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Profitability of Potassium Fertilization of Alfalfa Pasture

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Introduction

High soil acidity, low cation exchange capacity, and low amounts of available nutrients of tropical soils are the most common factors limiting high yield in crops and profitable farming in Brazil (Bernardi *et al.*, 2002), and is especially the case for forage alfalfa. Lime and fertilizers are therefore very much needed to maintain high quality and profitable yields (Moreira *et al.*, 2008). As already shown by Rassini and Freitas (1998), and Bernardi and Rassini (2009), potassium fertilization is essential for alfalfa production in Brazilian acid soils.

Well-established pastures that are properly managed and fertilized are the main source of food for cattle and are the most practical, as it is a less costly source of feed (Camargo *et al.*, 2002). In intensive dairy production the system - based on rotational grazing with an increased supply of fodder in periods of drought and careful management of soil fertility - allows increased rates of stocking and productivity (Corsi and Nussio, 1993; Primavesi *et al.*, 1999). In the summer, *Panicum maximum*, *Cynodon dactylon* or *Brachiaria brizantha* are used as grass forage and, in the winter, feed is based on chopped sugarcane or corn silage. Throughout the year, the feed diet may be complemented with alfalfa as a high source of protein.

Of the controllable factors determining forage yield and quality, soil fertility - including fertilizer treatment - is one of the most important. On these tropical acid soils naturally poor in plant nutrients, soil liming and balanced nutrient supply are therefore essential to ensure high yielding and high quality forage (Corsi and Nussio, 1993; Primavesi *et al.*, 1999; Camargo *et al.*, 2002). However, fertilization may represent as much as 27 percent of the total cost of production of alfalfa in typical Brazilian intensive dairy cattle production (Vinholis *et al.*, 2008) so that an adequate assessment of the fertilizer investment is critical. Economic studies on alfalfa fertilization in dairy production systems are therefore required to establish conditions under which returns may be maximized, especially with pastures on acid and low fertility soils. Hence the effects of various management practices and related issues become important factors for profitable dairy production.

This paper uses data from a field experiment by Bernardi and Rassini (2009) involving potassium fertilization over a two-year growing season on a Typic Hapludox (red tropical soil) in Brazil to evaluate the economic return of potassium fertilizer on an alfalfa pasture for dairy cattle production. The experiment comprised three levels of potassium applied as a topdressing, together with a control without any potassium treatment (i.e. 600, 1,200, and 1,800 kg ha^{-1} year^{-1} of K_2O as KCl.). There were four frequencies of application: after each cutting (12 applications), after every two cuttings (six applications) and after every three cuttings (four applications) and after every six cuttings (two applications per year). K doses were split equally between numbers of applications.

Methods

The results obtained from alfalfa dry matter yield due to potassium fertilizer treatment were used to simulate pasture stocking rate, milk production, production cost and resulting net profit.

The methodology for costing was based on the cost sheet drawn up by Vinholis *et al.* (2008) for a Brazilian intensive dairy cattle production system, where the forage diet of the cows consisted of pasture alfalfa and *Cynodon* spp. cv Tifton 85, and sugarcane provided during the winter (dry season).

The following data was used in the simulation:

a. Average cow live weight (LW) = 550 kg;
b. Cow dry matter (DM) consumption = 3.05% of LW, corresponding to 16.8 kg day^{-1} of DM;
c. The alfalfa pasture grazing represented 14% of the total of cow dietary consumption, and 20% of the forage consumption (Vinholis *et al.*, 2008).

Estimation of the stocking rate and the milk production was made using the following equations:

i) Stocking rate

Where:

$$SR = \frac{DM \times GE}{AGN \times GI \times DIFC}$$

SR = stocking rate in the alfalfa pasture, animal ha^{-1}

DM = dry matter yield, kg (according to Bernardi and Rassini, 2009)

GE = grazing efficiency (GE = 0.7)

AGN = annual number of grazing events (12 grazing events/year)

GI = grazing interval, days (30 days)

DIFC = daily individual forage consumption, kg of dry matter/cow/day

ii) Milk production

$$MP = \frac{SR \times MY \times 365}{1+(TPIA+SCIA) \times SR}$$

Where:

MP = annual milk production, liters ha^{-1} year^{-1}

MY = daily milk yield, liters cow^{-1} day^{-1} (20 liter cow^{-1}, 4% fat content)

TPIA = tropical pasture individual area,

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ha cow^{-1} (TPIA = 0.125 ha cow^{-1})

SCIA = sugarcane individual area, ha cow^{-1} (SCIA = 0.043 ha cow^{-1})

Note: TPIA and SCIA are the areas of tropical pasture and sugarcane used for feeding the cows that also graze in 1 ha of alfalfa.

iii) Milk cost production

$$MCP = \frac{TPC}{MP}$$

Where:

MCP = milk cost production, US\$ L^{-1}

TPC = total production cost of milk, US\$ L^{-1}

MP = annual milk production, liter ha^{-1} year^{-1}

iv) Net profit

$$NP = GR - MCP$$

Where:

NP = net profit, US\$ L^{-1}

GR = gross revenue, US\$ L^{-1}

MCP = milk cost production, US\$ L^{-1}

The net profit estimation was obtained by profit functions, considering four scenarios, provided by using a combination of two cost levels for milk and potash, representing a realistic fluctuation in prices (Table 1).

The currency exchange rate used was US\$ 1.00 = BRL 1.80. The data was submitted to the statistical analysis of variance for detecting differences among treatments, and crop response functions to the potassium fertilizer were adjusted.

Results

Previous results of Bernardi and Rassini (2009) show an increase in alfalfa DM yield as potassium fertilization increased. Considering two alfalfa seasons, the use of 1,420 kg ha^{-1} per year of K_2O applied after every two cuttings (6 applications per year) increased alfalfa dry matter yield up to

Table 1. Scenarios for simulations with two price levels for milk and potash.

Scenario	Milk price	Potash price (K_2O)
	US\$ L^{-1}	*US\$ kg^{-1}*
A	0.278	0.833
B	0.278	1.167
C	0.444	0.833
D	0.444	1.167

30,500 kg ha^{-1}. These results also indicate that adequate potassium supply increases the stand longevity, since a yield reduction from first year to second was greater with lower levels of potassium fertilization.

Stocking rate is a key management variable in determining productivity and profitability of grazing systems, since this index determines quality and use efficiency of forage, animal performance and milk production per area (Fales *et al.*, 1995).

Plotting the estimated stocking rate of alfalfa pasture (Fig. 1A) and milk production (Fig. 1B) against rate of potassium fertilization show, in both cases a quadratic relationship with maximum values at around of 1,500 and 1,380 kg ha^{-1} per year of K_2O, respectively. Potassium application increased the average stocking rate by approximately 30 percent from 15 (zero K) to more than 20 animals ha^{-1}, and milk production from 30,000 to 34,000 kg ha^{-1} yr^{-1}. Under good alfalfa pasture growth conditions, as with balanced nutrient supply, higher stocking rates were improved due to increased DM yield production as previously observed by Bernardi and Rassini (2009). Results of this simulation study show that alfalfa pasture, adequately fertilized with potassium fertilizer, is capable of supporting high stocking rates and high milk production per hectare. Therefore, as shown by Fales *et al.* (1995), the optimal stocking rate for a given dairy farm depends on individual farm resources (e.g., land, buildings, cows, etc.), and can be adjusted to meet the constraints of those resources without fear of significant adverse economic impact.

Fig. 2 (A to D) describe the polynomial regression curves of the net profit

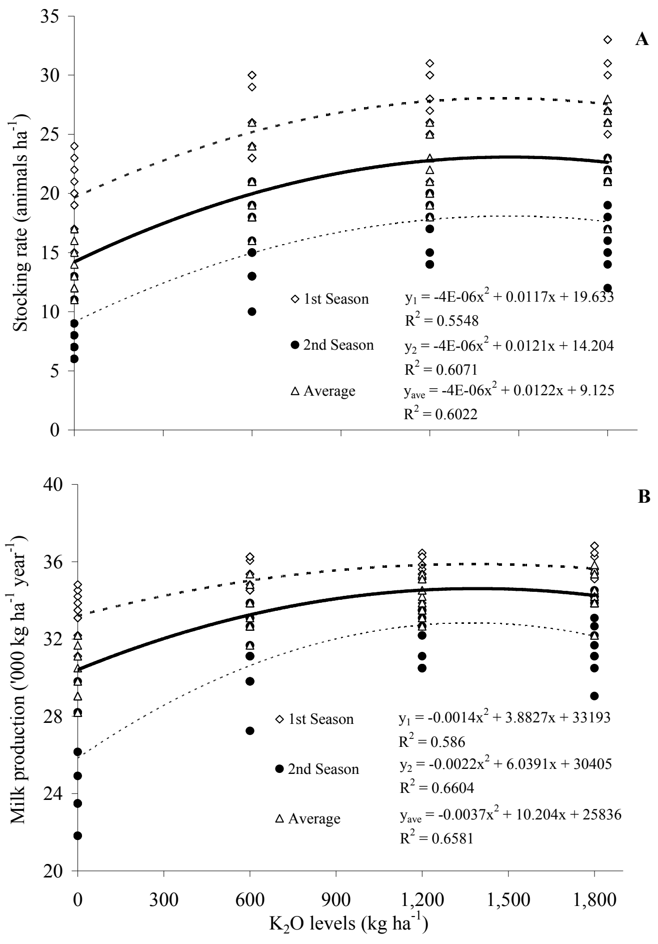

Fig 1. Estimate of stocking rate (A) for alfalfa pasture and milk production (B) according to levels of potassium fertilizer for 1st and 2nd crop seasons, and averages for the two growing seasons.

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functions of dairy production according to levels of potassium fertilizer for 1st and 2nd cropping seasons, and the averages of the two growing seasons in the four studied 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 price scenarios. Estimated profit functions serve as a useful aid in economic decisions for alfalfa fertilization other than dry matter yield curves alone.

Net profit was in the range of $US 0.05 to 0.5 per liter of milk. At the low milk price (US$ 0.278 L^{-1}), profitability was low at less than US$ 0.2 per liter of milk (Fig. 2A and 2B). Higher potash prices significantly reduced the net profit. In both scenarios (A and B), the maximum profit for K_2O doses was obtained with 1,212 kg/ha for the lower price of potash (US$ 0.833) and 1,045 kg/ha for the higher price of potash (US$ 1.667).

Under high milk prices (US$ 0.444 L^{-1}), profitability improved to between US$ 0.4 to 0.5 per liter of milk and was not affected by any change in potash price (Fig. 2C and D). The reason for this is the high agronomic response of alfalfa to potash supply so that, even with the additional cost of heavier potash applications, profitability of milk production was maintained; profitability being more sensitive to the price of milk than price of potash fertilizer.

The results indicate that the variation in total net profit accounted for by milk price was much greater than that accounted for by potassium fertilizer price. This is because the fertilizer represents 27 percent of the total cost of milk production (Vinholis *et al.*, 2008). Furthermore, the results show that even with a scenario of high prices of potassium fertilizer (Fig. 2B and D) this nutrient should not be neglected, due to the clear positive effects on production of alfalfa (Bernardi and Rassini, 2009). The price of input has little influence on production costs since the income associated with milk production is much more associated with yields produced than potash fertilizer price.

These results encourage further investigations toward estimating economic returns of alfalfa pasture grown in tropical acid low fertility soils.

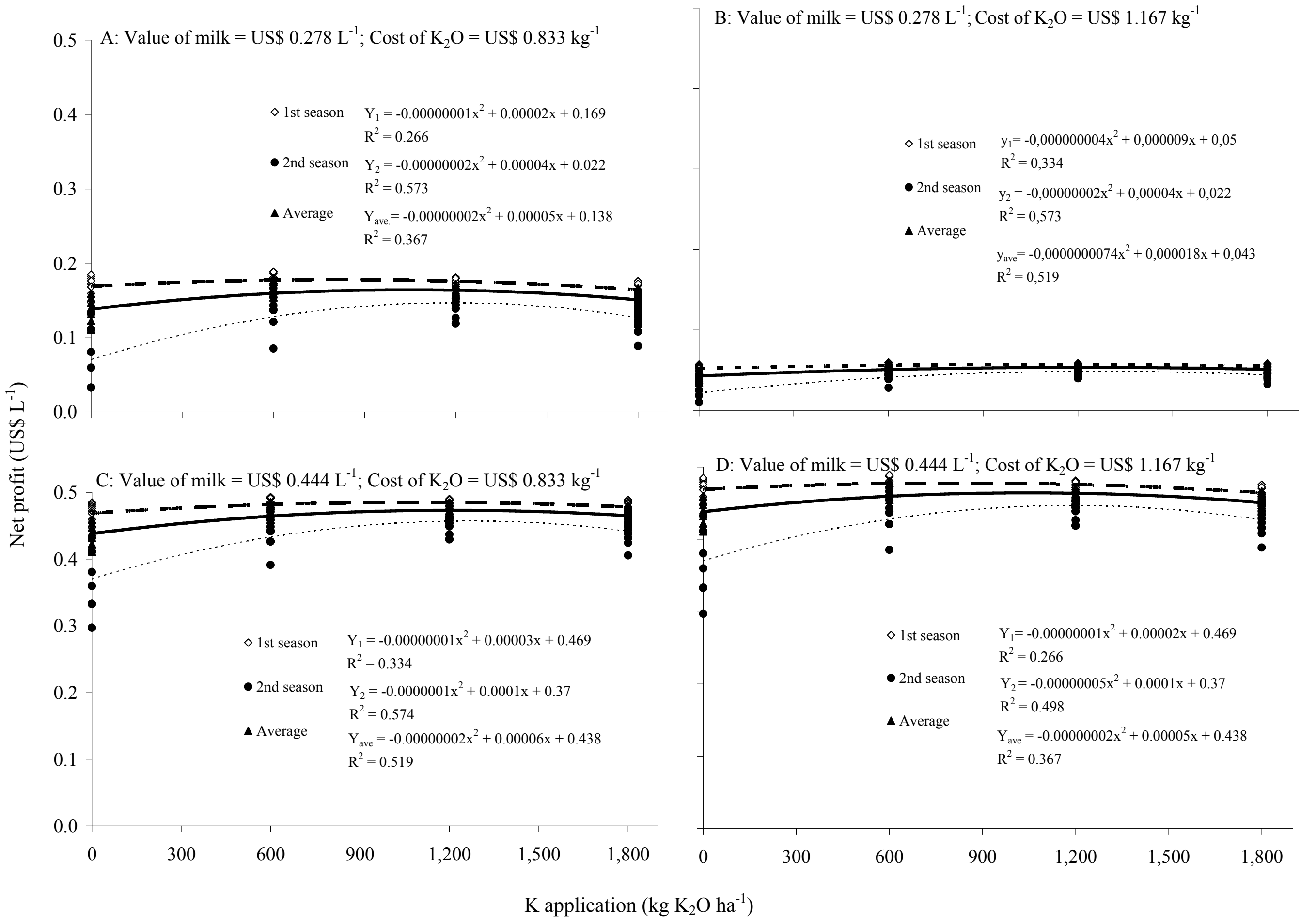

Fig 2 A-D. Net profit of milk production at low and high milk market prices (A-B & C-D), and low and high potash prices (A-C & B-D), respectively. Results are for 1st, 2nd cropping seasons, and averages for the two growing seasons.

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Conclusion

Estimated profit functions are a useful aid in economic decisions for alfalfa fertilization than dry matter yield curves alone. The maximum profit for K_2O doses were obtained at 1,212 kg ha^{-1} for the lower prices of potash and 1,045 kg ha^{-1} for the higher prices of potash. The net profit is more sensitive to price fluctuations of milk than to that of potash and, even after the costs of the high level of potash required for alfalfa fertilization, milk production can still be highly profitable.

Under the price relationship scenarios studied, a profitable strategy for increasing productivity is the maintenance of balanced fertilized pasture for more intensive grazing to produce more milk. More intensive dairy production by judicious fertilization of legume pastures and greater stocking density is a valuable strategy for producers to improve net economic returns under current conditions.

Cattle grazing on alfalfa field, Brazil. Photo by A. Bernardi.

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