Poster paper

Use of Inorganic Fertiliser in place of Poultry Manure for Rehabilitation of Gold and Bauxite Ore Refining Residues

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Introduction

Ore refining residues are difficult substrates for revegetation because they often contain extremely low plant-available levels of one or more essential elements (Hossner and Hons 1992). Organic amendments would generally be attractive additions for revegetation because residues also contain little organic matter, and organic amendments may also ameliorate elevated concentrations of salts and other elements. However organic materials are generally not available on mine sites in sufficient quantities and they are bulky handle. In the present study, the opportunities for substituting inorganic fertilisers in place of poultry manure were investigated for revegetation of three alkaline, variably saline residues: bauxite residue (mixed sand and clay fractions), bauxite residue sand, and gold refining residue from mined oxide clays.

Materials and Methods

Residue sand was collected from the Pinjarra Refinery of Alcoa World Alumina Australia. Gold refining residue was collected from the residue storage area of Hedges Gold Mine. Bauxite residue was collected from the Collie refinery of Worsley Alumina Pty Ltd. Each residue was dried, crushed, sieved through a 4 mm sieve then mixed with calcium sulphate at 5 % (w/w). Each pot was then leached with deionised water (DI) equivalent to a 100 -300 mm rainfall. After leaching, the residue was air-dried, then half of each type of residue had complete inorganic fertilizers added. When the nutrient solutions had dried on the residue, poultry manure (equivalent to 0, 50, 150, 300, 600 m^3/ha) was added to each pot and the contents were mixed thoroughly. The mixed residue was covered with a 350 g layer of coarse and medium sand. Plants were watered to 80 % of field capacity twice a week and as required at other times. Ten days after transplanting, triticale plants were thinned to 12 per pot. The plants were harvested for dry matter six weeks after transplanting when tops of plants were cut at ground level, washed in DI water, and dried at 70°C for 3-4 days. The dry material was analysed for N, P, Na, Cl and Zn.

Results and Discussion

All residues were strongly alkaline, especially the bauxite residue. Bauxite residue also contained an order of magnitude more water-soluble alkalinity than the residue sand and two orders of magnitude more than gold refining residue (Table 1). Bauxite and gold residue were both strongly saline in contrast to residue sand that was non-saline to marginally saline. Residue sand had low clay levels in contrast to the other residues. Bauxite and Gold oxide residues had similar clay content but the gold oxide residue contained much less sand. Variations in clay and sand among residues were consistent with those in water holding capacity.

Table.1. Chemical and physical properties of untreated residues

	Residue Sand	Bauxite Residue	Gold Oxide Residue
pH (1:5 H_2O)	10.3	10.6	9.3
Alkalinity - Water Soluble (g $CaCO_3$/kg)	1.97	15.5	0.37
Electrical Conductivity (1:5) (mS/m)	60	750	385
Exchangeable sodium %	81	54	62
Field Capacity (%)	11.8	28.4	37.3
Texture: (% clay)	2	38	43
(% sand)	87	38	18

On gypsum-amended, leached bauxite residue sand and bauxite residue N, P, and Mn were potentially deficient for plant growth. On the residue sand, complete inorganic fertiliser was effective in correcting the deficiencies of N and P but only partially effective in correcting Mn deficiency (Table 2). Growth potential in residue sand was as high as in well-watered, well fertilized triticale plants in sand culture (data not shown). These results suggest that no major growth constraints limited triticale growth on residue sand when it was supplied with a combination of poultry manure and inorganic fertilizer.

Table 2. Effect of poultry manure (0, 50 m^3/ha) and inorganic fertiliser (± complete inorganic fertiliser) on N, Ca, Cl and Mn concentration in whole shoots of triticale grown for 42 days on Residue Sand, in pots. Values are means of 3 replicates with standard errors in parentheses.

Poultry Manure	Inorganic fertiliser	N (%)	P (%)	Na (%)	Cl (%)	Mn (mg/kg)
0*	0	2.1	0.09	1.0	0.5	9
0	1	2.2 (0.10)	0.23	0.8 (0.04)	0.9 (0.08)	12 (0.4)
50	0	5.2 (0.08)	0.33	0.6 (0.06)	1.9 (0.29)	17 (5.2)
50	1	4.7 (0.14)	0.39	0.6 (0.04)	2.2 (0.10)	11 (1.1)

* Insufficient sample size for analysis so samples were bulked.

With residue sand, the moderate electrical conductivity obtained after leaching and gypsum treatment allowed strong responses to inorganic nutrients alone (figure 1). Further improvements in triticale growth were achieved by varying rates of p and n (data not shown). Thus, there were promising indications that replacement of poultry manure by inorganic fertilizers could be achieved for revegetation of residue sand. However, triticale shoots accumulated appreciable levels of both na and cl suggesting that the possibility of salt limitations for sensitive species grown on residue sand should not be overlooked in future field testing for revegetation.

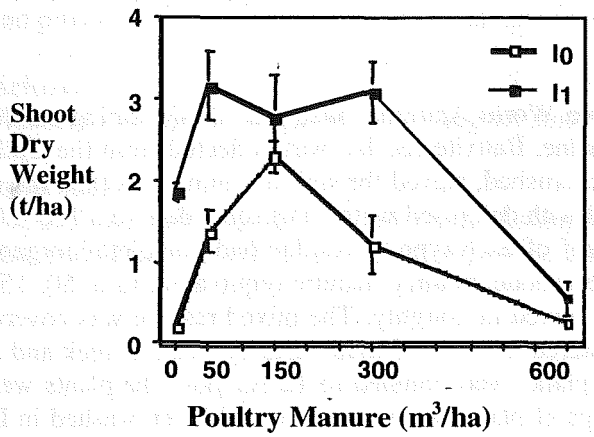

Figure 1. Effect of poultry manure (PM) and inorganic fertiliser (I_0 - no inorganic fertilizer; I_1 – complete inorganic fertilizer added) on the shoot dry weight (t/ha) of triticale grown on Residue Sand for 42 days. Values are means of three replicates. Vertical bars denote standard errors.

Low Mn uptake by plants is probably the consequence of low Mn levels in the residue, alkaline pH, and or the high levels of calcium in the residue sand. The first and third limitations can be overcome by increased levels of Mn fertilizer. However, if high alkalinity converts Mn to forms that are not readily available to plants, then Mn fertilizer may not readily overcome the Mn limitation and species and cultivar selection for efficient Mn uptake may be the more rationale approach.

Bauxite residue remained saline, sodic and alkaline even with gypsum amendment and leaching. Inorganic fertiliser alone was not effective in correcting nutrient deficiencies on bauxite residue and plant growth was strongly limited by excessive Cl uptake. Maximum growth on bauxite residue was obtained with a combination of inorganic fertiliser and poultry manure. Similarly plant growth on gold oxide residue was maximised with a combination of inorganic fertiliser and poultry manure which corrected N and P deficiencies and decreased Na and Cl accumulation by plants.

Acknowledgements

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References

Hossner L.R. and Hons F.M. (1992) *Advances in Soil Science* 17, 311-350.