CHAIRS' SUMMARY PAPER: Soil Fertility and Plant Nutrition

J.D. Beaton[1] and M. Corsi[2]
[1]Kelowna, B.C. V1W 3Z9, Canada and [2]University of Sao Paulo, Piracicaba, Brazil

In the first invited paper "Nutrient Management Of Humid Temperate Region Forages: Recommendations And Practices", Dr. M.P. Russelle referred to the following four principal reasons for fertilizing perennial forages:

- to increase total yield in cases of mown forages and when pasture production is insufficient for the number of grazing animals;
- to increase yields at specific times of the year such as during the "summer slump";
- to improve persistence of desirable species sensitive to stress conditions; and
- to improve forage quality by raising levels of nutrients including Mg and S.

Quantities of nutrients required to achieve the above goals are frequently based on soil tests. One or more of the several accepted approaches or philosophies to soil testing are used to develop plant nutrient recommendations. Most of the public soil testing laboratories in the USA operate according to the "feed the plant" or the "sufficiency level approach" where nutrient availability is assessed by means of a chemical extraction and nutrient additions are designed to optimize plant response.

With a second philosophy of soil testing referred to as "feed the soil" or "buildup and maintenance", nutrient additions are meant to replace those removed by the crop and to increase the supply of nutrients in the soil to optimum levels. It is usually based on soil extraction procedures but it can simply be founded on estimated or actual crop removal of nutrients.

A third approach, related to the "feed the soil" concept, aims for an optimum balance of nutrient cations, particularly Ca, Mg and K.

Public laboratory recommendations for N are generally dependent on yield goals rather than soil test values and are reduced when legumes are present in forage stands. Recommended rates of N are highest in the humid south and are generally lower in northern and western regions of the U.S. because of shorter growing seasons in the former and moisture limitations in the latter. Nitrogen recommendations in about one-half of the states were lower for pastures than for mown forages under comparable management. In the remaining states, the recommended rates of N were similar for the two systems. Several states including Minnesota and Georgia prescribe higher N rates for situations of greater grazing intensity or stocking rates.

The benefits of N on yield and quality of forages in grazed and harvested systems may not be adequately recognized by livestock and dairy producers in terms of the marginal cost of fertilizer N inputs versus the marginal income derived from animal outputs. It is also suggested that producers pay attention to the uneven distribution of nutrients excreted by livestock in pastures. Other plant nutrient management considerations are avoidance of N and K applications near watering sites and P additions where animals gather in shade or out of the wind.

Contrasted with N, prescribed amounts of P and K are generally founded on soil tests. More P for alfalfa than for other forages grown under the same conditions is recommended in some states. In some instances, however, suggested rates of P were similar for alfalfa and grasses while P recommendations were higher for clover and grass-clover mixtures than for alfalfa at comparable soil test ratings.

Prescribed K was usually higher for alfalfa than for other forages grown on soils with the same levels of available K and yield potential. Higher rates of K were advocated in the North Central and Northeastern regions of the U.S. where (i) soils had relatively low soil K supply, (ii) soil testing was practiced on the basis of nutrient maintenance and buildup and (iii) winterhardiness of legumes was an important consideration.

All forage systems can be overwhelmed by nutrient additions in excess of crop requirements. Thus, over fertilization should be avoided because of resulting disadvantages and potential problems including unfavourable economics, reduced forage quality and unwanted effects on the environment. Specialized soil sampling procedures will likely be needed to monitor nutrient accumulations and movement when environmental problems occur or are suspected. Problems of over fertilization should be largely overcome with the advent of precision farming systems adapted to forage production. With such systems it will be feasible to apply plant nutrients according to site specific requirements.

Livestock manures are an important source of plant nutrients and they are particularly effective when applied before establishing perennial forages. Part of manure benefits may arise from the N and micro-nutrients which they supply and perhaps from other factors not directly related to nutrient availability.

Nearly all states recommend that appropriate nutrient credits be assigned to manure additions with resultant reductions in the quantities of nutrients provided in fertilizers. Estimates are normally made of the availability of organic N in manure and a complete loss of ammonium N is assumed. About 80% of P and all of the K in manures is considered available during the first season of application.

Many states evaluate the risk of nutrient loss from manure through runoff and prohibit applications in areas where surface water accumulates or flows. Site specific management of manure in forage production is expected to produce important benefits because of its cumulative effects on soil nutrient status and physical properties.

A mail survey of soil fertility practices used in perennial forage management by 1,007 Minnesota dairy farmers was conducted in 1996 and the following observations were evident in the 354 statistically acceptable responses:

- about 60% used soil testing as a source of information for plant nutrient recommendations;
- nearly 50% also relied on fertilizer dealers for plant nutrient management details;
- daily or frequent manure hauling was the most typical manure handling practice, followed by manure pack in livestock housing and lagoon storage of liquid manure;
- trends in fertilizer use are tentative because of the small number of respondents providing this information; however about 14%

of those replying applied P, at rates ranging from 5 to 70 kg/ha, prior to seeding perennial forages. Approximately 23% of the respondents added K, before seeding forages, at levels of between 25 to 225 kg of K/ha. Lime was also incorporated before seeding perennial forages on about 28% of the farms at rates varying from 0.65 to 17.9 Mg/ha.

- alfalfa was topdressed with N on 16% of the farms, at rates of from about 5 to 70 kg/ha. Forages received topdressings of P on 26% of the farms at rates of between 5 to 80 kg of P/ha. Some 47% of Minnesota dairy producers applied K to existing stands of alfalfa in amounts ranging from 15 to 390 kg of K/ha. About 10% of dairy farmers topdressed alfalfa with from 7 to 100 kg of S/ha. Only a small proportion (~ 5%) of the respondents applied topdressings of B, at levels varying between 1 to 5.5 kg of B/ha.

- nearly 80% of the respondents supplying soil test results had high levels of available P, > 20 mg/kg and about 50% had high soil K (> 160 mg/kg) indicating that available soil levels of these two nutrients were sufficient.

The second invited paper entitled "Nutrient Management In Tropical Forage Systems - What Should Be And What Is Practiced" by Drs. Graeme Blair and Peter Kerridge provided much useful background information on trends in livestock production in Australia, S.E. Asia and Central America. They reported increasing cattle and human populations often accompanied by difficulties in farmer acceptance and adoption of technologies needed to improve animal productivity.

The wide diversity of tropical forage systems in Australia, S.E. Asia and Central America was described. This diversity ranged from "free" forage grazing in Malaysia within tree crop plantations, on idle lands and along roadsides and the communal grazing in the hills and forests of Laos during the wet season followed by a return to utilize crop residues of paddy fields in the dry season, contrasted with the heavily N fertilized and intensively managed pastures of coastal Queensland in Australia.

These degrees of diversity impose different constraints on the adoption of technology. For example, lack of funds restricts inputs of fertilizer, fencing, water supplies, etc and provision of support groups such as an effective extension service. Also, hierarchial social structures may discourage innovations and another major factor in some cultures is the importance of cattle for non-cash purposes such as draft, fertilizers, hides and hair.

The nutrient needs of forage systems in the various tropical regions were reviewed. It is noteworthy that soils of S.E. Asia and in other tropical regions are commonly highly weathered ultisols and oxisols with lesser areas of fertile alluvial or volcanic soils. This limitation in soils combined with the high demand for food crop production on the best tropical soils essentially confines forage production to lesser areas of inferior soils. Examples of the significant benefits of fertilization on tropical forages follow:

- responses of *Centrosoma pubesence* to S additions in S. Sulawesi, Indonesia.

- fertilization, particularly with P, will be required in Malaysia for satisfactory performance of forages in association with rubber and oil palm production.

- at many locations in Thailand, *Stylosanthes* has responded to applications of P, S and K.

- in Laos, P is the main nutrient limiting forage productivity.

- red clover and ryegrass have responded to S fertilization in Chile and Colombia.

- severe deficiencies of P are widespread in Northern Australia and attraction of cattle to P fertilized pastures has been recorded in Queensland.

- in Australia, fertilizer inputs are required to maintain the productivity of introduced grass and legume species and browse shrubs in dairy pasture swards containing tropical grasses.

- application of N at rates up to 150 kg/ha/yr in a subtropical dairy pasture system in Australia resulted in milk yield responses of 8 kg milk/kg of added N. In addition, conception rates improved with dressings of up to 600 kg N/ha/yr and the maximum return from N inputs occurred with the application of 334 kg N/ha/yr.

- prospects for increasing the quantity and quality of forages, grown specifically for livestock, in populated areas of S.E. Asia and Central America are low. A more acceptable approach of selecting forage species adapted to the prevailing adverse soil and growing conditions is proposed.

A total of 72 Poster Paper titles and 48 accompanying abstracts were submitted. The subject matter covered fell into 15 main areas listed below. Numbers of abstracts and/or titles assigned to these categories appear in the brackets.

- N fertilization and sources (10).
- P fertilization, sources and soil P fractions (11).
- K fertilization (1).
- N and K fertilization (1).
- N and P and N, P and S fertilization (7).
- P and S fertilization (2).
- Micronutrient fertilization (P and Zn interaction) and B fertilization (2).
- Phosphogypsum fertilization (1).
- Soil acidity and liming (6).
- Organic fertilizers including livestock manures and municipal biosolids (7).
- N fixation and other beneficial effects of soil microorganisms (13).
- Soil testing (1).
- Tissue testing (1).
- Nutrient budgets and dynamics (4).
- Forage types, grassland communities, forage management and miscellaneous (5).

Several examples of important findings reported in the many excellent

Posters follow.

- immobilization of labile inorganic P in New Zealand pasture soils is greatest in the autumn-early winter period and consequently the relative response to P is greatest from autumn to early spring.

- long-term application of single superphosphate or its equivalent (250 + kg/ha/yr for 15-20 years) to legume based pasture soils in New Zealand resulted in large accumulations of up to 1000 ug P/ g in the 0-7.5 cm soil depth. Olsen available soil P was the best predictor of pasture growth with 95% relative yield obtained at levels of 35-40 ug P/g.

- chloroform released P was shown to be a good indicator of P fertility status in agropastoral Oxisol soils of Colombia.

- under glasshouse conditions, increased P supply enhanced water uptake and water use efficiency by white clover.

- maximum winter growth of natural pastures in Argentina was achieved with N applications ranging from 150 to 250 kg of N/ ha/yr.

- Japanese researchers observed that N, from previous fertilization, in stubble during the 10 days prior to removal of the next cutting was more important than the content of nonstructural carbohydrates in determining yield of orchardgrass regrowth.

- in a C_4 subtropic pasture of a semi-arid South African environment, limestone ammonium nitrate fertilization tended to increase forage production more than the urea treatment. Although these yield differences were not statistically different, plants receiving urea contained twice the amount of aspartic and glutamic acid indicating that urea did not convert to nitrate and was absorbed as ammonium.

- all treatments with N increased herbage production on an irrigated perennial pasture in Argentina. NPS resulted in the highest yield but this treatment was not statistically different from the other N containing treatments. PS application raised the proportion of alfalfa in the pasture mix from a base of 5% to 25%. Crude protein production was highest with NPS followed by PS.

- Russell lupin oversown into low P and S tussock rangeland soil of New Zealand's South Island barely survived without the addition of S and it was capable of extracting P from soil low in this nutrient. Yield of grass was minimal in the absence of applied S.

- the drag-shoe method of banding cow manure slurry beneath tall fescue grass canopies was more effective than splash-plate applications (broadcast) on top of the canopy. Grass yields from most of the drag-shoe applications were similar to ammonium nitrate fertilization at rates up to 150 kg N/ ha while yields from all splash-plate treatments were lower.

- clover root nodules were found to host 12 bacteria species other than rhizobia. These bacteria often promoted *in vitro* growth and nodulation of red clover when applied in combination with *R. leguminosarum* BV *trifolii*.

- paddock surveys and preliminary glasshouse experiments have identified acidification of the soil surface layers as a contributing factor to the problem of declining lucerne yields in the mid north region of South Australia. Lime applications at rates of 2 and 4 t/ ha significantly improved lucerne production in a soil with an acidic topsoil and alkaline subsoil.