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Effect of soil properties on copper availability to plants

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SUMMARY OF EXPERIMENTAL RESULTS 1977

EFFECT OF SOIL PROPERTIES ON COPPER AVAILABILITY TO PLANTS

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EFFECT OF SOIL PROPERTIES ON COPPER AVAILABILITY TO WHEAT

Experimental glasshouse work involved examining the decrease in effectiveness of copper fertilizer in the soil through time. This seems to conflict with Mr. J.W. Gartrell's programme of field trials which have shown no evidence for any decline in the effectiveness of the original application.

However, because overseas literature refers to fixation and the need for repeat applications, there is a need to measure the degree of fixation which may occur in a range of W.A. soils. In the project, fixation is measured in terms of changes in availability to plants of applied copper with the objective of reaching a stage that the fixing potential of any W.A. soil can be taken into account in consideration of the residual effectiveness of Cu applied to the soils in the field.

In the glasshouse, the different soils were compared to see if they did differ in their ability to supply copper and determine if there was any decline in effectiveness of copper with time of contact with the soil. This was done by incubating the pots of soil for a set period and temperature. All pots had identical treatment except where the copper was applied. Copper Sulphate solution, at the specified levels, was either added just before the incubation treatment or just before seeding the pots. For incubation the soils were maintained at field capacity and 37°C.

TABLE 1

Properties of Soils used in comparison of their ability to supply fertilizer copper.

Soil	NH_4-OX Cu PPM	Organic Carbon %	PH 1:5 (0.1m $CaCl_2$)
Gingin-dark-red L/s	0.50	0.45	5.4
Plantagent-peaty sand	0.07	3.46	4.1
Dowerin-grey sand	0.35	1.03	5.2
Dongara-black calcareous L/s	0.46	4.15	6.9
Newdegate-gravelly L/s	0.15	0.89	5.5
Merredin-red brown L	1.89	0.65	5.5
S.W. Newdegate-yellow orange S/L	0.16	-	5.4

TABLE 2

Cu treatments added to 16.5 cm diameter pot with approx. 3 kg of air-dry soil.

Micrograms of Cu/Pot	Equivalent $CuSO_4.5H_2O$ Kg/ha	Addition of Cu ug Cu/g Soil
0	-	-
200	0.37	0.07
400	0.74	0.14
800	1.48	0.28
2400	4.44	0.8
4800	8.88	1.6

The plants were harvested at the sixth leaf stage and divided into two parts: the youngest fully emerged leaf and the remainder of the top. These will be analysed for copper concentration and hence the total copper content of the tops can be calculated.

Analysis of the youngest fully emerged leaf has been shown by the Department and Uni. of W.A. to be a sound technique for the detection of copper deficiency in wheat. It is a sound technique before anthesis as copper in the flag leaf increases inconsistently after anthesis.

Concentrations of 1.0 ppm or below in the youngest-fully emerged leaf (YFEL) the crop is definitely deficient and visual symptoms are seen. When the Cu concentration in the YFEL is 1.0 - 1.5 ppm there is almost certain to be a reduction in grain yield while concentration of 2.0 ppm and above are adequate for maximum yield.

The effect of incubation of copper in the soil can be looked at in two ways, either by its effect on total dry matter yield or its effect on copper uptake. In the glasshouse work both ways will be used to determine the effect of incubation on the residual effectiveness of copper.

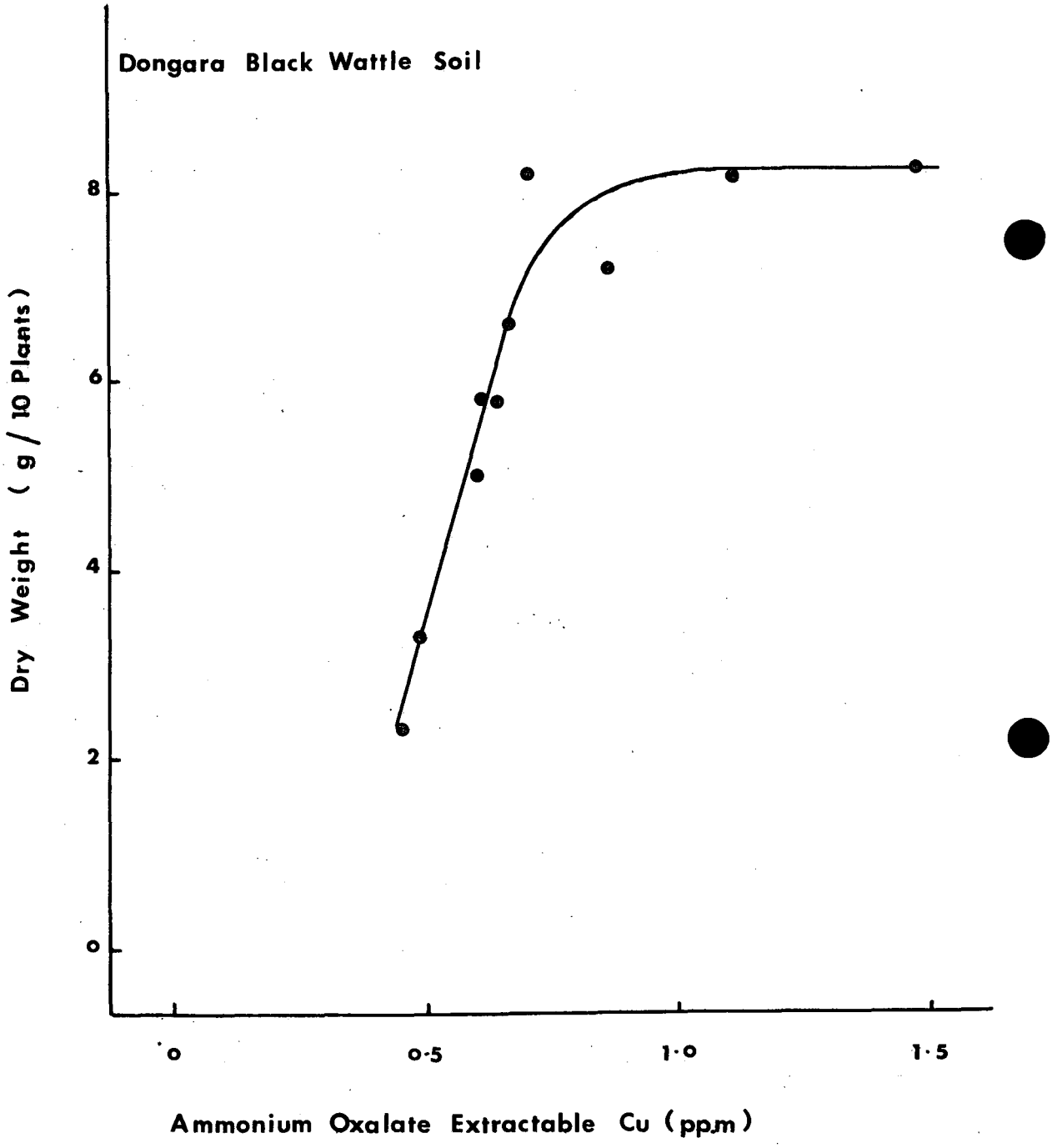
RESULTS

1. Ammonium oxalate extractable Cu

The soils were sampled and analysed for ammonium oxalate, EDTA and 0.1N HCL extractable copper. Because of the low rates of Cu needed for maximum yield chemical analysis was difficult therefore it is hard to determine any significant differences between incubated and fresh copper at the low Cu treatments. Incubation of copper with the soil was found to decrease the amount of copper extracted by NH_4-OX at 2400 and 4800 microgram Cu treatment.

Despite analytical chemistry problem at low copper treatments, ammonium oxalate is a good extractant of copper that is available to plant growth. It has been found in all experiments to date that NH_4-OX extractable Cu of 1ppm and over gives maximum yield.
Figure 1, for the Dongara soil, shows the relationship between NH_4-OX extractable Copper and dry matter yield. All other soils had similar response curves.

Figure 1. Relationship between Ammonium Oxalate extractable Copper and total dry matter yield



The application of copper was found to increase the dry weights of tops on all soils except the Merredin red-brown loam (Table 3). This soil had the highest Ammonium oxalate extractable copper value (Table 1). All other soils showed a yield response to increasing copper levels. On the high organic carbon soil (Dongara,) maximum yield was reached at 800mg Cu/3kg while on the mineral soils the maximum was reached at 400mg Cu.

TABLE 3 77GL3

The response to copper of Gamenya Wheat grown in a range of W.A. soils (Average dry weight (3 reps) - g/10 plants)

Soil		Cu Treatments ugCu/3kg soil					
		0	200	400	800	2400	4800
Dongara	F	2.4	5.8	7.3	8.2	8.3	8.5
	I	2.3	3.3	-	5.8	7.2	-
Gingin	F	2.3	3.8	4.0	4.3	4.2	4.5
	I	2.7	3.0	-	3.8	4.1	-
Dowerin	F	6.4	7.1	7.7	8.3	8.5	8.4
	I	6.3	7.1	-	7.6	8.8	-
Newdegate	F	2.3	4.6	4.9	5.0	5.2	5.8
	I	2.9	4.4	-	5.0	4.9	-
S.W. Newdegate	F	6.4	7.2	7.6	7.9	8.1	8.0
	I	6.4	7.0	-	7.6	8.0	-
Merredin	F	5.4	5.4	5.4	5.8	5.8	5.6
	I	5.4	5.3	-	5.5	5.7	-

F = $CuSO_45H_2O$ Solution applied just before sowing.
I = $CuSO_45H_2O$ Solution applied before incubation.

The incubation treatment was found to have no effect on the yield response for the Dowerin, Newdegate, S.W. Newdegate and Merredin Soil (Table 3) However, incubation of the copper with the soil led to different yield response curves for the Dongara and Gingin soils. The Dongara Black Wattle soil has high organic carbon while the Gingin soil is high in free iron oxides.

The different yield response curves for fresh and incubated copper indicate a reduction in effectiveness of the copper fertilizer through time on these soils. These differential effects of incubation suggest that the residual effectiveness of copper fertilizer on the Dongara, Gingin and Plantagenet peaty sand may be lower than that of other soils and highlights the need for determining the residual effectiveness of copper on these soils under field conditions. Field experiments will be commenced in 1978 with this aim.

The next step will be to look at the effect of incubation of copper on the copper uptake, as results from plant analysis become available.

77GL4

Further glasshouse work was performed in 1977 which involved the changing of the soil pH either by liming or acidification with sulphuric acid. At this stage only yield data is available. In this work only 3 soils, Lancelin, Gingin and Dongara soils were used and for each pH change there was a plus and minus incubation treatment. Incubation of copper with the soil again decreased effectiveness of the copper application

TABLE 4 77GL4

Effect of PH and incubation on the effectiveness of $CuSO_45H_2O$ to Gamenya.

Soil	Cu Treatment	PH Treatment	Mean dry Wt. g/10plants
Lancelin	Nil	Nil	1.5
	Nil	$+CaCO_3$	1.7
	100ugF	Nil	6.00
	100ugI	Nil	4.2
	100 F	$+CaCo_3$	6.3
	100 I	$+CaCo_3$	3.21
Dongara	Nil	Nil	1.3
	Nil	$+H_2SO_4$	8.2
	200ugF	Nil	7.9
	200ugI	Nil	4.3
	200ugF	$+H_2SO_4$	8.2
	200 I	$+H_2SO_4$	5.3
Gingin	Nil	Nil	1.1
	Nil	$+CaCo_3$	2.0
	200ugF	Nil	1.4
	200ugI	Nil	1.4
	200 F	$+CaCo_3$	2.7
	200 I	$+CaCo_3$	2.6

Results in general showed that treatments designed to alter pH had little effect on the dry matter response to copper. On the Lancelin (Figure 2) soil the incubation had a large effect on the effectiveness of the copper application. The addition of sulphuric acid to the black wattle soil where no copper was added resulted in increased yield suspected to be due to increased Cu availability (Table 4). However, acidification with the addition of copper had little effect on the plant yield on the reduction in yield that resulted from incubation. The Gingin soil showed a response to lime with little effect of incubation of copper with the soil.

This may suggest that more experiments be done with more rates of copper and varying pH changes.

The results of the experiments so far suggest that copper maybe fixed in some soils (using Total Dry Weights) and appears to be associated with high organic matter and high free iron oxide content. However, until the chemical analysis of the plant material eventually becomes available interpretation of the Dry Matter remains in doubt. Additional work is needed to check the implication of these results in the field where the turnover of organic matter may result in an equilibrium situation being reached but at a lower level of plant availability for each unit of copper applied.

FIGURE 2

Effect of pH and Incubation on the Response to Copper of Wheat on the Lancelin Soil