Plant nutrition in Western Australia

George Henry Burvill
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PLANT NUTRITION IN WESTERN AUSTRALIA

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PLANT nutrition is of great practical importance in Western Australia. Without a well developed fertiliser industry and research and experiments to guide farmers in appropriate fertiliser use the State's agriculture would be very restricted.

Where the climate is favourable for crops and improved pastures practically all soils are deficient in one or more plant nutrients. Phosphorus deficiency for example is so general that a soil is regarded as quite fertile if it requires only the addition of superphosphate to produce good crops or pastures.

In the winter rainfall region of the State extending from north of Geraldton to east of Esperance sandy and ironstone gravelly soils formed from old laterite profiles cover approximately half the total area. For crops and pastures these soils are generally deficient in nitrogen and one or more of the trace elements as well as...
Iron deficient oats (left) on Plantagenet peaty sand show up as a yellow patch in an otherwise healthy crop, most of which is on a different soil type.

Iron deficient oats on Plantagenet peaty sand show up as a yellow patch in an otherwise healthy crop, most of which is on a different soil type. The loamy and heavier soils intermingled with the lateritic residuals are inherently more fertile but with few exceptions are deficient in phosphorus.

Superphosphate use in W.A. rose to 850,000 tons in 1963-64. This is about a quarter of the Australian total. About half was used on eight million acres of legume-based pastures and half on seven million acres of cereal crops. Large areas also received the trace elements copper, zinc, manganese and molybdenum. Five million acres received copper and zinc in the 10 years 1947-1956; an up-to-date figure would be about ten million acres. Nitrogenous fertilisers are being used more frequently for cereal crops. Potassium deficiency is common on subterranean clover pastures in dairying areas. Plantations of exotic pines are improved by superphosphate and many would fail without zinc. Potatoes and vegetables invariably receive heavy dressings (up to 2 tons per acre) of mixed fertilisers sometimes including trace elements.

Deficiencies of copper, zinc, manganese, and magnesium have been demonstrated on apples, citrus and vines in various areas. Iron deficiency has occurred in oat crops and on pastures. Boron deficiency of celery was encountered near Perth and at York last year and cobalt has improved subterranean clover in experiments on sands north of Perth. Sulphur deficiency may be developing on some older farmlands. All the crops grown so far at Kununurra on the Ord River respond to phosphorus and nitrogen additions. Almost the full range of essential elements absorbed by roots has thus been the subject of investigation and field experiments because of deficiencies.

Practical experience with fertilisers coupled with research and field demonstrations in plant nutrition has changed W.A. in 60 years from a wheat importer to the largest wheat exporter among the States. Seven million acres are now planted annually to cereals. Fifteen million sheep—over 80 per cent. of the State's total—run on farms where pastures, either volunteer or sown, would be very sparse without regular use of superphosphate in the mixed farming programme. Land cleared for farming has increased from 16 million to 27 million acres since 1946 and is now increasing at nearly one million acres a year; it has been estimated that another 20 million acres can be developed.

Poor Soils But Good Climate

The farming areas from north of Geraldton to east of Esperance demonstrate that with knowledge of plant nutrition and modern fertilisers, climate, not soil, primarily determines the agricultural potential.
A close view of manganese deficient oats. Note general yellowing, collapsed appearance and death of lower leaves. Many leaves are showing the dead area at the centre of the leaf which is characteristic of manganese deficiency on oats.

Mild temperatures and average annual rainfalls from 11 to 60 inches, with 60 to 80 per cent. falling in the cooler six months of the year, allow winter and spring growth of cereal crops and pastures—mainly annuals. It is of interest to note that Flinders "Voyage to Terra Australis" records that the south coast of what is now Western Australia was discovered by the Dutchman Pieter Nuyts in 1627 and that a memoir published in Amsterdam in 1718 stated:—"Nuyts' Land being in the fifth climate, between 34° and 36° of latitude, ought to be like other countries so situated one of the most habitable, most rich and most fertile parts of the world."* Only since 1946 has modern knowledge of plant nutrition been able to prove this assertion in the vast areas of inherently infertile soils from Cape Leeuwin to east of Esperance.

**Development of W.A. Closely Linked with Plant Nutrition**

The development of Western Australia since its foundation in 1829 is very closely related to gold production, wheat and wool. Wool production first developed under extensive pastoral conditions and only limited areas were used for crops. Gold finds and production, especially after 1893, greatly increased population and the demand for cereal grains and hay so that wheat production increased early in the present century. Fortunately the value of superphosphate was recognised. The development of the wheatbelt has continued and its farms now carry 80 per cent. of the State's sheep. Wheat and wool are now the State's main primary products; each is worth about £50 million annually.

Farm development and plant nutrition are so closely related that they may be combined in the following brief outline:—

1829-1892—

Slow progress in the Colony. Wool was exported but some food imported. Limited areas of fertile soil were used for cropping. The only fertilisers were animal manure guano and bone dust.

1893-1903—

This was the great gold rush period following discoveries at Coolgardie and Kalgoorlie. A fourfold increase in population stimulated agriculture. Superphosphate use began.

1904-1928—

There was steady progress in agriculture even though gold mining declined. Regular

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* Rintoul (1963), Esperance Yesterday and Today. Published by Service Printing Co., 971 Hay Street, Perth W.A., to mark the Centenary of Esperance 1964.
wheat exports commenced 1904. Local manufacture of superphosphate commenced early in this period. Rapid wheat-belt expansion occurred before and after World War I, especially on heavy and medium textured soils.

"Light Lands" were still problem areas but Wongan Hills Light Lands Farm (now Wongan Hills Research Station) was established 1924. Experiments with rates of superphosphate increased.

English migrant Group Settlements for dairying were started in high rainfall South-West 1922-28. The subterranean clover and superphosphate era of pasture development began.

Manganese deficiency was demonstrated by W. M. Carne in 1927 as cause of "grey speck" or "white wilt" of cereals on some ironstone gravelly soils.

1929-1946—

Although this period embraced the Depression and World War II many advances in plant nutrition were made.

L. J. H. Teakle and associates in the Department of Agriculture carried out many trials with superphosphate and other phosphate sources on cereals and pastures. Residual value of past dressings of super was demonstrated during war period.

Trials with nitrogen and potassium demonstrated nitrogen deficiency on light lands.

In 1936 H. J. Pittman and R. C. Owen reported the cure of mottle leaf of citrus at Maddington by zinc sulphate sprays. S. L. Kessell and T. N. Stoate showed benefits to pines from zinc sprays in 1938 and about the same time T. C. Dunne found that "wither tip" or "summer dieback" of apples was due to copper deficiency. L. J. H. Teakle and E. T. Morgan from 1937 onwards found that copper and manganese were important for the growth of potatoes and tomatoes on some swamp soils of the Albany district. In 1939 a failure of cereals at Dandaragan was shown by Teakle to be due to copper deficiency. From this time onwards work with trace elements on cereals, pastures, fruit trees, vines, vegetables and pine trees has gone on without interruption. Zinc deficiency affected flax crops during the war.

The decade 1935-1945 saw not only the demonstration of widespread trace element deficiencies for plant growth but also the elucidation of cobalt and copper deficiencies affecting cattle and sheep in several farming areas of the south-western part of the State.
Sand plain country at Badgingarra about 100 miles north of Perth. This country is being developed for cereals and pastures, but requires additions of phosphate and copper and sometimes zinc, nitrogen, potassium and molybdenum.

1947—

The importance of zinc for sandy and ironstone gravelly soils was recognised from trials at Kojonup arranged by G. H. Burvill. Zinc impurity in post war superphosphate made from Christmas Island rock was only 150-200 parts per million; prewar super (Nauru rock) had 400-500 ppm. Except on calcareous soils at Dongara Nauru rock super had controlled zinc deficiency.

1947-1964—

Postwar land development moved forward and was aided by many fertiliser trials on new light land areas. Further land was cleared on Wongan Hills Research Station, and Esperance Downs Research Station was selected in 1949. Results from trials on these Stations, organised by T. C. Dunne and F. L. Shier, and from many farmers’ plots sown by Department of Agriculture officers, coupled with high wool prices in 1951, triggered a tremendous wave of new land development which is still proceeding at nearly one million acres per year. The developments centred on Esperance and on the scrubplains between Perth and Geraldton are examples; the hundreds of new farms north-east of Albany within a 100-mile radius are based on a good climate, plant nutrition and fertiliser knowledge and subterranean clover as the basis of pastures. New land has also been developed on or near thousands of farms established in earlier periods.

A response of subterranean clover to molybdenum at Bridgetown in 1954. The untreated area on the right has dried off while the treated area (left) has survived the spring drought.
Potassium deficiency symptoms on subterranean clover developed in pot trial. Similar symptoms are frequently seen in the field.

One bag (187 lb.) per acre of super-copper-zinc became the standard recommendation for crops and pasture establishment on new light land. This is not infallible; some areas need much more super, some need molybdenum or manganese and many need nitrogen for cereals.

1949-1955—
Molybdenum deficiency affecting sub-clover in Donnybrook-Bridgetown areas on brown and red brown soils was proved by T. C. Dunne and E. N. Fitzpatrick. In more recent years it has been found in widespread areas on ironstone gravelly soils. Cauliflowers and rock melons have also required molybdenum on some soils. R. C. Rossiter found molybdenum deficiency on Muchea sand in pot trials.

1956—
Earlier indications of potassium deficiency at Busselton, Margaret River and Manjimup on dairy farm pastures became more definite and severe and were clarified by T. C. Dunne and E. N. Fitzpatrick.

1955-1956—
Acid peaty sands of the lower South-West (related to Plantagenet peaty sand) were shown by the Department of Agriculture workers and a few farmers to be capable of development for subterranean clover and mixed pastures using lime phosphate copper and zinc. Potassium is often necessary in the second year for good growth.

1956-1963—
The use of nitrogenous fertilisers on cereals has increased rapidly in this period, especially on sandy and ironstone gravelly soils in 15 to 30 inch rainfall areas. Many field trials have shown benefits from nitrogen and with urea available at £47 per ton it has become profitable to use it. Fertiliser companies and the Department of Agriculture are now exploring the use of anhydrous ammonia.

Calcium deficiency on some strongly acid soils results in short stubby roots on subterranean clover. The plant on the left is lime-treated. The other plants show various stages of poor root development found on unfed areas.
1960-1963—

Cobalt salts were shown by P. G. Ozanne and associates of C.S.I.R.O. to improve the growth of subterranean clover on poor grey siliceous sands near Perth.

1963—

L. T. Jones of Department of Agriculture obtained a positive benefit from boron (borax) on celery on sand near Perth and on loam at York. Swedes and cauliflowers have often been suspected of boron deficiency but clear field responses have not been obtained.

Recent Developments and the Future

The importance of understanding plant nutrition principles and applying them in farming practice is well recognised by farmers in W.A.

The generally favourable economic conditions for wheat and wool in the past ten years have led to big increases in production. Correspondingly there has been a big increase in research and field experiments in plant nutrition and in the closely associated work of selection and testing of new species and strains of pasture legumes and their root nodule bacteria. The nutrition of these legumes and their symbiotic rhizobia is important for pasture improvement but also for the benefit in general soil fertility which follows periods when land is under legume-based pastures.

Four main groups of workers are now actively advancing plant nutrition knowledge in W.A. These are—

(a) C.S.I.R.O. Divisions of Plant Industry and Soils;

(b) Institute of Agriculture of University of W.A.;

(c) State Department of Agriculture;

(d) State Forests Department.

The Government Chemical Laboratories assist the State Departments with chemical analysis of soils and plants which are being studied in the research programmes. Farmers are supporting some of the work through industry funds subscribed or levied on the basis of production.

Although development of virgin scrub and timber country for farming has been very great in recent years there are also large areas which have been farmed for 30 to 50 years or more.

The changes in physical and chemical properties of these older soils, whose nutrient status has been substantially changed by fertilisers, legumes and farm practices are being studied in various ways and provide many avenues for plant nutrition research. For example the build-up
of available phosphate from repeated dressings of super over many years makes crops and pastures on many areas less responsive to super. However reducing super dressings may cause sulphur deficiency. Sulphur may now be more necessary on some soils than phosphate. The sulphur : phosphorus ratio of superphosphate may not be the most desirable one in a fertiliser supplying both elements.

Phosphorus is such an important and widely deficient plant nutrient in W.A. that continued research on soil-plant relationships involving phosphorus is a continuing need. So too is work on the trace elements because copper and zinc and to a less extent molybdenum and manganese have greatly improved the productivity of vast areas, yet there are many uncertainties about their role and interactions. A zinc-copper antagonism has repeatedly occurred in field trials with wheat, barley and oats. Zinc applied in the absence of copper has often reduced yields on copper-deficient soils but can improve yields if copper and zinc are in suitable proportions. Zinc deficiency problems became common when wartime and post war super (Christmas Island rock phosphate) were in use. Now that Nauru rock is being used along with
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Phosphorus deficiency and nitrogen deficiency on light land are demonstrated in this picture. The plots were planted with wheat with varying rates of super following a wheat crop with the same rates the previous year. The poor strip has received no phosphate fertilizer. The plot to the left has had super 120 lb. per acre twice, to the right 200 lb. per acre twice. The better grown strip across all plots has had sulphate of ammonia 112 lb. per acre (Forrestania 40 miles east of Hyden).

Christmas Island rock the need for special additions of zinc must be re-examined.

Flax and linseed are usually considered quite sensitive to zinc deficiency. However when Kameniza linseed was sown at Esperance in 1963 on a residual trace element trial commenced in 1951 the linseed failed on all plots which had never received a deliberate addition of copper. Plots which had received super only or super and zinc were apparently affected by the copper deficiency which had not previously been noted on linseed.

The establishment of subterranean clover pastures on several million acres in the cereal and sheep belt of W.A. has improved soil fertility very greatly. Cereal crops grown after three to five years of clover ley have given much higher yields than were ever achieved on the same soils in the pre-clover period.

Many trials with wheat on well prepared new land with liberal dressings of super, trace elements and nitrogenous fertiliser have failed to exceed 20 bus. per acre. But on similar light land, for example at Wongan Hills and Esperance, after several years of clover with super topdressings 40 bus. per acre is quite common in plots. Plot yields up to 89 bus. per acre have been obtained with Avon oats at Esperance. In 1960 and 1961 Avon oats gave 40-70 bus. per acre without any fertiliser in the year of cropping on plots of phosphate trials with sub. clover commenced in 1951 on virgin country. Some plots had received several dressings of super, some rock phosphate and the total applications 1951 to 1959 ranged from 2 to 12 cwt. per acre of super or its equivalent. Copper and zinc had been applied in 1951. The changes in available nutrient status shown by such results offers a fruitful field for study of the complex soil plant relationships which are embraced in, but not specifically defined by, the term “soil fertility.”

It is possible of course that cereal varieties bred and selected in W.A. at centres like Wongan Hills have the capacity to give high yields with comparatively low levels of available nutrients. The final consequence may be high yields of grains containing low levels of phosphorus and nitrogen and other elements. Avon oats have been found to be less affected by manganese deficiency than other well known varieties but the better growth did not, in a pot trial, absorb more
manganese. Avon may also not be as sensitive to zinc deficiency as other varieties and it is already noted for being less affected by barley yellow dwarf virus. The current research programme of several workers at the University Institute of Agriculture and of C.S.I.R.O. officers at Kojonup, Baker’s Hill and Crawley may elucidate some of the above phenomena.

The nutrition of a wide range of legume species and strains and their associated root nodule bacteria is another important field in which much has been done but where work must continue. W. P. Cass Smith and Miss O. M. Goss of the Department of Agriculture and C. A. Parker and associates at the University Institute of Agriculture are exploring various factors which may encourage the multiplication, survival and functioning of effective strains of Rhizobium. Subterranean clover, rose clover, cupped clover (T. cherleri) barrel medic, harbinger medic, lucerne, serradella and lupins are all familiar legumes to many W.A. farmers who look forward to improved grazing and improved soil fertility when they are used under suitable circumstances.

Many other lines of work in plant nutrition could be outlined relating not only to cereals and pastures but also to vegetables, potatoes, hops, fruit trees and vines. The establishment of cotton, sugar, rice and safflower on the Ord River and the banana plantations at Carnarvon all require knowledge of plant nutrition.

**Conclusion**

Plant nutrition studies in Western Australia have largely resulted from field problems in the growth of cereals, subterranean clover, vegetables, fruit trees, vines and exotic pines.

The practical benefits from this work have been spectacular, but a better understanding of the role of essential plant nutrients and of how plants obtain them from their normal root medium—the soil—should lead to more efficient fertiliser practices. Higher yields of better quality agricultural produce and pastures should follow, for, even without irrigation, the maximum potential of the natural climate has not been achieved.

The programme for the 1964 Plant Nutrition Conference has been planned to bring together fundamental aspects of plant growth and soil-plant relationships with the very practical problems of soil deficiencies and fertiliser use.
SELECTED BIBLIOGRAPHY

General


Forestry


Phosphorus

(See also under Forestry)

Nitrogen


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