1981

1981 Trace element nutrition

J. W. Gartrell

R F. Brennan

DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

EXPERIMENTAL RESULTS 1981

TRACE ELEMENT NUTRITION

J.W. Gartrell
R.F. Brennan
Plant Research Division

CONTENTS

1. LONG TERM COPPER TRIAL - NEWDEGATE RESEARCH STATION
66N14

Block 3 was cropped to Clipper barley in 1981 in accordance with the one crop : three clover pasture. Copper was originally applied to Block 3 in 1969. Within each two hectare plot of Block 3 a small trial of four treatments and two replicates was sown to determine the response to 1981 copper applications.

Basals: Urea 40 kg/ha
Superphosphate 150 kg/ha
Clipper barley 45 kg/ha

Date sown: June 25, 1981

Table 1. Effect of the 1981 copper application on grain yield (t ha^{-1}) on areas which had different rates of copper applied in 1969

BARLEY YIELD (t ha^{-1})

Copper sulphate applied in 1969 (kg/ha)	Copper sulphate (kg/ha) applied in 1981			
	0	2.75	5.5	8.25
0	0.3	0.7	0.8	0.8
2.75	1.0	1.1	1.0	1.1
5.50	1.2	1.3	1.2	1.2
8.25	1.2	1.2	1.3	1.2
11.00	1.2	1.2	1.2	1.2
11.00 + 0.5 yearly	1.2	1.2	1.1	1.3

Grain yield illustrates:

(1) response to currently applied copper on the nil copper plot;

(2) the highest rate of Cu (8.25) on the nil Cu plot was insufficient to raise grain yields to the same level as where 2.75 kg/ha copper sulphate was applied in 1969;

(3) 2.75 kg ha^{-1} copper sulphate applied in 1969 was still sufficient for maximum grain yields in 1981.

The low availability of copper drilled with the crop can be explained by limited contact between wheat roots capable of absorbing copper and the discrete grains of fertiliser copper in a band containing only a small proportion of the roots.

2. ZINC RESIDUAL WITH HIGH ANALYSIS NP FERTILISERS FOR WHEAT
80NO31/2247EX - WYALKATCHEM

Aim: To measure any decline in effectiveness of zinc on this soil type, using high NP fertilisers low in zinc

Soil: Grey gritty sand

Sown: June 14, 1981
Wheat 50 kg/ha

Table 2. Wheat grain yields. Harvested 9.12.81

Treatment 1980	Treatment 1981	Grain yield t/ha	Dry matter t ha^{-1} (August 18, 1981)
DAP + 1.5 Cu + S(30)	DAP	1.60	2.04
DAP + Cu(1.5) + Zn(0.75) + S(30)	DAP	1.62	2.68
DAP + Cu(1.5) + Zn(1.5) + S(30)	DAP	1.66	2.53
DAP	DAP	1.59	1.86
DAP + Cu(1.5)	DAP	1.66	1.89
DAP + Cu(1.5) + Zn(0.75)	DAP	1.63	2.46
Super-Agran 34	Super/Agran	1.65	2.52
Super-Agran 34 + Cu(1.5)	Super/Agran	1.82	2.33
Super-Agran 34 + Cu(1.5) + Zn(0.75)	Super/Agran	1.63	2.46

Plants were sampled for dry matter yield and youngest leaves for Cu, Zn concentration. Chemical analysis of these samples are unavailable at this time.

1. DAP = 125 kg/ha
2. 1.5 Cu = Copper sulphate at 6.0 kg/ha mixed with DAP
3. Zn 0.75 = Zinc oxide at 2 kg/ha mixed with DAP
4. S(30) = Gypsum at 167 kg/ha mixed with DAP

N.B. 1981 - No further additions of micronutrients

3. ZINC RESIDUAL WITH HIGH ANALYSIS NP FERTILISER FOR WHEAT
79Me22/2247EX

Aim: To measure any decline in effectiveness of zinc on this soil type, using high NP fertilisers

Soil: Gravelly sand
Narembeen: Della Vedova

Sown: June 16, 1981 - wheat at 39 kg ha^{-1}

Table 3. Wheat yields (t ha^{-1}) for 79Me22 - harvested December 4, 1981

Treatments 1979		Treatments 1981	Grain
1.	CuS	S	0.75
2.	CuZnS	S	1.02
3.	CuS	ZnS	1.06
4.	CuZnS	S	1.01
5.	-	-	0.48
6.	Cu	-	0.66
7.	CuZn	-	1.16
8.	Super-Agran	-	0.55
9.	Cu	-	0.90
10.	CuZn	-	1.19

TRS No. 1-7 incl. - sown with DAP (100 kg ha^{-1})
TRS 8-10 - sown with Super-Agran mix
TR4 - sown with twice the recommended zinc rate

S = Gypsum at 167 kg ha^{-1} mixed with DAP
Cu = Copper sulphate at 6 kg ha^{-1} mixed with DAP
Zn = Zinc oxide at 1 kg ha^{-1} mixed with DAP

152

4. ZINC RESIDUAL WITH HIGH ANALYSIS NP FERTILISER FOR WHEAT 79Me23/2247EX

Aim: To measure any decline in effectiveness of zinc on this soil type using high analysis NP fertiliser

Soil: Sand

Location: Narembeen - Della Vedova

Sown: June 16, 1981 wheat 39 kg ha^{-1}

Table 4. Wheat yields (t ha^{-1}) for 79Me23 harvested December 4, 1981

Treatments 1979	Treatments 1981	Grain
1. CuS	S	0.68
2. CuZnS	S	1.15
3. CuS	ZnS	1.09
4. CuZnS	S	1.09
5. -	-	0.74
6. Cu	-	0.76
7. CuZn	-	1.27
8. Super-Agran	-	0.66
9. Cu	-	0.71
10. CuZn	-	1.12

TRS 1-7 incl. - sown with DAP (100 kg ha^{-1})
TRS 8-10 - sown with Super-Agran mix
TR4 - sown with twice the recommended zinc rate

S = Gypsum at 167 kg ha^{-1} mixed with DAP
Cu = Copper sulphate at 6 kg ha^{-1} mixed with DAP
Zn = Zinc oxide at 1 kg ha^{-1} mixed with DAP

153

5. ZINC, SULPHUR, COPPER RESIDUAL WITH HIGH ANALYSIS NP FERTILISER FOR WHEAT 78WH66/2247EX

Aim: To measure any decline in effectiveness of Cu, Zn, S on this soil type using DAP fertiliser

Location: Wongan Hills Research Station

Soil: Grey sandy loam

Sown: June 29, 1981 - wheat at 50 kg ha^{-1}

Table 5. Grain yields (t ha^{-1}) for wheat at Wongan Hills Research Station 78WH66

	Treatments 1979	Treatments 1981	Grain
1.	Cu + Zn	Zn	1.87
2.	Cu + Zn + S	Zn	2.05
3.	Cu + Zn	Zn + S	1.94
4.	Cu + S	S	1.91
5.	Cu + Zn + S	S	1.91
6.	Cu + S	Zn + S	1.82
7.	Zn + S	Zn + S	1.60
8.	Cu + Zn + S	Zn + S	1.81
9.	Zn + S	Cu + Zn + S	1.72
10.	-	-	1.50
11.	Cu	-	1.39
12.	Cu + Zn	-	1.71
13.	Super-Agran	-	1.72
14.	+ Cu	-	1.34
15.	+ CuZn	-	1.89

TRS 1-12 incl. - DAP treatments, TR 13-15 Super-Agran mix

154

6. WHEAT RESPONSE TO ZINC RATES
81MO8/4035EX

Aim: To measure the response of wheat to zinc applied with super and zinc sprayed on the soil immediately before seeding on this site which produced zinc deficient plants in 1980

Soil: Grey clay loam, calcareous sub-soil
Surface pH 8.8

Basals: Urea 50 kg ha^{-1} T.D.
Plain Super 100 kg ha^{-1}

Location: Gabalong

Farmer: Crane

Sown: June 18, 1981 - Miling wheat 47 kg ha^{-1}

Table 6. Grain yields (t ha^{-1}) from zinc rates trial 81MO8

Treatment	Grain (t ha^{-1})
1. Nil Zn	1.48
2. Nil Zn	1.51
3. Nil Zn	1.52
4. Nil Zn	1.48
5. ZnO 1 kg ha^{-1}	1.71
6. ZnO 2 kg ha^{-1}	1.75
7. ZnO 4 kg ha^{-1}	1.79
8. ZnO 6 kg ha^{-1}	1.86
9. $ZnSO_4$ (3.5 kg ha^{-1})	1.72
10. $ZnSO_4$ (7.0 kg ha^{-1})	1.81

TRS 9-10 - sprayed immediately before seeding

155

7. MANGANESE ON WHEAT AND OATS
81KA29/1509EX

Aim: To determine the response to manganese on wheat and oats on land where low levels of manganese were found in clover pasture in 1980

Location: Kojonup
Forrester

Sown: June 19, 1981
Wheat 48 kg ha^{-1}
Oats 50 kg ha^{-1}

Table 7. Yields (t ha^{-1}) for wheat and oats
Harvested December 20, 1981
Dry weight of top sampled September 23, 1981

Treatments		Grain	Dry weight of tops
1. Super (170 kg ha^{-1})	Wheat	2.64	1.45
2. Super + $MnSO_4$ (15 kg ha^{-1})	Wheat	2.87	1.52
3. Super + $MnSO_4$ (30 kg ha^{-1})	Wheat	2.98	1.53
4. Super + $(NH_4)_2 SO_4$ (167 kg ha^{-1})	Wheat	3.15	1.75
5. Super + S/A + $MnSO_4$ (15)	Wheat	3.13	1.73
6. Agras No. 1 (200 kg ha^{-1})	Wheat	3.01	1.76
7. Agras No. 1 + $MnSO_4$ (15)	Wheat	3.32	1.74
8. Agras No. 1 + $MnSO_4$ (30)	Wheat	2.95	1.76
9. Super + Urea TD (76 kg ha^{-1})	Wheat	2.85	1.69
10. Super + $MnSO_4$ (15) + Urea TD	Wheat	3.05	1.74
11. Super + Urea TD + Mn spray	Wheat	2.69	1.50
12. Super (170)	Oats	3.13	2.88
13. Super + $MnSO_4$ (15)	Oats	3.19	2.93
14. Agras No. 1 (200)	Oats	3.04	3.49
15. Agras No. 1 + $MnSO_4$ (15)	Oats	3.27	3.46

N.B. Dry weight of tops. Plants sampled on September 23, 1981. Wheat at Stage 8. Oats Stage 10.

Results

1. Suggest a response to nitrogen with little or no effect of manganese fertiliser at this site for both wheat and oats.

2. The effects of manganese rates and nitrogen fertiliser on the uptake of manganese could be reflected in the concentraion of manganese in plant parts as results become available.

156

8. MOLYBDENUM AND AMMONIUM SULPHATE (S/A) ON WHEAT
81NO40/1213EX

Aim: To determine the response of wheat to molybdenum at different rates of S/A at this site where low Mo levels were found in wheat samples

Basals: Super 150 kg ha^{-1}
Wheat 50 kg ha^{-1}

Location: A.R. Uppill and Co.
Tammin

Soil: Hard setting yellow sandy loam

Table 8. The effect of molybdenum and rates of sulphate of ammonia on wheat grain yield (t ha^{-1}) - harvested December 7, 1981

Treatment	Grain yield t ha^{-1}
1. Nil Mo or S/a	0.83
2. Mo oxide 180 g/ha	1.17
3. Mo oxide 360 g/ha	1.23
4. Nil Mo; S/A 120 kg/ha	0.52
5. Mo oxide 180 g/ha; S/A 120 kg/ha	1.16
6. Mo oxide 360 g/ha; S/A 120 kg/ha	1.17
7. Nil Mo; S/A 240 kg/ha	0.45
8. Mo oxide 180 g/ha; S/A 240 kg/ha	1.15
9. Mo oxide 360 g/ha; S/A 240 kg/ha	1.20

Results illustrate:

(1) Response to molybdenum at each S/A rate to at least 180 g $MoO_3 ha^{-1}$
(2) Application of S/A reduces grain yield with no Mo applied due to pH effect and dilution of plant Mo resulting from response to nitrogen

Table 9. Mo concentration (ppm) in YFEL - Tammin

	S/A rate kg ha^{-1}		
Mo rate (g ha^{-1})	0	120	240
0	0.04	0.02	0.04
180	0.26	0.14	0.15
360	0.70	0.36	0.37

Sampled August 19, 1981 - Stage 5-6

Results

(1) Illustrate the effect of sulphate of ammonia on the concentration of Mo in the youngest fully emerged leaves and consequently plant uptake of molybdenum
(2) Levels of 0.04 ppm Mo in the YFEL at this stage of sampling would be considered deficient

9. MOLYBDENUM AND AMMONIUM SULPHATE (S/A) ON WHEAT
81NO41/1213EX

Aim: To determine whether wheat would response to rates of molybdenum at different rates of ammonium sulphate at this site where low Mo levels were found in previous wheat samples (83µg/g)

Basals: Super 150 kg ha^{-1}
Wheat 50 kg ha^{-1}

Location: C. Drakebrockman - Northam

Soil: Red brown loam - jam country

Table 10. The effect of molybdenum and rates of sulphate of ammonium wheat grain yields (t ha^{-1}) - harvested December 14, 1981

Treatment	Grain yield t ha^{-1}
1. Nil Mo or S/a	1.72
2. Mo oxide 180 g/ha	1.80
3. Mo oxide 360 g/ha	1.75
4. Nil Mo; S/A 120 kg/ha	2.33
5. Mo oxide 180 g/ha; S/A 120 kg/ha	2.34
6. Mo oxide 360 g/ha; S/A 120 kg/ha	2.26
7. Nil Mo; S/A 240 kg/ha	2.33
8. Mo oxide 180 g/ha; S/A 240 kg/ha	2.51
9. Mo oxide 360 g/ha; S/A 240 kg/ha	2.55

Results illustrate:

(1) Greater response to nitrogen than molybdenum

Table 11. Mo concentration (ppm) in YFEL - Northam

	S/A rate kg ha^{-1}		
Mo rate (g ha^{-1})	0	120	240
0	0.21	0.09	0.07
180	0.70	0.59	0.51
360	1.43	1.27	1.04

Sampled August 19, 1981 - Stage 6 (first node of stem visible)

Results

(1) Illustrate the effect of additions of molybdenum on its concentration in YFEL for each rate of sulphate of ammonia
(2) Illustrates the effect of additions of ammonium sulphate on the concentration of molybdenum in the youngest fully emerged leaves for each addition of molybdenum
(3) Levels of 0.07 ppm Mo in the youngest fully emerged leaves would not be considered deficient and no response to molybdenum was observed in this trial

10. MOLYBDENUM AND AMMONIUM SULPHATE (S/A) ON WHEAT
81NO39/1213EX

Aim: To determine whether wheat grain yields woud resopnse to molybdenum at different rates of ammonium sulphate at this site where Mo levels in wheat plants were found to be 94μg/g in youngest fully emerged leaves.

Basals: Super 150 kg ha^{-1}
Wheat 50 kg ha^{-1}

Location: P.B. Kelly, Meckering

Soil: Light grey sand - blackboy

Table 12. The effect of molybdenum and rates of S/A on wheat grain yield (t ha^{-1}) - harvested December 14, 1981

Treatment	Grain yield t ha^{-1}
1. Nil Mo or S/a	0.19
2. Mo oxide 180 g/ha	0.23
3. Mo oxide 360 g/ha	0.18
4. Nil Mo; S/A 120 kg/ha	0.52
5. Mo oxide 180 g/ha; S/A 120 kg/ha	0.41
6. Mo oxide 360 g/ha; S/A 120 kg/ha	0.47
7. Nil Mo; S/A 240 kg/ha	0.45
8. Mo oxide 180 g/ha; S/A 240 kg/ha	0.44
9. Mo oxide 360 g/ha; S/A 240 kg/ha	0.37

Trial site poorly worked.

Table 13. Mo concentration (ppm) in YFEL

	S/A rate kg ha^{-1}		
Mo rate (g ha^{-1})	0	120	240
0	0.13	0.09	0.09
180	0.88	0.71	0.84
360	2.07	1.87	2.17

Sampled August 19, 1981 - Stage 3 tillers formed
Kelly: Meckering
Grey sand, blackboy country

Mo concentration of 1980 sample = 94μg/g

Site: Poorly prepared, weed control poor, waterlogged (partly)

159

11. Mo, LIME, Mg ON SUB. CLOVER - TALBOT BROOK
80NO29

Aim: To check for any résonse to Mo, lime, Mg and super at this site

Soil: Brown gravelly sand

Table 14. Dry matter yield and per cent response for 80NO 29
Sample October 15, 1981

Treatments 1980	DM yield (kg/ha)	% yield response to TR4
1. Mo oxide 180 g/ha	681	80
2. Mo oxide 180 g/ha + Super 100 kg/ha	759	89
3. Mo oxide 180 g/ha + super 200 kg/ha	793	94
4. Mo oxide 180 g/ha + Super 400 kg/ha	845	100
5. Super 200	801	95
6. Super 200 + ground limestone 2 t/ha	793	94
7. Super 200 + ground limestone 2 t/ha + Mo oxide 180 g	792	94
8. Super 200 + magnesium carbonate 2 t/ha + Mo oxide 180 g	806	95
9. Super 200 + magnesium sulphate 150 kg/ha + Mo oxide 180 g	802	95

TRS 1981: Super applied at those rates defined in 1980 schedule. Topdressed May 12, 1981

N.B. Trial grazed continuously until September 7

Conclusion

1. Marked response to super

2. Mo, lime, Mg appeared to have no beneficial effect that carried over into second year

3. Mo, lime, Mg had no beneficial effect on pasture production in 1980

12. COPPER AND ZINC RESIDUAL ON PEATY SAND
75A124/2247EX

Aim: To meaure the rate of decline, if any, on the effectiveness of topdressed copper and zinc

Soil: Plantagenet peaty sand

Basal: Super 400 kg/ha T.D.

Table 15. Dry matter yield and plant analysis

Treatment	Dry matter t/ha	Zinc concentration (ppm)	Cu concentration
A. Nil copper and zinc	1.4	38	5.5
B. 11 kg/ha $CuSO_4$ in 1975	1.7	37	6.9
C. 3.3 kg/ha ZnO in 1975	1.7	40	7.1
D. 11 kg/ha $CuSO_4$/ha + 3.3 kgZnO in 1975	1.8	39	6.4
1. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975 + 5.5 kg/ha $CuSO_4$TD in 1975	1.5	38	6.2
2. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975 + 5.5 kg/ha $CuSO_4$ in 1977	1.9	45	8.0
3. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975 + 5.5 kg/ha $CuSO_4$ in 1980	1.9	45	9.8
4. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975	1.6	42	5.6
5. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975	1.5	41	8.2
6. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975 + 1.65 kg/ha ZnO in 1975	1.6	46	6.9
7. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975 + 1.65 kg/ha ZnO in 1977	1.7	45	6.7
8. 5.5 kg/ha $CuSO_4$ + 1.65 kg/ha ZnO in 1975 + 1.65 kg/ha ZnO in 1980	1.8	77	7.1

161

13. COPPER, ZINC RESIDUAL ON CLOVER PASTURE
78MO36/2247EX

Aim: To measure any decline in the effectiveness of copper and zinc at this site

Location: Dandaragan - P. Shields

Soil: Red sand

Basals: 3.3 kg copper sulphate/ha
1 kg zinc oxide, applied in 1978 drilled with Seaton Park

Table 16. Effect of zinc application on the concentration of zinc in clover plant tops from 78MO36. Results the mean of three replicates.

Treatment	Zinc concentration in whole tops (ppm)
1. ZnO 1 kg/ha 1978*1	24
2. ZnO 1 kg/ha 1978 TD	25
3. ZnO 1 kg/ha 1980	26
4. Basals only 1978	21

*1 Drilled

No difference between treatments in plant growth was measured

162

ZINC: CORRECTION OF PASTURES DEFICIENT IN ZINC FOR SHEEP

Objectives:

1. Defining soils and soil characteristics associated with the most rapid rate of decline in plant availability of applied zinc.

2. Measuring leaching losses of zinc in field situations varying in soil type and amount of precipitation.

3. Measuring the rate of decline in the residual effectiveness for plant uptake of zinc fertiliser at 10 field sites and the rate of annual zinc fertiliser application required to maintain herbage zinc levels.

Results

1. Rate of movement of zinc through soil:

(a) Radioactive zinc as chloride was converted to zinc oxide and sulphate. The equivalent of 1 kg of zinc oxide per hectare spiked with radioactive zinc was applied to 1 sq. m plots either as oxide or sulphate. The soil type was a silty sand in a 1,100 mm rain zone. The plots were topdressed with the equivalent of 800 kg superphosphate and 5.6 kg copper sulphate per hectare.

Samples of the profile were taken at fortnightly intervals and sliced into 10 mm segments. To minimise contamination of the profile by the sampling tube, each 10 mm slice was sub-sampled using a smaller diameter tube forced through the slice from the lower to upper surface.

Measurement of residual radioactivity in each sub-sample demonstrated that after 875 mm of rainfall, 90 per cent of the zinc remained in the top 20 mm of soil with the remaining 10 per cent retained in the top 20 to 30 mm. These plots will be sampled again in 1981 possibly on monthly intervals as results to date show very little movement of zinc in soils even in this high rainfall zone.

(b) Two field trials were sampled for movement of zinc through the soil after one and two years of rainfall. These sites were located on sandy soil types in a 1,150 mm rainfall zone.

These trials involved rates of zinc, as zinc sulphate, applied either as a solution or solid. The method of application resulted in uneven distribution over the soil surface (1 sq. m plots) resulting in variability in the ammonium oxalate extraction of zinc. This variability was overcome to a certain extent by both increasing the number of samples taken per plot as well as increasing the number of replicates of each zinc level.

The cores taken from each plot were sliced into 25 mm lengths and analyses separately for ammonium oxalate and total extractable zinc.

163

Measurement of ammonium oxalate zinc after two years of rainfall demonstrated that 90 to 95 per cent of the zinc applied originally could be accounted for in the top 25 mm.

These results show zinc moves slowly in these soils.

It appears that leaching is not important in reducing the availability of fertiliser zinc to plants and sheep. The principle thrust of this project will now be to identify those soils and soil properties causing zinc availabilty to decline, and to establish satisfactory methods for maintaining adequate zinc supplies on these soils.

2. Zinc incubation studies:

(a) Effect of zinc application and incubation on the availability of zinc to clover plants

All sections of this experiment need to be completed before overall conclusions can be made of soil types and soil factors which are involved in the "fixation" of zinc and what soils are most likely to require repeat application (or maintenance applications) of zinc.

In this glasshouse work an incubation technique was employed. This period of warm moist incubation was to allow zinc to react with soil constituents and then this treatment was compared to where zinc was applied just before sowing the clover seed.

Table 1. Effect of zinc rates and incubation of zinc on the dry matter yield of Nungarin clover tops (g/five plants) harvested mid to late flowering (August 1981)

Soil	Zinc treatment					
	0	400F	400I	800F	800I	Zn800F-ZnO x 100%
Badgingarra - grey sand	1.5	8.9	7.7	9.8	9.7	85
Esperance - grey sand	3.4	6.9	6.5	8.0	8.0	58
Jerramungup - pink moort clay	7.9	8.6	8.5	8.9	8.9	11
Jerramungup - grey moort clay	6.4	8.2	7.6	8.6	8.5	26
Pindar - brown S/L	8.7	8.8	8.9	9.1	9.0	4
Tenindewa - brown sand	3.3	7.6	6.9	9.0	9.0	63
Gingin - red loamy sand	5.1	7.4	6.8	8.3	8.0	38
Wyalkatchem - red brown S/L	5.9	6.9	6.9	6.8	6.9	13
Salmon Gums - circle valley sand	4.4	7.3	7.0	8.2	8.1	46
Bramley - mungite sand	3.3	8.5	7.4	9.9	9.8	67
Hyden - grey brown S/L	2.2	6.8	5.0	8.4	8.5	74
Talbot Brook - brown gravelly	1.2	7.1	4.5	9.5	6.7	87

Soils varied on the magnitude of the dry matter response to applied zinc (Table 1). Small responses to applied zinc were observed on the pink moort clay (11 per cent), the brown sandy loam from Pindar, and the red-brown loam collected from Wyalkatchem (Table 1).

At the lowest level of applied zinc, 400 micrograms per pot, incubation of the zinc with the warm moist soil reduced the availability of the zinc and hence reduced the dry matter production of clover tops. When the analysis of clover tops and plant parts becomes available, calculation of zinc content will be made and the effectiveness of the incubated zinc compared to that freshly applied can be made. Previous experimental work with copper, has shown that plant uptake is far more sensitive in measuring plant availability of micronutrients than dry matter of plant tops.

Symptoms of severe zinc deficiency in sub. clover were easily recognised on all soils where there were large responses to zinc. The growth rates of tops were drastically depressed in zinc deficient plants. Trifoliate initiation on the main axis and lateral initiation were also both delayed and as a result at anyone time lateral production and hence trifoliate number were markedly lower than for zinc-adequate plants. Trifoliate size and petiole length were also markedly reduced.