Bioassay of long term phosphorus trial, 80Ba6

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Purpose: To determine the long term effects of 1980 P treatments on soil fertility
Location: On Geoff Pearson's farm, Watheroo Road, Badgingarra
Soil Type: Deep grey over pale yellow sand
Soil Test Results: Part of the soil fertility assessment – see results below
Rotation: Pasture ley for 35 years then a failed wheat crop followed by wheat in 2016
Growing Season Rainfall (April- October 2015): Use Badgingarra Research station rainfall

BACKGROUND SUMMARY

The residual effects of 1980 sources of P (superphosphate, C grade ore from Christmas Island (C ore) and calcined .at 500degreesCore (C 500) were noted in passing in 2013. Funds were obtained from NACC to characterise and analyse the long term soil fertility effects of the 1980 treatments. These effects included soil wettability, the build-up in soil organic matter, cation exchange capacity, exchangeable cations, soil acidity P residuals and nutrient availability. The latter was to be assessed via a crop bioassay. Initial results and background information was presented in a paper to the 2015 crop updates and in Bolland et al (AJEA p 647-56, 1987). This paper outlines results obtained from soil and plant sampling in 2015 and 2016 and gives an overall analysis of the changes in soil fertility factors with time.

TRIAL DESIGN and MANAGEMENT

The 1980 plots ran north south and were 2.5 metres wide on 3 metre centres and were 60 metres long There were 3 replicates of the treatments which comprised 5 rates (nil plus 4 levels) of 3 sources of P (super, Core and C 500). Subsequent (1985) current P rates as superphosphate were applied to some of the nil plots and at each end of the original trial.

In 2015 (failed crop) and 2016, (on May 9th) wheat was sown in strips across (east/west) the original plots and treatments included nil, plus P (100 kg TSP/ha) only, plus N only, plus NP and a luxury supply of all nutrients (Gusto gold 100kg/ha each year). The strips were approximately 10 metres wide. In 2015 they were sown in 2 runs with a commercial combine. In 2016 a precision plot seeder was used with multiple runs, wheel on tyne. The nitrogen was applied by hand in 2015 (100 kg Urea/ha about 4 weeks after seeding) and as a liquid (80 litres of UAN/ha, 3 weeks after seeding) in 2016. Pre-emergent weed control was used in both years and a broadleaf spray successfully controlled late emerging capeweed and blue lupins in 2016.

A major problem with the attempts at a bioassay has been grazing by kangaroos. In 2015, our attempts at control were unsuccessful. We managed one hand harvest of visibly ungrazed plants and had them analysed but those results were dubious. In 2016 we eventually kept the kangaroos out of our sampling areas for about a month prior to sampling at ear emergence and the results are presented below.

Surface soil samples were taken in 2014 and results were reported in the previous paper. Profile soil samples (to 90 cm) were taken in November 2015 and the results are presented below. Analyses were also carried out on profile samples taken in 1980 and 1986 and stored in the DAFWA soil bank.
An image from a drone was obtained in October 2016 but because of poor weather conditions when it was first intended, the ultimate pass was too late (the crop was too mature) to show the best contrasts.

TRIAL LAYOUT

1980 plots run NS (vertically) and 2015, 2016 fertiliser cross strips run WE (horizontally).

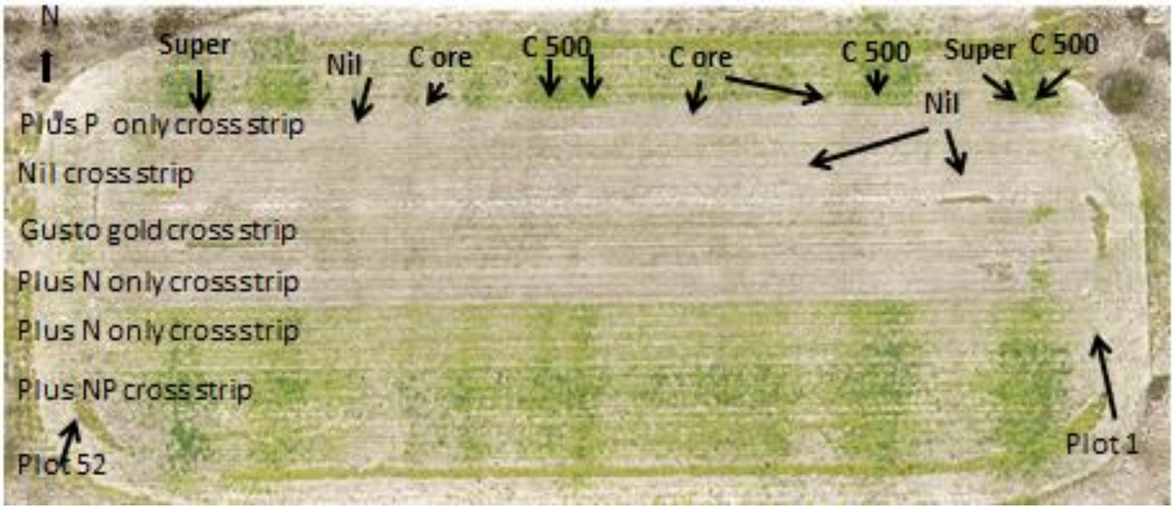

Figure 1. Aerial (drone – thank you Stan from Murdoch University) view of trial site in October 2016. The vertical, green, striping reflects capeweed and blue lupin growth on the 1980 high available P plots. The central grey area is in the kangaroo exclosure which was sprayed for weed growth and when the remaining wheat crop was maturing, at about soft dough stage.

RESULTS and DISCUSSION

Tissue analyses of plant samples taken on 16 September from the 2016 nil strip within the exclosure for selected (high P) 1980 treatments are presented below. The Gusto plus N and plus P strips were also sampled.

Table1.Residual effects of 1980 treatments as seen from wheat tops analyses on the strip with no fertilizer applied in 2016

Bioassay of residual effects on 2016 nil plots					
1980	1980	wt and analysis of 20 plants			
source	kg P/ha	gm	P%	K%	N%
C ore	1386	18.1	0.19	0.99	1.07
C 500	1188	23.7	0.24	1.21	1.18
nil	0	15.5	0.16	0.88	0.92
Super	420	28.5	0.20	1.18	1.21
	stdev	4.0	0.03	0.14	0.13
		gm	Pupt	Kupt	Nupt
C ore	1386	18.1	3.5	17.9	19.3
C 500	1188	23.7	5.6	28.1	27.2
nil	0	15.5	2.5	13.8	14.2
Super	420	28.5	5.5	32.9	33.7
	stdev	4.0	0.7	5.4	4.3
recovered growth after grazing by kangaroos					
wheat crop at ear emergence/anthesis					

Differences between means of greater than 2*st dev are significant.
The 20 plant, sample size was too small to reflect the regrowth of the crop after grazing by kangaroos, so the tissue NP and K analyses are a better indicator of residual effects than the dry weights and nutrient uptake figures. It is apparent that the high rates of C ore and C 500 in 1980 still have large effects on the NPK status of the crops while the even higher dressings of P as C ore are little better than the Nil controls.

Soil profile samples to 90 cm depth were taken in October 2015 from the control and high P rate plots of the 3 sources. The fractional recovery of P after 35 years was calculated and plotted below.

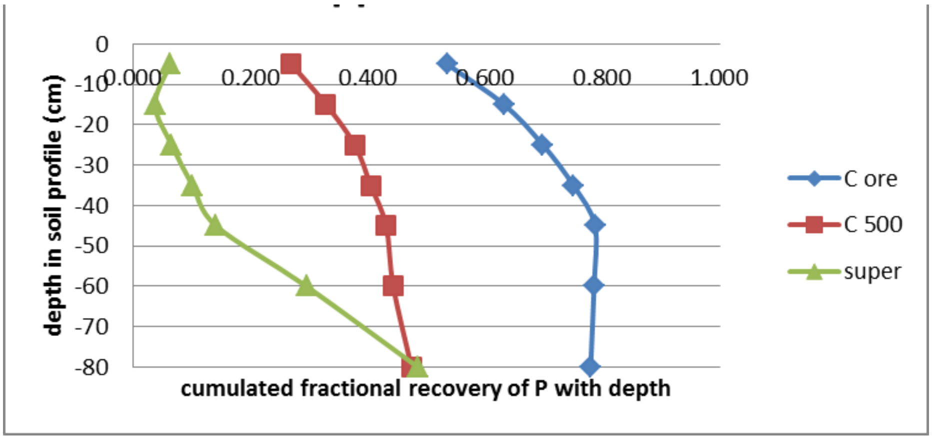

Figure 2. 2015 fractional recovery of P, cumulated to depth, of 1980 high P rate treatments

The C ore was very insoluble and poorly plant available except in the first year and so has a high recovery (80% to 50 cm). C 500 has a high citrate solubility and so is more plant available and has a lower recovery (40 % to depth) while superphosphate, which is 80% water soluble had poor recovery (15%) in the top 50 cm, but surprised with more recovery at depth.

Table 2. Changes of soil fertility factors in the top 10 cm of soil as affected by time since application and the highest rate of P for each of the 3 P sources

		OC%	Ca	Mg	K	CEC	N%	P mg/kg	C:N	pH	MED
1981	**base**	0.55	1.22	0.20	0.04	1.46	0.03	21.0	18.3	5.0	0.0
1986	**super**	0.62	1.44	0.13	0.06	1.75	0.04	69	15.5	5.1	0.0
1986	**c500**	0.63	1.29	0.14	0.06	1.59	0.04	379	15.8	5.3	0.0
1986	**core**	0.63	1.29	0.13	0.05	1.57	0.04	481	14.5	5.3	0.0
1986	**nil**	0.67	1.47	0.16	0.04	1.76	0.04	56	16.8	5.1	0.0
1986	**stdev**	0.06	0.16	0.02	0.01	0.21	0.01	93	2.2	0.04	**0.0**
2014	**super**	1.17	2.14	0.35	0.11	2.73	0.09	66	13.0	5.3	3.0
2014	**c500**	0.93	1.89	0.29	0.10	2.41	0.09	318	10.3	5.5	3.1
2014	**core**	1.04	2.35	0.36	0.11	2.96	0.08	489	13.0	5.6	2.5
2014	**nil**	0.83	1.78	0.27	0.08	2.25	0.07	73	11.9	5.3	1.8
2014	**stdev**	0.11	0.28	0.04	0.02	0.33	0.01	54	1.3	0.10	0.4
year effect?		yes	yes	yes	yes	yes	yes	no?	yes	yes	yes
treatment effect?		no	no	yes?	no	no?	no	yes	no	yes	yes?
Exchangeable cations in meq/100 g					LSD roughly twice stdev				MED = non-wetting index		

2*st dev differences are significant.

The changes of some of the soil fertility factors with time are striking.
In the 2015 crop update paper the effect of blue lupin growth on soil wettability was marked but even more remarkable was the general very low wettability across the site compared with complete wettability in 1981 and 1986.

Soil organic carbon and total soil nitrogen, built up with time but surprisingly, there was little difference between plots/treatments which grew several t/ha of blue lupins for the last 20 years and those which grew less than 1 t/ha of volunteer weed species over the same time period. Summer satellite imagery suggests the ground was often quite bare and there could well have been wind erosional movement of surface soil across the plots.

Changes in cation exchange capacity reflected the changes in organic carbon and increased with time – which is common with permanent pasture leys on these coarse textured sands. Exchangeable calcium, magnesium and potassium all increased after 1986, probably due to their cycling from depth into the surface layers. Though there was little effect of the massive differences in pasture (blue lupin) growth through time.

C:N ratio decreased with time but again, but only slightly with treatment, despite the large amount of blue lupin biomass grown on the high C 500 and super plots.,. The trends were in the right direction.

Surface soil pH increased slightly with time though this effect was likely to be due to the initial input of lime in the form of the rock phosphates (C ore and C 500) and not due to the deposition of residues with an ash alkalinity (liming effect) because super always had a lower pH that C 500.

KEY FINDINGS

The trial was dogged by non-wetting and kangaroo grazing problems and so the bioassay of the residual effect of the original source of P treatments was poor.

Recoveries of applied phosphorus in the surface layers was poorest for the water soluble, plant available source superphosphate which had large leaching losses below 50 cm. The less immediately available but citrate soluble source retained more P in the surface layers while the very insoluble C ore source produced poor growth but had only very low P leaching to depth. The compromise in choice of source, between plant availability and leaching into the ground water and subsequently the waterways, is well illustrated by this trial.

As a rule, soil fertility factors (non-wetting, organic carbon, CEC, soil organic nitrogen, acidification etc. were all more affected by length of pasture ley than by pasture composition and cumulated production. Cross plot transfer of surface soil may well have affected this finding.

ACNOWLEDGEMENTS
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