Phosphorus in Semiarid Forage Production

By Fernando Selles and P.G. Jefferson

Phosphorus (P) fertilization increased the yield of alfalfa-Russian wildrye forage mixtures by 21 to 34%, but had no impact on the yield of monoculture alfalfa.

There is renewed interest in alfalfa (*Medicago sativa* L.) for pasture in the semiarid region of the northern Great Plains due to its productivity, forage quality, and new technologies for ruminant bloat control. Mixtures of alfalfa and wildrye [*Psathyrostachys juncea* (Fischer) Nevski], a recommended species for summer and fall grazing, have been used in the past to reduce ruminant bloat hazard. However, alfalfa persistence in these mixtures is reduced due to the competitive nature of the grass.

Southwestern Saskatchewan soils (Aridic Haploborolls) are generally deficient in available P, and P additions have been shown elsewhere to improve the persistence of legumes growing in mixtures with forage grasses. Our objective was to determine the response to P fertilization of dry matter yield, P balances, and soil available P of monoculture alfalfa and alfalfa-Russian wildrye grass mixtures (RWRM).

This dryland trial was seeded on a silt loam soil with a pH of 6.0 in May 1997 at the Semiarid Prairie Agricultural Research Centre in Swift Current, Saskatchewan (13 in. of annual precipitation). The study was set up as a split plot design with four replicates. Main plots were three cropping treatments: monoculture alfalfa; Russian wildrye and alfalfa seeded in alternate rows; and Russian wildrye and alfalfa seeded in the same row. Subplots were seven P fertility treatments: 0 (check); 18, 36, and 72 lb P_2O_5/A pre-plant; 9, 18, and 36 lb P_2O_5/A annual. The forage was seeded in 12 in. rows and both pre-plant and annual P treatments were applied as triple superphosphate banded 1 in. deep in the center of every mid-row space. Pre-plant applications were made before seeding in 1997; annual applications were repeated annually in early spring.

Forage yield was determined by harvesting with a flail-type plot harvester. Forage sub-samples were removed and analyzed for moisture content and P concentration. In fall 2002, after forage harvest, soil samples were taken with a 3 in. diameter core sampler from the alfalfa monoculture treatments. Soil samples (0 to 6 in. depth) were removed from random locations within the plot area at the beginning of the study, and every spring (except 1998) from the mid-row band and next to the plant row of every plot; available P was determined by the Olsen method.

Olsen P in the soil (0 to 6 in. depth) at the beginning of the experiment was only 5.4 parts per million (ppm)…95% confidence limit 5.0 to 5.8 ppm. At these P levels, annual crops in this region respond readily to P fertilization. Although the level of forage production was primarily affected by growing season conditions, P fertilization…especially at the highest annual rate…produced large increases in the production of the grass-alfalfa dry matter (**Figure 1**). Annual application of 36 lb P_2O_5/A (total of 216 lb P_2O_5/A) produced the largest increase in forage yield, followed by application of 36 or 72 lb P_2O_5/A applied once pre-plant, and finally by annual application of 18 lb P_2O_5/A (total of 108

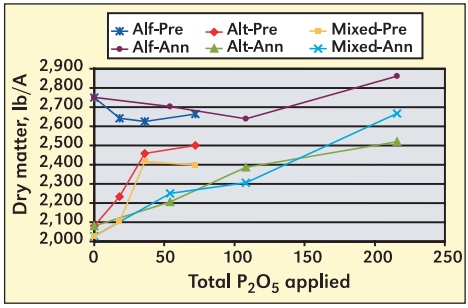

Figure 1. Total P application over 6 years and average annual dry matter production.

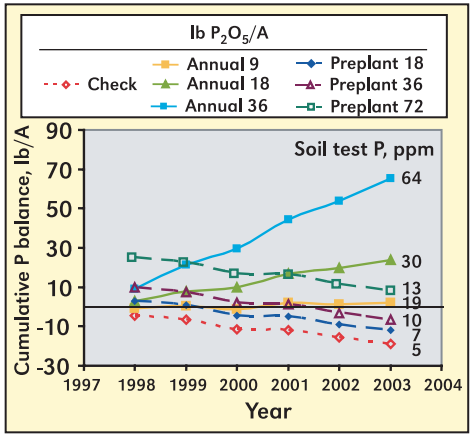

Figure 2. Cumulative P balance in response to P fertilizer application and forage P removal. Values at the end of each line represent soil test P at the end of the study (initial soil P = 5 ppm).

lb P_2O_5/A).The response of the different crop mixes, however, was not consistent. Monoculture alfalfa did not respond to P applications regardless of rate or application method, and unfertilized monoculture alfalfa yielded as much or more than the well-fertilized mixtures (**Figure 1**). The two RWRM showed marked responses to the application of fertilizer P, but there was no difference between the mixed row and alternate-row cropping configuration. We attributed this difference in response between the monoculture alfalfa and the RWRM to possible differences in arbuscular mycorrhizal (AM) infection between the systems. The RWRM may inhibit infection of alfalfa by AM in the mixtures as well as suppressing alfalfa via intra-species competition, as evidenced by the P responses of these mixtures.

The amount of P removed by the crop was highly dependent on total dry matter production. Thus the cumulative balances, calculated as the sum of the annual differences between P inputs and P outputs from the system, show a separation of the treatments that received annual applications of P from those that received a one time pre-plant fertilizer application, or no fertilization (**Figure 2**). During the study period, the concentration of Olsen P in the soil at the 0 to 6 in. depth showed the combined effects of the amounts of P applied (in bands) and the amount of P removal by the crop (data not shown). Available P concentration in the soil receiving no P fertilizer remained unchanged near the original level of 5 ppm throughout six harvests that removed in excess of 19 lb P/A (43 lb P_2O_5 /A). Treatments receiving the pre-plant P application showed minor increases in available soil P from the initial level. All annual P application treatments increased their available P levels at a rate proportional to the amount of P applied in excess of crop removal with a maximum soil P of 64 ppm for the high rate of annual applied P (**Figure 2**). Observed changes in soil P are consistent with the results of other studies at this location that have shown increases in Olsen P for treatments receiving P fertilization, and unchanged Olsen P levels in unfertilized treatments.

Difference in responses to P fertilization between cropping mixes suggests that microbial-root associations may be an important factor determining the capacity of this crop to use soil P under monoculture alfalfa. BC

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