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ZINC AND COPPER DEFICIENCY IN PLANTS.

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STUDIES OF ZINC AND COPPER DEFICIENCY IN THE FIELD
AND IN THE LABORATORY

(The subject of published work submitted to the Faculty of Science of the University of Adelaide for the Degree of Doctor of Science, by D. S. Riceman, M.Sc.)

PREFACE AND NOTES

These studies were begun in 1935 when the writer joined the staff of the Animal Nutrition Laboratory of the Council for Scientific and Industrial Research (which was later to become the Division of Biochemistry and General Nutrition of the Commonwealth Scientific and Industrial Research Organization). At this time the cause of "coast disease", a fatal wasting disease of sheep grazing on the calcareous littoral in the vicinity of Robe, South Australia, was one of the problems being investigated. The natural pastures which were supported by this soil consisted almost entirely of inferior annual grasses. Rye was the only cereal that could be grown successfully. Wheat, oats and barley grew poorly, developed disease symptoms, and produced little or no grain. Attempts made to establish sown pastures invariably failed. It was the writer's responsibility to investigate the cause of plant failure and to devise ways of overcoming it. Preliminary experiments with the common fertilizers, plant species, and methods, all gave negative results, but at this time the group investigating the cause of "coast disease" showed that an insufficiency of copper in the diet of the ruminant animal was involved in that malady. This information was acted upon and in a very short time it was proved that the chief reason for the failure of pasture plants and crops sown in these soils could be attributed to copper deficiency. There were no previous records of copper deficiency affecting pastures or crops in this country, and a programme of experimental work was carried out, as a result of which it became possible to recognise the deficiency in different plant species, and to recommend ways of correcting it, or of preventing its occurrence. This research, which extended over a period of ten years, indicated how several hundred square miles of coastal country of this type

could be brought profitably into production, and stimulated the re-examination of refractory soils by workers in other parts of the Commonwealth.

In 1944 the writer began a study of the mineral nutrition of plants grown in the sandy soils of the Ninety-mile Desert in South Australia, a region which was later referred to as the Ninety-mile Plain and which has now become officially known as the Coonalpyn Downs. The soils here are siliceous sands of varying depth over clay or limestone, as distinct from the deep, calcareous sand of adjacent coastal areas, as at Robe. This region occupies an area of some 10,000 square miles in South Australia and Victoria, and although the climate over the greater part of it is suitable for the production of cereal crops and sown pastures, scarcely any development had taken place because of the poor yields or the actual failure of the plants that were sown. There were good reasons to suspect the occurrence of mineral deficiencies here. Experiments were begun and these demonstrated the occurrence of deficiencies of zinc and copper as well as of phosphorus and nitrogen in these soils. Methods by which the deficiencies could be economically corrected were examined, and, so that the behaviour of pastures composed of several species might be more readily understood, studies were made of the effects of interspecific competition and of the effects of differential response by plant species to fertilizer treatment. Large areas of land in the Coonalpyn Downs have been brought into production as a result of this research.

There then arose a need to investigate the potentialities of grain legumes in the sandy soils of the Coonalpyn Downs and so, to supplement the main theme of experimental work being carried out, a detailed study was made of the characteristics and performance of a wide range of these species.

Then followed a close study of the growth of subterranean clover in solution culture, and of the distribution of zinc and copper among the plant organs. Seeds and seedlings were examined first, and then the growth of the plant organs and the distribution of zinc and copper among them were followed over the whole growing period. Data of this sort, which were not available before, provided the background for studies of the amounts and concentrations of zinc and copper in individual leaves and petioles as they emerged and expanded. This research

contributed to an understanding of the rapidly changing concentrations of zinc and copper that are observed in plant organs, and has helped to clarify the relationship between zinc content, zinc concentration, and zinc status of the plant.

The published work which is submitted includes two review papers. One was presented at the British Commonwealth Scientific Official Conference held in Adelaide in 1949; the other was presented by invitation at a symposium held by the Soil Science Society of Florida in 1950. Unpublished sections of the work appear in the Annual Reports of the C.S.I.R.O., but these are not submitted to the examiners.

Much of the published work is the result of co-operative effort, and the inclusion of the names of junior authors indicates where this has been the case. However, in all the papers in which he is the senior author the candidate took the initiative in the work, made his own interpretation of the results, and prepared either the whole or the major part of the paper for publication. The candidate pays special tribute to his colleague G. B. Jones; the precise chemical work - method and performance - was entirely his responsibility.

The candidate was a junior author in two of the papers which are submitted. In one of them (by W. V. Ludbrook, J. Brockwell, and D. S. Riceman) he recognised the initial problem and its implications but took no part in the experimental work. In the other (by G. B. Jones, D. S. Riceman, and J. O. McKenzie) his contribution was limited to discussion at the planning stage of the experiments.

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