Utilising Chicken Litter as a Soil Improvement Agent

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Abstract
In addition to chicken litter from meat chicken sheds being utilised in broadacre farming systems as an alternative nutrient source for crops, in South Australia cereal growers are applying chicken litter to poor producing or problem soils in an attempt to improve them. Low fertility sand hills and hard-setting red-brown earth soils are particularly targeted. The rates of chicken litter applied to these problem soils are often 2 to 5 times higher than district practice rates with the aim of supplying high amounts of nutrients and organic matter to elevate fertility levels.

A trial was established on a low productivity sandhill near Balaklava in SA's mid North cropping district in 2010 to evaluate the effectiveness and risks associated with using high application rates of chicken litter as a soil improver. This trial measured cereal crop performances, grain quality parameters, plant tissue and soil nutrient levels over two years in response to a single application of chicken litter in 2010 at rates between 5 and 20 t/ha. Wheat yield responses of up to 0.67 t/ha or 19.5% were achieved by the application of high rates of raw chicken litter in the year of application. Applications of chicken litter increased plant tissue concentrations of key macro and trace elements including nitrogen, phosphorus, potassium, sulphur, zinc, manganese and copper for two successive years, and elevated soil phosphorus and organic carbon .

Key Words
chicken litter, soil fertility, cereal yield

Introduction
Chicken litter from meat chicken sheds is being utilised in broadacre farming systems as an alternative nutrient source for crops. In addition to this use pattern, some growers are applying high rates of chicken litter to poor producing or problem soils in an attempt to improve them.

Low fertility sand hills and hard-setting red-brown earth soils are particularly targeted. The rates of chicken litter applied to these problem soils are often 2 to 5 times higher than district practice rates of 2.5-3t/ha with the aim of supplying high amounts of nutrients and organic matter to boost fertility levels.

These high rates may pose potential risks. Production of excessive crop growth due to high application levels of nitrogen in particular, resulting in higher screenings and "burning off" of crops in dry seasonal finishes is a key risk, at least in the year of application.

Methods
To investigate chicken litter as a soil improver a simple replicated demonstration trial was established on a low fertility sandhill near Balaklava in SA's mid North cropping district in 2010. Soil test results from the site are detailed in Table 1.

Table 1: Site soil test data (0-10cm) prior to the application of chicken litter in 2010

Colwell Phosphorus ppm	Phosphorus Buffering Index	Phosphorus DGT ug/L	Colwell Potassium ppm	Sulphur ppm	Organic Carbon %	pH $CaCl_2$	Nitrate and Ammonium N 0-60cm kg/ha
14	5	193	234	3.83	0.6	6.1	56.7

The trial included rates of chicken litter of 0, 5, 10 and 20 tonnes per hectare spread in autumn prior to sowing a wheat crop. The aim was to monitor crop performance, grain quality parameters, plant tissue, and soil nutrient levels over two years to evaluate the effectiveness, longevity of responses and potential risks associated with this use pattern for chicken litter. The trial was a randomised block design with three replicates of large (4m x 10m) plots. Raw, straw-based chicken litter was sourced from a commercial chicken meat farm near Mallala in SA. The chicken litter was hand broadcast on the 17th of May 2010 and subsequently direct drilled with Clearfield Stiletto wheat on the 28th of May 2010 together with 100kg/ha of

NPK 24:16:0 fertiliser using a commercial airseeder fitted with 4" shares and finger-tyne harrows.An additional 80kg/ha of urea was applied to all plots post emergence (13th July 2010). Plots were also spread with mouse bait due to high mouse numbers which caused some initial damage. Youngest Emerged Blades (YEB's) were sampled from all plots on the 31st of August 2010 and were analysed for macro and micro nutrients . Harvest was conducted using a plot header and grain quality was assessed using commercial testing equipment at Viterra's Owen receival site.

In 2011 the site was sown with 90kg/ha of Fleet barley together with 100kg/ha of NPK 24:16:0 fertiliser on the 28th of May 2011. Visual vigour scoring was conducted on the 18th of August 2011 using a 0-10 scale (a score of 10 representing highest vigour). Youngest Emerged Blades (YEB's) were sampled from each treatment on the 18th of August 2011 and were analysed for macro and micro nutrients. Plots were topdressed with an additional 80kg/ha of urea on the 13th of July 2011. Harvest was conducted using a plot header and grain quality was assessed using commercial testing equipment at a Viterra grain receival site. Soil samples (0-10cm depth) were taken in February 2012 and analysed for macro nutrients, pH, EC and organic carbon. Nutrient and heavy metal content of the chicken litter applied to the trial is detailed in Table 2.

Table 2: Chicken litter macro and micronutrient and heavy metal content (dry weight basis)

Nitrogen %	Phosphorus %	Potassium %	Sulphur %	Zinc mg/kg	Manganese mg/kg
3.88	1.36	1.67	0.53	360	385
Copper mg/kg	**Magnesium %**	**Lead ug/kg**	**Nickel mg/kg**	**Sodium %**	**Iron mg/kg**
135	0.53	1048	4160	0.52	1099
Arsenic ug/kg	**Boron mg/kg**	**Cadmium ug/kg**	**Calcium %**	**Chromium ug/kg**	**Moisture %**
320	19.4	84	2.51	134.6	22

Results and Discussion

Grain yield, key grain quality parameters and visual crop vigour scores for 2010 and 2012 are detailed in Table 3.

Table 3: Grain Yield, Quality and Crop Vigour Results

Treatment	Grain Protein %	Grain Screenings %	Grain Test Weight kg/hL	Grain Yield t/ha	Vigour visual score 0-10
2010 Wheat					
Untreated	11.83	5.13	73.33	3.43	-
5t/ha	10.47	4.20	74.83	3.76	-
10t/ha	10.47	4.13	74.50	4.09	-
20t/ha	10.27	6.74	74.83	4.10	-
lsd(P=0.05)	n.s.	n.s.	n.s.	0.65	-
2011 Barley					
Untreated	12.37	2.97	62.33	2.10	5.3
5t/ha	12.20	2.82	62.20	2.16	7.0
10t/ha	12.70	2.13	61.80	2.10	7.7
20t/ha	14.60	2.64	62.40	2.37	10.0
lsd(P=0.05)	1.07	n.s.	n.s.	n.s.	-

Significant wheat grain yield increases were measured at the 10 and 20 tonne per hectare application rates in 2010. Grain quality was not significantly affected although screenings levels appeared to be slightly higher when chicken litter was applied at 20 tonnes per ha. Although not scored in 2010, the wheat plots showed visual responses in crop growth and vigour in all treatments where chicken litter was applied. Responses were proportional to the rate of chicken litter applied, with the untreated showing the least visual response and 20 tonnes per hectare showing the greatest visual response.

The application of up to 20 t/ha of chicken litter did not have an adverse affect on grain yield and quality in the 2010 wheat plots despite the risk of "burning off" associated with increased crop growth and This is likely to be attributable to the above average spring rainfall and cool seasonal finish experienced in 2010.

Visual crop vigour responses were again evident in 2011 barley plots, with responses proportional to the amount of chicken litter applied. In 2011 barley yield responses of 0.27 tonnes per hectare were measured in the 20t/ha treatment, however the increase in yield was not statistically significant. In 2011 the trial was severely affected by *Rhizoctonia* root rot which is likely to have limited yield responses and increased variability within the trial. The 20t/ha treatment resulted in a significant increase in grain protein in 2011.

Plant analysis results from the 2010 wheat and 2011 barley plots are summarised in Table 4.

Table 4: Macro and micronutrient concentrations in plant tissue (YEBs) for cereals grown in plots with or without chicken litter applied in 2010

	Copper mg/kg	Manganese mg/kg	Phosphorus %	Potassium %	Sulphur %	Nitrogen %	Zinc mg/kg
2010 Wheat							
Untreated	3.15	28.77	0.39	2.86	0.26	3.57	21.94
5t/ha	4.81	38.73	0.44	3.15	0.27	3.93	26.22
10t/ha	4.68	46.60	0.48	3.40	0.31	4.44	29.94
20t/ha	5.68	60.63	0.49	3.53	0.34	4.87	32.21
LSD (P=0.05)	1.39	19.7	0.05	0.31	0.05	0.48	4.00
2011 Barley*							
Untreated	5.82	45.00	0.53	4.50	0.31	4.00	26.94
5t/ha	6.27	47.94	0.62	4.92	0.39	4.89	31.31
10t/ha	6.43	40.89	0.60	4.84	0.39	4.87	36.07
20t/ha	8.14	48.20	0.60	4.84	0.45	5.27	39.54

**plant tissue sampling was un- replicated in 2011*

Levels of key plant nutrient increased in response to chicken litter application rates in both years of the trial. Elevated plant levels of nitrogen, phosphorus, potassium, sulphur, manganese, zinc, copper and levels were measured in response to the application of chicken litter.

Soil analysis results from 0-10cm soil samples collected in February 2012 (19 months after chicken litter application) are summarised in Table 5.

Table 5: Soil test results (0-10cm) February 2012

	Colwell Phosphorus mg/kg	Colwell Potassium mg/kg	Sulphur mg/kg	Organic Carbon %	Conductivity EC 1:5 dS/m	pH $CaCl_2$	Phosphorus Buffering Index
Untreated	32.7	204.7	4.6	0.5	0.068	6.0	18.7
5t/ha	39.7	217.0	4.8	0.5	0.070	6.1	17.6
10t/ha	52.0	216.0	5.9	0.7	0.086	6.1	17.6
20t/ha	70.7	243.3	6.3	0.8	0.090	6.1	20.7

Soil phosphorus as measured by the Cowell test increased as rates of chicken litter application increased, with the 20t/ha application rate doubling soil P from 33ppm to over 70ppm. Soil sulphur and potassium levels also showed responses. Soil organic carbon levels increased from 0.5% to 0.7% and 0.8% respectively with the 10t/ha and 20t/ha application rate.

Conclusions

High application rates of chicken litter improved cereal crop yields and soil fertility on a poor producing sandhill. No adverse effects on grain quality or crop performance were measured with application rates of up to 20 tonnes per hectare, however, this result may have been influenced by a favourable seasonal finish.

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