Research Findings

Photo by A.C.C. Bernardi.

Soil Fertility Management and Weed Occurrence in Alfalfa Pasture

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Introduction

Grazed pastures in Brazil provide the major source of food for beef and dairy cattle. For this reason, well established, properly managed pastures of high productivity are essential in order to support adequate gains in animal weight. Soil fertility is one of the most important controllable factors for determining forage yield and quality. Alfalfa (*Medicago sativa* L.), which is highly important for forage production in Brazil, is extremely demanding in soil nutrients, so that the provision of an adequate supply of nutrients is essential to maintain high forage quality and profitable yields (Moreira *et al.*, 2008; Bernardi *et al.*, 2013a,b). Interestingly, this crop requires higher levels of soil fertility than other tropical pastures (Bernardi *et al.*, 2012).

The most common nutrient inputs for alfalfa are lime, phosphorus (P) and potash (K) fertilizers in the high weathered, low-fertile and acids soils of tropical regions (Moreira *et al.*, 2008; Bernardi *et al.*, 2013a,b). No nitrogen (N) fertilizer sources are used in the alfalfa production system in Brazil since all N is supplied by biological fixation by *Sinorhizobium meliloti*. Liming is essential for growing alfalfa in order to increase soil pH because of the sensitivity of the crop to soil acidity; the recommended

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pH range being between 6.5 and 7.5 (Honda and Honda, 1990). In addition, liming has other beneficial effects including raising the base saturation of the soil to 80% (Moreira *et al*., 2008), reducing the aluminum (Al) and manganese (Mn) toxicity as a consequence of increased soil pH, and thereby also increasing the availability of the macronutrients calcium (Ca), magnesium (Mg), K and P. Liming also favors organic matter mineralization, increasing the efficiency of symbiotic N fixation, fertilizer use efficiency and microbiological activity in the soil. Phosphate and micronutrient fertilizers are usually applied once a year. In tropical soils, P can be immobilized as precipitated phosphates of iron (Fe) or Al, or adsorbed phosphate on soil particles. This adsorption is reversible and phosphate is released into the soil solution with increasing soil pH from acid conditions by liming (Bernardi *et al*., 2012; Berg *et al*., 2005; Sarmento *et al*., 2001). Three forms of K (unavailable, fixed and exchangeable) are present in soils. Potassium considered readily available to plants is that in soil solution, which is in rapid equilibrium with K held on exchangeable cation sites of the soil complex. Potassium fertilizer, as muriate of potash (KCl), is usually applied after each grazing or cut, thereby avoiding loss of K to the crop as a result of K leaching through the soil profile, which can be a problem on these tropical soils of low cation exchange capacity (CEC) (Bernardi *et al*., 2012, 2013a., 2013b).

In addition to soil fertility, the main limiting factors for cultivation of alfalfa in tropical regions are weed management, cultural practices and grazing management (Honda and Honda, 1990, Vilela *et al*., 2008). Adequate soil fertility in established alfalfa pasture allows the forage to compete more effectively with weeds (Peters and Linscott, 1988; Lillak *et al*., 2005). Weed interference may be responsible for 30-40% reduction in agricultural production in the tropics (Vilela, 1992). Weeds may lead to a decrease in alfalfa biomass production due to allelopathic effects and competition for water, light, nutrients and space (Peters and Linscott, 1988; Moyer, 1992). In addition to competing with alfalfa forage, weeds may also serve as hosts for pests and disease, and, moreover, may complicate grazing or mechanical harvesting causing losses of both pasture productivity and quality. Little is known in Brazil concerning alfalfa used in the dairy cattle system and the interaction between soil fertility and weed occurrence. Both crop and weed species are affected by changing levels of soil fertility. According to Liebman and Davis (2000), the differences among species involving root and shoot responses to nutrient enrichment, supply of fertilizer, or lack of supply, could shift the balance in competitive relationships between crops and weeds. During the establishment of the alfalfa crop, if soil fertility is adequate and the crop is managed well, high vigor seedling growth should occur. However, the problem of weeds may worsen during the maintenance phase of the alfalfa pasture. Previous investigations have shown that weeds may invade established alfalfa stands if they become thin (Peters and Linscott, 1988).

In the present paper, the effect of soil amendment with lime and gypsum and K fertilizer on a typical low fertile, highly weathered, acid tropical soil is evaluated in relation to alfalfa pasture yield and the occurrence of weeds.

Materials and methods

The study was conducted at Embrapa Pecuaria Sudeste, in Sao Carlos-SP, Brazil (22°01' S and 47°54' W; 856 m above sea level). The soil is a typical Haplurtox on which an irrigated alfalfa (*Medicago sativa* cv. Crioula) pasture had been intensively grown for two years. The forage was managed under a rotational system with a one day-grazing period and 30 days between the cycles throughout the year. The experimental plots were set up inside the paddocks (Photos 1). Lime was added to the soil to give a

Photos 1. Plots inside the paddocks (left) and dairy cows grazing alfalfa pasture (right). Photos by A.C.C. Bernardi.

base saturation of 80% in half the plots, and 60% in the other half. Gypsum was applied at 3 t ha^{-1} or not applied. Potassium fertilizer as KCl was applied to all plots at four rates increasing from 0 to 1.667 kg K_2O ha^{-1} (0, 833, 1,250 and 1,667 kg K_2O ha^{-1}). There were 16 treatments in total. Effects were evaluated during 10 alfalfa growth cycles. With soil fertility decline, an increase in occurrence of weeds was observed and assessed between the 7th and 10th growth cycle. At harvest, weeds and alfalfa biomass were separated and weighed. Alfalfa shoot dry matter yield was evaluated when 10% of the crop was flowering, one day before dairy cattle grazing.

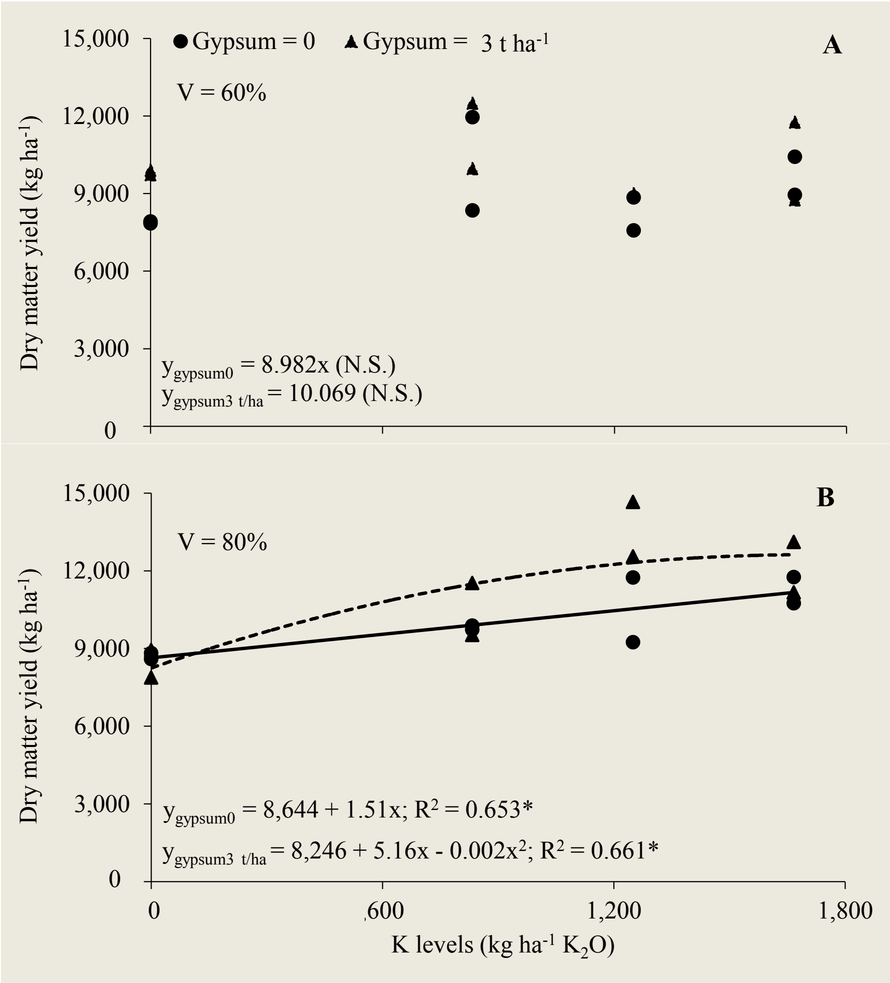

Fig. 1. Alfalfa dry matter yield due to K fertilization, gypsum and at base saturation of soil of 60% (A) and 80% (B); N.S. = not significant.

Results and discussion

The results indicated that alfalfa responded positively and significantly to K fertilization (Fig. 1) at higher base saturation (80%). The highest yield (11,574 kg ha^{-1}) was obtained with 1,290 kg ha^{-1} of K and using 3,000 kg ha^{-1} of gypsum. In the absence of gypsum, for the same amount of K, the maximum production was about 4% lower (11,162 kg ha^{-1}). At the lower base saturation (60%), no response to K fertilization was observed. These results confirm the beneficial effect of liming on increasing the efficiency of K fertilizer use in these acid tropical soils (Moreira *et al*., 2008). The findings are also in accord with previous results of Syed-Omar and Sumner (1991), who observed increases in production of alfalfa up to a rate of 2,000 kg ha^{-1} of gypsum.

Alfalfa dry matter yield increased from 29 to 40%, which was directly related to K fertilization and confirmed previous findings of Smith (1975), Kafkafi *et al.* (1977), Rando and Silveira (1995), Rassini Freitas (1998), and Bernardi *et al.* (2013b). The positive effect of lime was the same as already described by Honda and Honda (1990) and Moreira *et al*., (2008). A decrease in alfalfa productivity due to low soil fertility levels resulted in an increase in weed invasion into the forage stand (Photos 2). Fig. 2 shows the linear decrease in the occurrence of weeds with increasing K fertilizer doses. Considering the two levels of base saturation of 60% and 80% (supplied with 3,000 kg ha^{-1} of gypsum), resulting decreases in weed occurrence were from 30 to 22%, and from 21 to 9%, respectively. At both levels of base saturation (60% and 80%), in the absence of gypsum, K fertilization promoted a quadratic effect on the occurrence of weeds, indicating that the initial K levels favored the growth of weeds, probably because of their more efficient use of nutrients. These differences in nutrient use efficiency were pointed out by Liebman and Davis (2000). The results in this study also indicate that soil amendment, gypsum and K supply in adequate doses can contribute to the longevity of the alfalfa stand, as has been shown by Smith (1975), Berg *et al.* (2005), and Bernardi *et al.* (2013).

Conclusions

Soil fertility management has an impact on alfalfa yield and the potential for weed competition. Low soil fertility leads to loss of alfalfa pasture vigor and an increasing occurrence of weeds. Lime, gypsum and K fertilization can contribute substantially to the increased longevity of alfalfa. The major responses of alfalfa to K fertilization occurred at the higher soil base saturation (80%).

Photos 2. High fertility plot of alfalfa (left) free of weeds, and (photo right) low fertility plot with high weed occurrence. Photos by A.C.C. Bernardi.

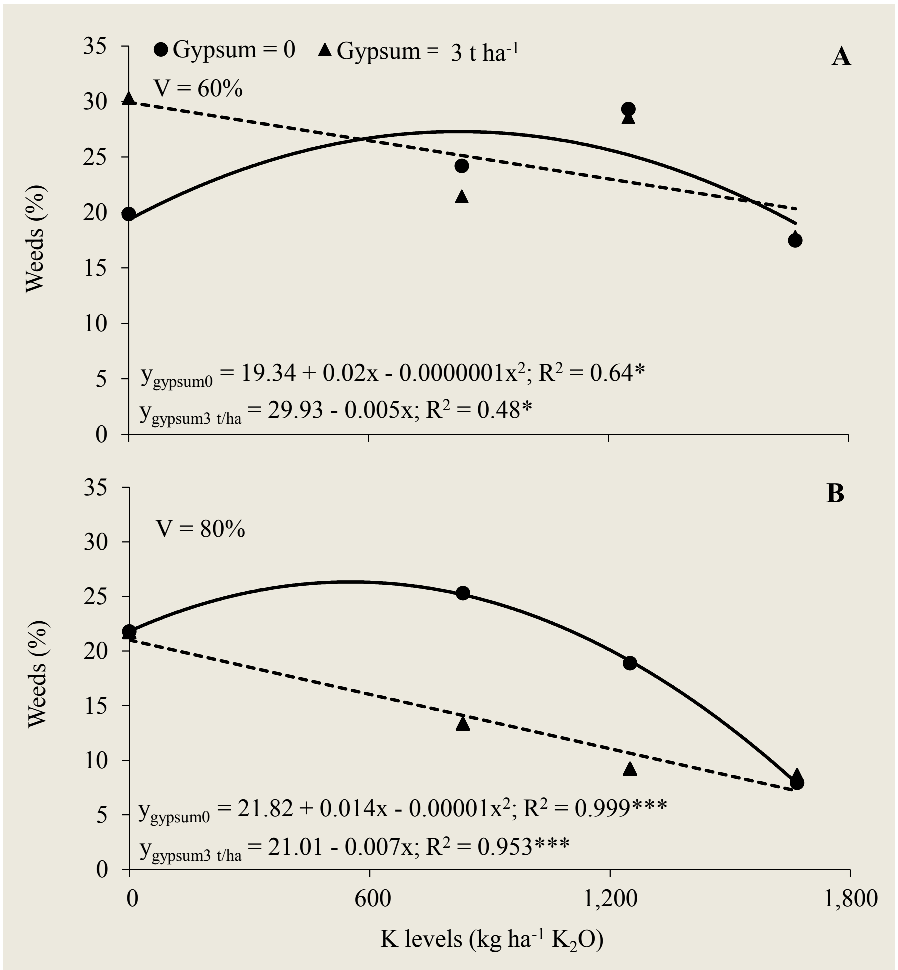

Fig. 2. Weed percentage (DW weed (kg)/DW alfalfa (kg)) of the total alfalfa dry matter yield due K fertilization, gypsum and at base saturation of 60% (A) and 80% (B).

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