A MACRONUTRIENT BULLETIN FOR THE PRAIRIES

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ABSTRACT

This paper briefly highlights some of the contents of a recently completed bulletin, which provides an up-to-date record of the status of our knowledge with regards to crop responses to, and impact on the environment of N, P, K and S, on the Canadian prairies. This 12 Chapter, 527 page book presents information on nutrient balances, trends in fertility levels of soils, nitrogen use efficiency, N, P, K and S cycles, fertilizer N practices, the influence of nutrients on soil organic matter, response of forages to nutrients, biotechnology and crop nutrition, and the impact of nutrients on the environment. This manuscript, which was prepared through funding provided under the Canada-Saskatchewan Environmental Sustainability Initiative (ESI), should be of considerable assistance to students, educators, scientists and agricultural extensionists in the three prairie provinces.

Key Words: Nitrogen, Phosphorus, Potassium, Sulfur, Sustainable Agriculture

INTRODUCTION

Fertility research has a long, productive history in western Canada, dating back to the early 1900's. The knowledge base that has been generated has allowed our producers to increase production efficiencies and lower costs. The increase in efficiency has also allowed producers to limit the impact of their farming practices on the environment. Some would suggest that our quest for increased efficiency in production has been at the expense of the land and the detriment of the environment. On the contrary, however, years of fertility research in western Canada have demonstrated the positive role fertilizers play in maintaining soil quality and productivity and in preventing land degradation. Our land resource must be maintained, and even improved, if western Canadian agriculture is to be sustainable. This does not mean that there are not further questions to be answered, nor does it mean that further improvement in nutrient efficiencies cannot be realized.

This bulletin documents the impact of N, P, K and S research on crop productivity and environmental sustainability on the Canadian prairies. Agricultural research repays, by up to 200%, every dollar invested but some feel that new technology remains on the researchers' shelf. One of our major goals was to compile, organize and interpret the published literature on N, P, K, and S nutrient technology. We also looked at unpublished files of a select number of senior researchers, to verify whether a significant amount of R&D had not been made public. The authors of the 12 chapters were required to assess, not only the impact of available research on crop production, but also on environmental protection of the soil and water and the quality of food.

We feel that this bulletin will be of substantial technical interest to students and researchers as they continue to unravel the principles of soil fertility and fertilizer technology. It will perhaps be of greatest strategic value to research managers and funding agencies in assisting them to establish research priorities and to allocate funding accordingly.

This paper summarizes a few of the highlights of this 12-chapter, 527 page bulletin, with a view to informing the reader of its availability for his/her future use.

RESULTS AND DISCUSSIONS

Balance of Nutrient Inputs (Fertilizers) and Exports (Grain) in Alberta, Manitoba and Saskatchewan (P.J. Doyle and L.E. Cowell)

The average negative balance of N, P_2O_5 and K_2O on the prairies over the past 25 years is 24, 5, and 18 kg $ha^{-1}yr^{-1}$, respectively. Estimates of the contribution of fertilizer nutrients to grain production range from 15 to 37% of total production, which was equivalent to 8.2 to 18.8 million tonnes of grain.

The Changing Fertility of Prairie Soils (L.E. Cowell and P.J. Doyle)

A significant change appears to have taken place in the available P level of prairie soils. Prior to 1970,the probability of obtaining a yield response of 250 kg ha^{-1} was 48% on stubble and 71% on fallow land. Since 1970, this probability has declined to 32 and 48%, respectively.

Nitrogen which during the 1940s and 1950s was seldom considered an important nutrient, now has become the dominant fertilizer nutrient used by farmers. Nitrogen fertility levels in general have declined sharply.

No trends in yield responses to K and S were identified principally because the area of deficient soils remain relatively small.

Nitrogen Use Efficiency (L.E. Cowell and P.J. Doyle)

Nitrogen fertilizer use efficiency (FUE) based on grain, rarely exceeds 50% and perhaps more commonly in the vicinity of 20-30%. Mean recoveries of fertilizer N based on 37 well-designed field experiments across the prairies were 38% in the whole plant, 32% remaining in the soil, and 30% lost.

Management practices, including soil testing, extended crop rotations, snow trapping, and variable rate fertilization, which improved the use of either water or N, will enhance the efficient use of applied fertilizer N. In general, under optimum fertilizer management practices, all nitrogen sources were equivalent in FUE.

Phosphorus (P.J. Doyle and L.E. Cowell)

The ability of plant roots to take up soil P is aggravated by the marginal amounts of plant available P, low soil moisture and/or low soil temperature. The maximum plant utilization of applied fertilizer P is in the vicinity of 20% and this declines sharply depending on fertilizer management practices. Residual fertilizer P is, on a relative scale, large and is quickly immobilized due to adsorption, precipitation and biological reactions. In general, residual P remains relatively highly available from a chemical standpoint, but frequently is positionally unavailable. Most of the phosphorus applied in large applications, i.e., 200 kg P_2O_5 ha^{-1} or higher, can be expected to be recovered over periods of 10 years or more.

Cultivation has substantially decreased the organic P content of soil. However, conservation tillage and extended cropping systems will rebuild organic P as a part of the new soil organic matter.

The P cycle, P fertilizer management practices, and factors influencing plant available soil P, have been extensively researched, yet reasons for the decline in response to applied fertilizer P, the practical significance of organic P, and the large annual fluctuations in sodium bicarbonate extractable P (i.e., Olsen-P) remains speculative.

Potassium (P.J. Doyle and L.E. Cowell)

A large amount of field research has been conducted on potassium fertilizer management practices.

Potassium deficient soils occupy approximately 1.4, 0.4, and 0.4 million ha in Alberta, Saskatchewan, and Manitoba, respectively. Soils with severe deficiencies exist in the coarse-textured Black, Dark Grey, Grey Luvisolic and Organic soil orders. The average available K of Luvisolic soils is typically 400 kg K_2O ha^{-1}, while that of a Brown Chernozem is over 1000 kg K_2O ha^{-1}.

Sulphur (P.J. Doyle and L.E. Cowell)

Approximately 4.0 million ha of cultivated soils across the prairies are deficient and 6.7 million ha are potentially deficient in sulphur. This places sulphur as the third most limiting nutrient to crop production on the prairies, after N and P. Sulphur-deficient soils are rare in the Chernozemic soil regions, primarily because these soils contain large amounts of ester-bonded sulphates in the soil organic matter. The increase in area of S-deficient cultivated soils noted in the past decade is partly related to soil degradation that has occurred, partly to lower S deposition from the atmosphere, partly to export via higher crop yields, and partly to the increased production of high S-requiring crops such as canola.

Strong interactions between N and S have been recorded with canola. A desirable N/S ratio for canola is approximately 7. Both the protein concentration and total yield of oil may be enhanced by the addition of S to canola grown on sulphur-deficient soils. Soil tests offer an effective guide for S fertilizer requirements.

Fertilizer N application practices (J.T. Harapiak, S.S. Malhi, C.A. Campbell and M. Nyborg

Band application of N has been 30 to 40% more effective than broadcasting, in trials concentrated on reasonably well-drained fields. In the more arid regions, where minimum till or direct seeding are more popular, research findings support the application of wide bands of seedrow fertilizer at the time of seeding or for spring-seeded cereal crops.

Significant problems continue to restrict the effective use of fertilizers on cereal crops in a minimum till or direct seeding mode. The development of the technology to nest/point-inject fertilizers, as a means of applying N fertilizer under no-till conditions, is theoretically appealing.

A recent survey of farmer attitudes indicates strong regional differentiation of fertilizer application preferences. This survey also confirmed that practices adopted by prairie farmers is a direct reflection of the extensive research findings of soil scientists.

Trends in Available Soil N, P, K, and S. (D.A. Rennie)

A well-defined, upward trend in levels of available soil N was observed in Manitoba. In contrast, available soil N has remained relatively constant in Saskatchewan while Alberta falls between these two extremes.

A downward trend in available soil P was noted in Saskatchewan, which bottomed out in the early 1980s and then increased since that time. Trends in Alberta were similar to Saskatchewan on a micro-scale. Soil P levels in Manitoba declined initially, as in Saskatchewan, but in recent years have remained fairly constant.

Soil K levels were essentially constant. Records of available soil S were too limited to establish any trends in Saskatchewan and Alberta. However, during the past 10 years, fields requiring additional fertilizer S have increased from 10 to 18% in Manitoba, suggesting a significant decline in available soil S.

The Role of Fertilizer Nutrients in Rebuilding Soil Organic Matter (N.G.Juma)

Estimates of the annual input of C into prairie soils range from 900 to more than 3000 kg ha^{-1} yr^{-1}. Large variations in amount of C are related to plant species, growth stage, environmental conditions, and a balanced fertilizer program. Roots provide approximately one-third of this total C. This C has been shown to play a significant and positive role in conserving fertilizer N as organic N and reducing losses by leaching and denitrification. It is conservatively estimated that 25% of the 835, 500 tonnes of fertilizer N applied during the five-year period ending in 1989 may have been transformed into new soil organic matter. While this amount of new soil organic matter is small relative to the total already present in prairie soils, it is significant in the long run.

Fertilization of Forage Crops and Rangeland (L.E. Cowell and P.J. Doyle)

Yield increases of forages, particularly for per unit of N, were low and quite inconsistent during drier periods. There was a strong varietal interaction. In general, the effect of fertilization of forage crops was complex and frequently resulted in disappointing responses due to our lack of understanding and our inability to predict the influence of fertilizer under dry and wet conditions. This problem was further aggravated by market conditions, including hay and livestock prices, which vary widely and are so unpredictable.

Soil Microorganisms: Key Players in Crop Nutrition on the Prairies (R.J. Rennie)

Microorganisms can increase the available nutrient status of the soil by direct addition (N_2 fixation), solubilization (P and S), or chelation (Fe) of the nutrients required by plants. Microorganisms also alter the sensitive balance of root diseases and exude plant growth regulators which stimulate both root and plant development. The few commercial microbial products which exist to manipulate the plant rhizosphere are very successful. Rhizobial legume inoculants can result in fixation of 100 kg N ha^{-1}. Phosphorus-solubilizing fungi and biological control agents are in the early stages of having an economic impact.

Crop Nutrients and the Environment (L.E. Cowell and P.J. Doyle)

Recent reports from Environment Canada and the Science Council of Canada state that fertilizer nutrients damage the environment. To the contrary, research relevant to the issue of N, P, K, and S fertilizers in the environment show that these nutrients play an indispensable and key role in the sustainability of western Canadian agriculture. In the prairie environment, maximum economic crop production can in fact be equated with environmentally sound field management practices, including fertilizer application where required.

CONCLUSIONS

This book on NPKS on the Canadian prairies has gathered together and distilled the findings of hundreds of studies, conducted by numerous scientists, costing millions of dollars, spent by various agencies. The authors are to be commended for a job well done. Now, it is up to you, the reader, to glean from this treatise, all the pertinent information you have been seeking but never knew

where it could be found. The ball is in your court! We recommend that you get a copy and read it.

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