# Enhancing root proliferation in an alkaline dispersive subsoil: a comparative study of organic and inorganic amendments with different amelioration mechanisms

Shihab Uddin1 \*, Maheswaran Rohan1, Zhe H. Weng2, Iman Tahmasbian3, Yunying Fang4, Helen L. Hayden5,7,8, Roger Armstrong6,7 and Ehsan Tavakkoli2

1NSW Department of Primary Industries and Regional Development, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW 2650, Australia.

2School of Agriculture, Food and Wine, Waite campus, The University of Adelaide, Glen Osmond, SA 5064, Australia.

3Department of Primary Industries, Queensland Government, Toowoomba, QLD 4350, Australia.

4Australian Rivers Institute, School of Environment and Science, Griffith University, Nathan, QLD 4111, Australia.

5School of Agriculture, Food and Ecosystem Sciences, Faculty of Science, The University of Melbourne, Parkville, VIC 3010, Australia.

6Agriculture Victoria, Grains Innovation Park, Horsham, VIC 3400, Australia.

7Agriculture Victoria, AgriBio, La Trobe University, Bundoora, VIC 3083, Australia.

8Present address: Department of Applied Chemistry and Environmental Science, School of Science, RMIT University, Melbourne, VIC 3000, Australia.

\***Corresponding authors:** NSW Department of Primary Industries and Regional Development, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW 2650, Australia. Emails: [shihab.uddin@dpi.nsw.gov.au](mailto:shihab.uddin@dpi.nsw.gov.au).

**Table S1**. List of different organic, inorganic and combined amendments used to ameliorate an alkaline dispersive subsoil and their application rates. PAM: Polyacrylamide; N: Nitrogen; P: Phosphorus; S: Sulphur

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No | Amendments | Groups | Application rate  (t ha-1) | Application rate  (g kg-1 dry soil) | Notes |
| 1 | Control | Control | nil | nil |  |
| 2 | Bean residues | Organic | 15 | 12 | *Vicia faba* L. |
| 3 | Compost+Biochar | Organic | 15 | 12 | 49:1 w/w mature green waste compost: green waste biochar ratio; blended post-composting |
| 4 | Compost chicken manure | Organic | 15 | 12 | Mature poultry litter compost |
| 5 | Compost green organics | Organic | 15 | 12 | Mature municipal green waste compost |
| 6 | Compost pig on straw active | Organic | 15 | 12 | Immature pig bedding material compost |
| 7 | Cow manure | Organic | 15 | 12 | Uncomposted |
| 8 | Humate | Organic | 15 | 12 |  |
| 9 | Pig manure | Organic | 15 | 12 | Uncomposted |
| 10 | Poultry litter | Organic | 15 | 12 | Uncomposted poultry litter; Charcoal was present at the sampling site |
| 11 | Reed winter residues | Organic | 15 | 12 | *Phragmites australis* |
| 12 | Shortland biosolid | Organic | 15 | 12 | Taken from a small suburban wastewater treatment plant receiving domestic commercial and industrial inflows. |
| 13 | Wheat | Organic | 15 | 12 | *Triticum aestivum* L. residues |
| 14 | Gypsum\_low | Inorganic | 5 | 4 |  |
| 15 | Gypsum\_high | Inorganic | 15 | 12 |  |
| 16 | PAM | Inorganic | 5 kg ha-1 | 4 mg kg-1 |  |
| 17 | PAM+Gypsum | Inorganic | 5 kg ha-1 PAM +  5 t ha-1 gypsum | 4 mg kg-1 PAM +  4 g kg-1 gypsum |  |
| 18 | Compost+Zeolite | Combined | 15 | 12 | 9:1 w/w mature green waste compost: zeolite ratio; blended post-composting |
| 19 | Wheat+Nut1a | Combined | 15 | 12 | *Triticum aestivum* L. residues + N, P and S containing fertilisers |
| 20 | Wheat+Nut2b | Combined | 15 | 12 | *Triticum aestivum* L. residues + N, P and S containing fertilisers |

a:wheat residues received 65 mg N, 15 mg P and 11 mg S as supplementary nutrients per kg of dry soil.

b: wheat residues received 130 mg N, 30 mg P and 22 mg S as supplementary nutrients per kg of dry soil.

**Table S2** Total carbon (C), nitrogen (N) and C:N ratio of the alkaline dispersive subsoil and the organic amendments used in the study.

|  |  |  |  |
| --- | --- | --- | --- |
| Soil & amendments | Total C (%) | Total N (%) | C:N ratio |
| Alkaline dispersive subsoil | 0.7 | 0.05 | 13.0 |
| Bean residues | 42.2 | 2.5 | 16.9 |
| Compost+Biochar | 21.9 | 1.3 | 16.8 |
| Compost+Zeolite | 14.4 | 1.3 | 11.1 |
| Compost chicken manure | 31.0 | 4.2 | 7.4 |
| Compost green organics | 20.1 | 1.6 | 12.6 |
| Compost pig on straw active | 31.4 | 1.7 | 18.5 |
| Cow manure | 18.0 | 2.1 | 8.6 |
| Humate | 47.5 | 0.9 | 52.8 |
| Pig manure | 38.6 | 2.4 | 16.1 |
| Poultry litter | 37.3 | 3.2 | 11.7 |
| Reed winter residues | 43.5 | 0.5 | 87.0 |
| Shortland biosolid | 23.1 | 3.2 | 7.2 |
| Wheat | 43.6 | 0.4 | 108.9 |