (meq/100g)	0.42	1.92	2.93	4.92	6.93	12.64
N (mg/kg)	3.0	3.6	4.0	4.6	5.9	9.3
P (mg/kg)	2.3	7.0	11.0	19.0	20.7	61.0
K (mg/kg)	17	147	202	314	330	758
ESP (%)	0.93	1.09	1.36	1.48	1.56	4.43
Al (mg/kg)	16.29	2.99	1.89	0.43	0.26	<0.20

The effect of the chemical properties of soil mixtures (5, 10, 20 and 50%; w/w) also showed that significant variations in several properties among the different rates (Table 2). For example, increased soil pH significantly decreased aluminium (Al) concentrations were found with increasing rates of heavy soil incorporated to acid sandy soils. Thus, acid sandy soils amended with alkaline non-cracking soils could minimise soil Al toxicity by increasing soil organic carbon, soil pH and total CEC (Figure 2).

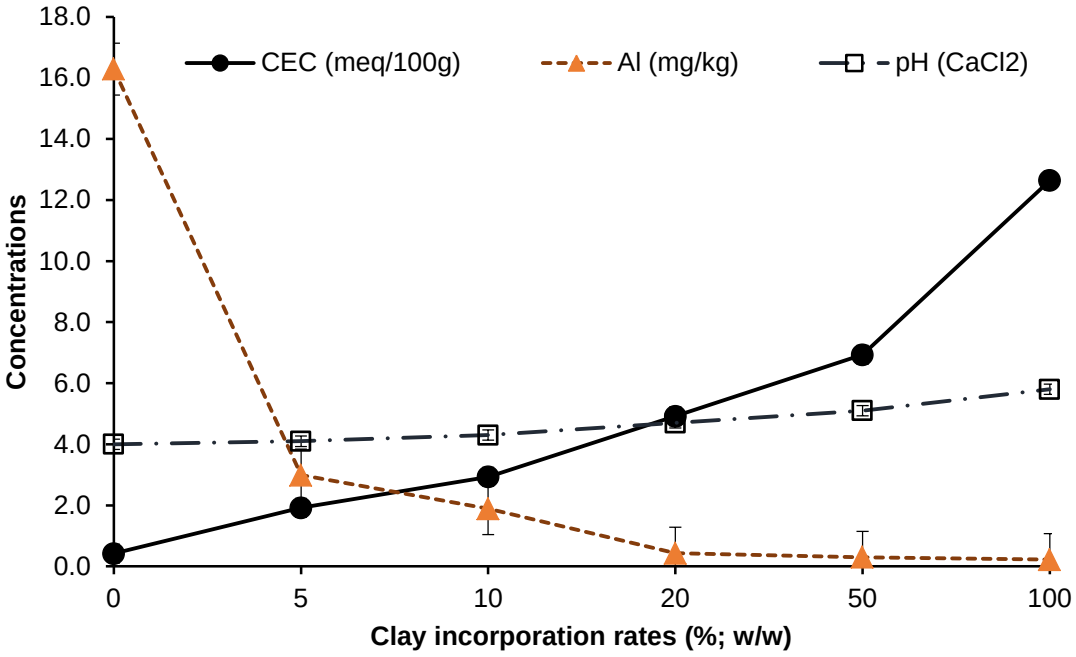

Figure 2: Effect of grey non-cracking clay incorporation at increasing rates (%, w/w) on soil pH (open symbol), total CEC (solid line) and Al level (dotted line) of acid yellow sand. Values are the mean of 3 replicates and error bars are the SEM.

Wheat dry biomass increased with increasing incorporation of clay to the sand: addition of 10% clay more than doubled wheat biomass after 42 days (Figure 3). It is suggested that this effect was because of the lower acidity, lower Al concentration, higher nutrient status, and (possibly) higher water holding capacity of the amended sand.

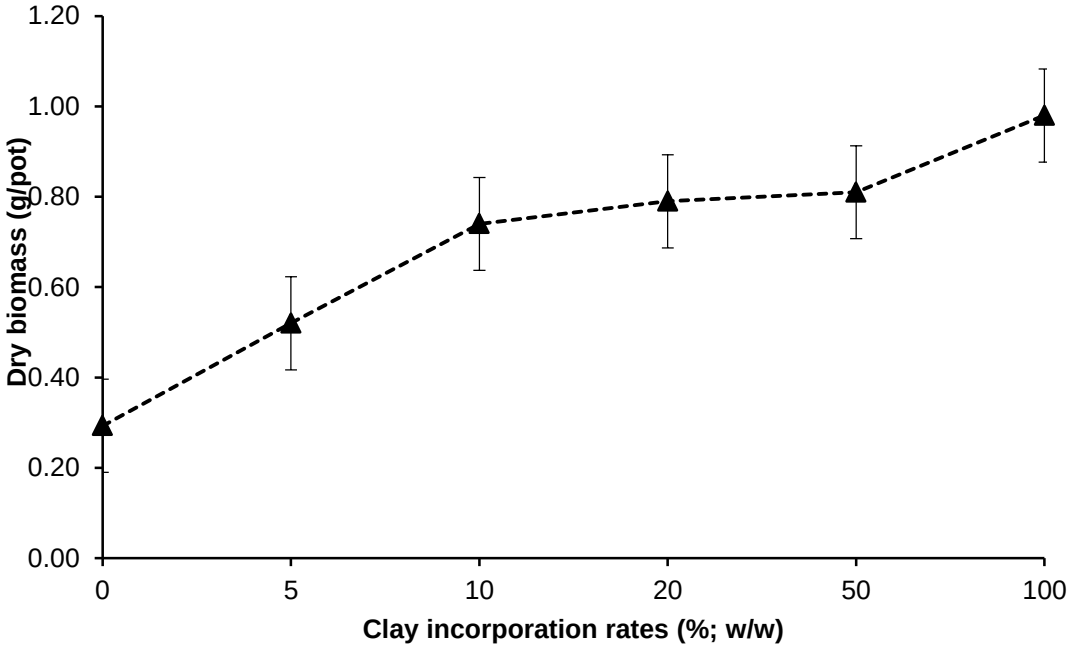

Figure 3: Effect of grey non-cracking incorporation at increasing rates (%, w/w) on plant dry biomass of acid yellow sand. Values are the mean of 3 replicates and error bars are the SEM.

The profitability of applying clay to acid sandy soils at the farm-scale is still to be investigated. The addition of 5 and 10% grey non cracking clay to the acid sands equates to the addition of 65 and 130 t/ha of soil when applied to a depth of 10cm. While adding clay to water repellent sands has been shown to be profitable on the south coast (Hall *et al.* 2010), further work is required to identify if alkaline subsoils are a profitable alternative to the addition of lime and nutrients.

Conclusion

The beneficial aspects of the amendment of light-textured soils with heavy-textured soils at moderate rates is encouraging, but further field research is needed to understand the influence of amendment on soil physical-chemical properties, on crop yields and on profitability.

Depending on the source of soil used, alkaline heavy-textured soil amendments could minimise Al toxicity and improve plant nutrition.

Key words

Acid yellow sand; Grey non-cracking clay; Incorporation; soil properties

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