QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 529

METHODS OF CORRECTING ZINC DEFICIENCY IN IRRIGATED MAIZE GROWN ON A BLACK EARTH SOIL, DARLING DOWNS, QUEENSLAND

By D. E. HIBBERD, B.Agr.Sc.

SUMMARY

Soil applications of 28-42 lb/ac of zinc sulphate heptahydrate and 12 lb/ac of zinc oxide increased grain yields of maize when applied in drills near the seed. Spray applications of zinc sulphate also increased grain yields but to a lesser extent. Spray applications of zinc sulphate following soil applications of zinc sulphate or zinc oxide did not give further yield increases. Zinc oxide dusting of seed increased grain yields and appears to be a promising remedial technique.

I. INTRODUCTION

The role of zinc in maize nutrition has been reviewed by Pierre, Aldrich and Martin (1966). Zinc deficiency in maize has been corrected by zinc sulphate sprays (Viets 1951; Lingle and Holmberg 1956; Pumpfrey and Koehler 1959; Grunes *et al.* 1961; Brinkerhoff *et al.* 1967) and also by soil applications of zinc sulphate (Grunes *et al.* 1961). Shukla and Morris (1967) found soil applications of zinc sulphate to be more effective than soil applications of zinc oxide. Soil applications at excessively high rates (the level varies with soil type and species) can be toxic to plant growth (Mitchell 1963) and can cause an imbalance of nutrients (Lucas 1945; Brown and Tiffin 1962). In their review, Pierre, Aldrich and Martin (1966) found that where soil and foliar treatments had been compared under field conditions, soil applications had usually given better results.

Maize grown on the heavy black earth soils of the Darling Downs frequently suffers from a sporadic zinc unavailability. Symptoms of the disorder have been described by Duncan (1967), who indicated that control with zinc sulphate in commercial rain-grown maize crops is achieved by zinc sulphate sprays. Under flood irrigation the disorder may be aggravated (Cass-Smith and Harvey 1948; Rai 1959). The investigations reported here were carried out to compare soil and spray applications of zinc sulphate, soil applications of zinc oxide, and some combinations, on an irrigated black earth soil classified Ug5 16 (Northcote 1967).

II. EXPERIMENTAL

Experiment 1:1967–68 *season.*—The aim was to compare the effectiveness for zinc deficiency control of soil applications of zinc sulphate with one or more foliar sprays. Zinc sulphate mixed with sand was drilled in rows (42 in. apart) to a depth of about 1 in. below where the seed was to be placed. Planting with standard machinery was then carried out and the seed (cv. Q739) planted 3 in. deep.

A basal dressing of 90 lb N/ac as anhydrous ammonia was applied to the experimental area about 3 months prior to planting. Standard soil analytical data are given in Table 1.

TABLE 1

MEAN SOIL ANALYSIS OF THE TOP 4 IN. OF SOIL FROM BOTH EXPERIMENTS

—	Experiment 1	Experiment 2
pH	8·2	7·3
Available P (p.p.m.) by 0·01N H_2SO_4 extraction ..	170+	570
Replaceable K (m-equiv. %)	1·74	1·45
Total N (%)	0·051	0·055
Organic carbon (%)	0·9	0·9
Colour	Dark grey	Dark grey
Texture	Silty clay loam	Clay

The trial was laid down as an 11 x 3 randomized block, with a harvested plot area of 0·01 ac and a plant population of 11,700 plants per acre. Treatments are shown in Table 2.

Experiment 2:1968–69 *season.*—The aim was to compare the effectiveness for zinc deficiency control of soil and spray applications of zinc sulphate, soil applications of zinc oxide, and some combinations.

Zinc sulphate and zinc oxide, mixed with sand, were drilled in 30 in. rows, using a manual planting device, at a depth of 1 in. below the predetermined seed planting depth of 3 in. Seed (cv. DS28) was then planted in the same row in a separate operation.

A basal dressing of 110 lb N/ac as anhydrous ammonia was applied to the experimental area approximately 3 months prior to planting. Standard soil analytical data are given in Table 1.

The trial was laid down as a 14 x 3 randomized block, with a harvested plot area of 0·004 ac and a plant population of 24,000 plants per acre. Treatments are given in Table 3.

A zinc oxide dust coating over seeds was provided by mixing 8 oz of zinc oxide with 10 lb seed. The zinc oxide pellet was made by using a modification of the method of lime-pelleting lucerne seed used by Roughly, Date and Walker (1966). In this experiment, quantities used were gum arabic 0·5 oz, hot water 200 ml, zinc oxide 8 oz; 3–5 lb maize seed was then pelleted and more water was added as required.

III. RESULTS

Experiment 1.—Data on grain yields, number of cobs per stalk and number of grains per cob are presented in Table 2. Highest grain yield per acre (4,000 lb) was given by 42 lb zinc sulphate per acre applied to the soil, though this was not significantly greater than the grain yield of the plots receiving 28 lb zinc sulphate per acre as a soil application. No single spray application or combination of spray applications produced a similar yield increase. There was no significant yield increase when spray applications were given to plots receiving 28 lb zinc sulphate per acre as a soil application. An examination of the yield components indicated that the yield increases resulted from increases in the number of cobs per stalk and the number of grains per cob.

TABLE 2

EFFECT OF ZINC SULPHATE ON GRAIN YIELD, COB AND GRAIN SET IN MAIZE, EXPERIMENT 1

Treatment	Grain Yield (lb/ac)	No. of Cobs per Stem	No. of Grains per Cob
1. Control	1,758	1·13	262
2. 14 lb per acre $ZnSO_4$, soil application	3,183	1·45	335
3. 28 lb per acre $ZnSO_4$, soil application	3,683	1·51	397
4. 42 lb per acre $ZnSO_4$, soil application	4,000	1·48	424
5. 84 lb per acre $ZnSO_4$, soil application	3,917	1·44	387
6. 1% $ZnSO_4$ spray at 3 weeks	2,600	1·35	347
7. 1% $ZnSO_4$ spray at 5 weeks	2,083	1·28	310
8. 1% $ZnSO_4$ spray at 3 + 5 weeks	2,650	1·31	344
9. 1% $ZnSO_4$ spray at 3 + 5 + 7 weeks	2,583	1·31	340
10. 28 lb per acre $ZnSO_4$, soil application + 1% spray at 3 weeks	2,700	1·48	402
11. 28 lb per acre $ZnSO_4$, soil application + 1% spray at 3 + 5 weeks	3,833	1·41	428
S.E. of treatment means	203	0·06	19
Necessary differences for significance 5%	595	0·16	56
Necessary differences for significance 1%	807	0·22	76

Experiment 2.—Data on grain yield, grain weight per cob and number of grains per cob are given in Table 3. Grain yield of control plots was high at 5,080 lb/ac. No serious zinc deficiency symptoms were observed during growth. Nevertheless, soil applications of zinc sulphate and applications of zinc oxide to the soil and to the seed (as dust and as pelleted seed) gave grain yield increases approaching significance ($P < 0{\cdot}05$; $P < 0{\cdot}1$). There was no significant difference between sources of zinc. Spray applications did not significantly increase yields above soil applications. In this trial increased grain yields resulted from an increase in grain weight per cob; the number of grains per cob remained relatively constant. Soaking the seed in 3% zinc sulphate solution for 12 hr prior to planting reduced grain yield.

TABLE 3

EFFECT OF SOURCE OF ZINC AND METHOD OF APPLICATION ON GRAIN YIELD, COB NUMBER AND GRAIN SET IN MAIZE, EXPERIMENT 2

Treatment	Grain Yield (lb/ac)	Grain Weight per Cob (g)	No. of Grains per Cob	No. of Stems per Acre at Maturity
1. Control	5,080	343	304	26,100
2. 1% zinc sulphate spray at 3 weeks	5,254	331	280	26,500
3. 1% zinc sulphate spray at 3 weeks and when required	5,105	365	293	25,100
4. Soil application of 42 lb zinc sulphate per acre	5,553	393	324	24,700
5. Soil application of 42 lb zinc sulphate per acre + 1% zinc sulphate spray at 3 weeks	5,603	387	317	25,200
6. Seed soaked in 3% zinc sulphate solution for 12 hr	4,457	313	279	24,200
7. Seed soaked in 3% zinc sulphate solution for 12 hr + a 1% zinc sulphate spray at 3 weeks	5,005	417	333	22,000
8. Soil application of 12 lb zinc oxide (12 lb ZnO = 42 lb $ZnSO_4 \cdot 7H_2O$) per acre	5,727	407	338	23,500
9. Soil application of 12 lb zinc oxide + a 1% zinc sulphate at 3 weeks	5,453	364	294	25,400
10. Zinc oxide dust on seed	5,727	416	359	23,600
11. Zinc oxide dust on seed + a 1% zinc sulphate spray at 3 weeks	5,428	386	325	24,300
12. Zinc oxide pelleting of seed	5,677	372	330	25,700
13. Zinc oxide pelleting of seed + a 1% zinc sulphate spray at 3 weeks	5,553	424	339	23,700
S.E. of treatment means	234	5	17	900
Necessary differences for significance 5%	672	15	48	NS
Necessary differences for significance 1%	573	9	40	2,100

IV. DISCUSSION

The data obtained from both trials indicate that soil applications gave better results than spray applications and this is in line with the comments of Pierre, Aldrich and Martin (1966). The superior efficiency of soil applications may be explained by the continuous availability of zinc to the seed from germination onwards. The data also suggest that yield increases from soil applications of zinc can be obtained even when plants appear to be growing satisfactorily and when visual deficiency symptoms are not marked.

No explanation can be offered for the reduced grain yield resulting from soaking the seed in 3% zinc sulphate for 12 hr. This treatment would no doubt initiate the germination processes and perhaps the germinating seed received a setback when transferred to the less hospitable environment of the soil. While the plant population in this treatment was lower than that in many other treatments, it was not greatly lower than the trial mean—24,600 plants per acre.

The lower yields in experiment 1 are undoubtedly due to the low plant population—11,700 plants per acre, which approximates the optimal plant population figure for rain-grown maize. In experiment 2 the plant population was adjusted to the figure shown by Dickson (1968) to be optimal for irrigated maize.

These investigations indicate that, for irrigated maize, soil applications of 42 lb zinc sulphate ($ZnSO_4.7H_2O$) per acre or 12 lb zinc oxide (ZnO) per acre are reasonable for maximum yields. Dusting of the maize seed with pure zinc oxide powder in experiment 2 also gave high yield increases. It is considered, however, that there is insufficient experience with this technique and further studies are desirable before it is recommended.

V. ACKNOWLEDGEMENTS

Grateful appreciation is expressed to Mr. J. Eggleston, "Melrose", Brookstead, and Mr. R. Stirling, "Braemar", Brookstead, for their keen interest and co-operation in these investigations.

REFERENCES

BRINKERHOFF, F., ELLIS, B., DAVIS, J., and MELTON, J. (1967).—Field and laboratory studies with zinc fertilization of pea beans and corn in 1966. *Q. Bull. Mich. agric. Exp. Stn* 49:262-75.

BROWN, J. C., and TIFFIN, J. O. (1962).—Zinc deficiency and iron chlorosis dependent on the plant species and nutrient element balance in Tulare clay. *Agron. J.* 54:356-8.

CASS-SMITH, W. P., and HARVEY, H. L. (1948).—Zinc deficiency of flax. *J. Dep. Agric. W. Aust.* 25:136-42.

DICKSON, T. (1968).—Plant density and nitrogen studies with irrigated hybrid maize in the Lockyer Valley, Queensland. *Qd J. agric. Anim. Sci.* 25:199-210.

DUNCAN, O. W. (1967).—Correction of zinc defiiciency in maize on the Darling Downs, Queensland. *Qd J. agric. Anim. Sci.* 24:293-300.

GRUNES, D. L., BOAWN, L. C., CARLSON, C. W., and VIETS, F. G. Jr. (1961).—Zinc deficiency of corn and potatoes as related to soil and plant analysis. *Agron. J.* 53:68-76.

LINGLE, J. C., and HOLMBERG, D. M. (1956).—Sweet corn, tomatoes, beans and sugar beets used in tests for zinc deficiency. *Calif. Agric.* 10:13-4.

LUCAS, R. E. (1945).—The effect of the addition of sulphates of copper, zinc and manganese on the absorption of these elements by plants grown on organic soils. *Proc. Soil Sci. Soc. Am.* 10:269-74.

MITCHELL, R. L. (1963).—Soil aspects of trace element problems in plants and animals. *J. R. agric. Soc. Eng.* 124:75-86.

NORTHCOTE, K. H. (1967).—"Atlas of Australian Soils. Explanatory data for Sheet 4. Brisbane-Charleville-Rockhampton-Clermont area". (C.S.I.R.O. and Melbourne University Press: Melbourne).

PIERRE, W. H., ALDRICH, S. A., and MARTIN, W. P. (Eds.) (1966).—"Advances in Corn Production: Principles and Practices". (Iowa State University Press: Ames).

PUMPFREY, F. V., and KOEHLER, F. E. (1959).—Symptoms and control of zinc deficiency in corn. *Circ. Nebr. agric. Exp. Stn* No. 102.

RAI, K. D. (1959).—Zinc sulphate as a corrective of chlorosis in maize on the heavy alkaline soils of the central rainlands, Tozi, Sudan. *Indian J. Agron.* 4:82-91.

ROUGHLY, R. J., DATE, R. A., and WALKER, M. H. (1966).—Inoculating and lime pelleting legume seed. *Agric. Gaz. N.S.W.* 77:142-6.

SHUKLA, U. C., and MORRIS, H. D. (1967).—Relative efficiency of several zinc sources for corn (*Zea mays* L.). *Agron. J.* 59:200-2.

VIETS, F. G. Jr. (1951).—Zinc deficiency of corn and beans on newly irrigated soils in Central Washington. *Agron. J.* 43:150-1.

(Received for publication November 13, 1969)

The author is an officer of Agriculture Branch, Queensland Department of Primary Industries, and is stationed at Toowoomba.