Economic return of potassium fertilization of alfalfa pasture in a tropical soil

Alberto C. de Campos Bernardi and Fernando Campos Mendonça

Embrapa Pecuária Sudeste, C.P.339, CEP: 13560-970, São Carlos, SP, Brazil, Email alberto@cppse.embrapa.br

Abstract
The objective of this study was to evaluate the effect of doses and frequency of application of potassium fertilizer on the alfalfa dry matter yield and economic return to dairy cattle production. The experiment was carried out on a Typic Hapludox and was designed in randomized blocks in 4 X 4 factorial with 3 replications. The treatments were 4 levels of potassium in topdressing fertilization (0, 600, 1200 and 1800 kg/ha/year of K_2O) and 4 frequency of application (12 = after each cutting, 6 = after two cuttings, 4 = after three cuttings; and 2 = two applications per year). The use of 1420 kg/ha/year of K_2O applied after two cuttings (6 applications per year) increased alfalfa dry matter yield until 30,500 kg/ha. Profit functions were adjusted considering four scenarios for milk and potassium fertilizer prices. Estimated profit functions were a useful aid in economic decisions for alfalfa fertilization than just the dry matter yield curves. Since the maximum profit for K_2O doses was 1,212 kg/ha for the lower price of fertilizers and 1,045 kg/ha for the higher price of fertilizers.

Key Words
Medicago sativa, dairy cattle, profit function.

Introduction

Providing an adequate supply of nutrients is important for alfalfa production and is essential to maintain high quality and profitable yields. Potassium fertilization is essential for alfalfa production (Rassini and Freitas 1998) and is the most common nutrient input for this crop in the high weathered, low-fertile and acids soils of tropical regions (Moreira *et al.* 2008). High-yielding alfalfa removes large amounts of potassium from the field in each cutting (Smith 1975). Lloveras *et al.* (2001) found extractions from 1500 to 1700 kg/ha (with productivity of 21.5 t/ha of DM) in soil of high fertility. Potassium uptake by plants is in ionic form, and diffusion to plant roots accounts for the majority of plant uptake, while mass flow contributes to only a small fraction of total plant K. The salts of K in general show high solubility and can reach high concentrations in soil solution, which may lead to depletion by leaching and excessive absorption by plants (Havlin *et al.* 1999; Moreira *et al.* 2008). High soil acidity, low cation exchange capacity, and low amounts of available nutrients of tropical soils are the most common limiting factors to sustain crops for high yields and profits, especially in the case of alfalfa forage. Lime and fertilizers are required. So fertilizer may represent 27% of total cost of production of alfalfa in a Brazilian intensive dairy cattle production (Vinholis *et al.* 2008). Economic studies on alfalfa fertilization in dairy production systems are needed to learn the conditions under which returns may be maximized, especially with pastures grown in acid and low fertility soils. Hence the effects of various management practices and issues become important factors for profitable dairy production. The objective of this study was to evaluate the effect of doses and frequency of application of potassium fertilizer on alfalfa dry matter yield and economic return to dairy cattle production.

Methods

A two-year growing seasons field study was conducted at Embrapa Cattle Southeast, in Sao Carlos (22°01'S and 47°54'W; 856m above sea level), Brazil. The climate is a Cwa (Köeppen), with yearly average of low and high temperatures of 16.3 and 23.0°C, respectively, and a total precipitation of 1502 mm falling mostly in summer. Soil type was a Typic Hapludox, with the following chemical properties in the 0-0.2, 0.2-0.4 and 0.4-0.6m layers: pH_{CaCl2} = 5.9, 5.3 and 5.1; organic matter = 21, 11 and 10 g/dm^3; P_{resine} = 42, 10 and 3 mg/dm^3; K = 1.3, 0.9 and 0.5 mmol$_c$/dm^3; Ca = 29, 14 and 11 mmol$_c$/dm^3; Mg = 13, 5 and 2 mmol$_c$/dm^3; CEC = 69, 50 and 48 mmol$_c$/dm^3; and basis saturation = 63, 39 and 28%; and the physical characteristics: sand = 730, 710 and 689 g/kg; clay = 253, 273 and 302 g/kg; and silt = 17, 17 and 9 g/kg. Irrigated alfalfa (*Medicago sativa* cv. Crioula) was sown with planting density of 20 kg/ha of seed inoculated with *Sinorhizobium meliloti*. Dolomite lime was applied to increase basis saturation at 80% before planting. Plots were fertilized uniformly at planting with 120 kg/ha of P_2O_5 (single superphosphate) and 30 kg/ha of FTE BR-12 (1.8% of B, 0.8% Cu, 3% Fe, 2% Mn, 0.1% Mo, 9% Zn). Soil liming and phosphorus and micronutrients fertilization was repeat always when soil testing indicated fertility decrease.

The experiment was carried out in $3.2m^2$-plots, formed by eight sowing 2m-length rows, with a 0.2m-interlinear space. The experimental design was in 4 X 4-factorial randomized blocks with three replications. Treatments comprised 4 levels of potassium: 600, 1200 and 1800 kg/ha of K_2O as KCl; and 4 frequency of application: after each cutting (12 applications), after two cuttings (6), after three cuttings (4); and two applications per year (2).

Alfalfa shoot dry matter yield was evaluated when the crop was 10% of flowering. A minimum of six 1-m length rows was harvested per plot. Twenty-five growing seasons were evaluated. The simulation of the production cost was accomplished with base on the methodology of the total cost and the sheet cost drawn by Vinholis *et al.* (2008) for a Brazilian intensive dairy cattle production with alfalfa pasture. Some regard were established: a) live weight (LW) of cows = 550 kg, b) milk yield= 21 L/day corrected to 4% of fat, c) dry matter (DM) consumption = 3.05% of LW which correspond to 16.8 kg/day of DM, d) alfalfa represented 14% of the total of cow dietary, and 20% of the forage consumption. For the estimation of the net profit by profit functions two situations were considered: high and low prices of the potassium fertilizer and milk, resulting in four different scenarios. So the milk prices considered were US$ 0.278 and US$ 0.444 per litre and the potassium fertilizer were US$ 0.833 and US$ 1.167 per kg of K_2O. For calculating currency exchange adopted was US$ 1.00 = BR$ 1.80. Data were tested for differences among treatments using analysis of variance and response function and equations were adjusted.

Results

Dry matter yield of alfalfa at first and second growing season as a function of K fertilizer level and frequency of application is illustrated in Figure 1. The highest DM yield in both years (36,890 and 24,131 kg/ha) were obtained with 1,411 and 1,432 kg/ha of K_2O applied after two cuttings. These values are approximately 57 and 59% higher than those obtained without potassium fertilizer. Results are consistent with those observed by Smith (1975), Rassini and Freitas (1998), who found an increase in alfalfa DM yield as potassium fertilization increased. The yield increases in this study were higher than the increases reported by Kafkafi *et al.* (1977) and Lloveras *et al.* (2001). The percentage of yield reduction from first year to second was greater with the lower levels of potassium fertilization (Figure 1D). The lower reduction (33.5%) was obtained with 1,346 kg/ha of K_2O applied approximately after two cuttings. These results are indicative that the adequate potassium supply increases the stand longevity as already shown by Smith (1975) and Berg *et al.* (2005).

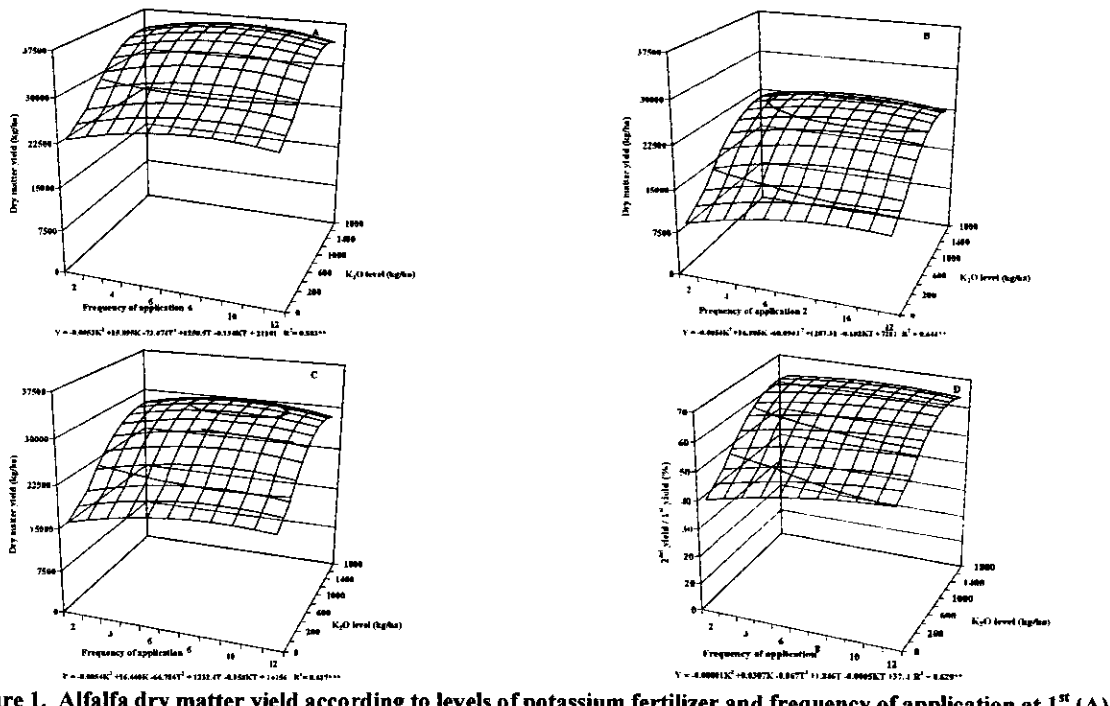

Figure 1. Alfalfa dry matter yield according to levels of potassium fertilizer and frequency of application at 1st (A) and 2nd (B) crops season, average of both growing season (C) and ratio of yield at 2nd and 1st growing seasons (D).

1 – 6 August 2010, Brisbane, Australia. Published on DVD.

Figure 2 give the polynomial regression curves of the net profit functions of dairy production according to levels of potassium fertilizer at 1st and 2nd crops season, and average of both growing season in 4 scenarios of milk and potassium fertilizer prices. Profit was estimated as a function of income and expenses associated with maintenance and production of dairy cows during one year in a system described by Vinholis *et al.* (2008). Income and expenses were calculated by multiplying the actual requirements of various commodities with the low and high prices. Results indicated that the amount variation in total net profit accounted for by the milk price was much greater than that accounted for by potassium fertilizer price (Figure 2).

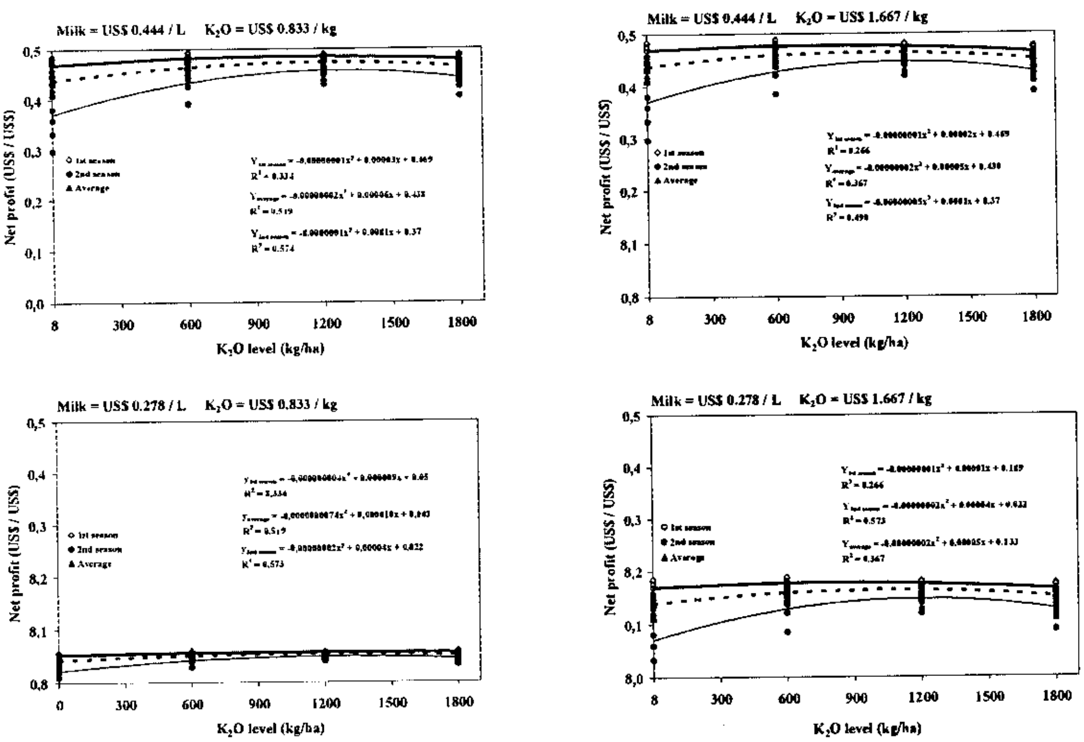

Figure 2. Net profit functions of dairy production according to levels of potassium fertilizer at 1st, 2nd crops season, and average of both growing season in 4 scenarios of milk and potassium fertilizer prices.

Estimated profit functions serve as a useful aid in economic decisions for alfalfa fertilization than just the dry matter yield curves. The maximum profit for K_2O doses were 1,212 kg/ha for the lower prices of fertilizers and 1,045 kg/ha for the higher prices of fertilizers. These results encourage further investigations toward estimating economic returns of alfalfa pasture grown in tropical acid low fertility soils.

Conclusion

The use of 1,420 kg/ha/year of K_2O applied after two cuttings (6 applications per year) increased alfalfa dry matter yield until 30,500 kg/ha. Estimated profit functions were a useful aid in economic decisions for alfalfa fertilization than just the dry matter yield curves. The maximum profit for K_2O doses were 1,212 kg/ha for the lower prices of fertilizers and 1,045 kg/ha for the higher prices of fertilizers.

Acknowledgments

The authors wish to thank IPI (International Potash Institute) for the financial support to the study and in particular to Dr. A. Naumov.

References

Berg WK, Cunningham SM, Brouder SM, Joern BC, Johnson KD, Santini J, Volenec JJ (2005) Influence of phosphorus and potassium on alfalfa yield and yield components. *Crop Science* **45**, 297-304.

Havlin J, Beaton JD, Tisdale SL, Nelson WL (1999) 'Soil Fertility and Fertilizers: An Introduction Nutrient Management'. (Prentice Hall: Upper Saddle River).

Kafkafi U, Gilat R, Yoles D, Noy Y (1977) Studies on fertilization of field-grown irrigated alfalfa. *Plant Soil*

46, 165-173.

Lanyon LE, Smith FW. (1985) Potassium nutrition of alfalfa and other forage legumes: temperate and tropical. In In'Potassium in Agriculture'. (Eds Rs Rominger, D Smith, LA Peterson) (Madison: ASA).

Lloveras J, Ferran J, Boixadera J, Bonet J (2001) Potassium fertilization effects on alfalfa in a Mediterranean climate. *Agronomy Journal* **93**, 139-143.

Moreira A, Bernardi ACC, Rassini JB (2008) Correção do solo, estado nutricional e adubação da alfafa. In 'Cultivo e utilização da alfafa nos trópicos'. (Eds RP Ferreira, JB Rassini, AA Rodrigues, AR Freitas, AC Camargo, FC Mendonça) pp. 95-138. (Embrapa Pecaria Sudeste: São Carlos, Brazil).

Rassini JB, Freitas AR (1998) Desenvolvimento da alfafa (*Medicago sativa*) sob diferentes doses de adubação potássica. Revista *Brasileira de Zootecnia* **27**, 487-490.

Smith D (1975) Effects of potassium topdressing a low fertility silt loam soil on alfalfa herbage yields and composition and on soil K. *Agronomy Journal* **67**, 60–64.

Vinholis MMB, Zen S, Beduschi G, Sarmento PHL (2008) Análise econômica da utilização de alfafa em sistemas de produção de leite. In 'Cultivo e utilização da alfafa nos trópicos'. (Eds RP Ferreira, JB Rassini, AA Rodrigues, AR Freitas, AC Camargo, FC Mendonça) pp. 409-434. (Embrapa Pecaria Sudeste: São Carlos, Brazil).