Potassium balance in soybean grown under no-till

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Abstract

A well managed K fertilization program can avoid nutrient losses, and soil K depletion thus minimizing costs. Cover crops can be important in recycling K, contributing to the sustainability of the crop system. An experiment was conducted in Botucatu, SP, Brazil, for two years, using different K rates and managements in a soybean-millet-black oat rotation system in no-till. Soil, plant and straw samples were taken during the experiment period and analyzed for K contents. Soil exchangeable and non-exchangeable K were analysed. In order to maintain K levels in the system relatively stable, it was necessary the apply at least 38 kg ha^{-1} of K_2O per year (Fig 3-a). If K contents in the straw were not taken into account, in two years K deficit in the system would amount to over 180 kg ha^{-1} (Fig 3-C and 3-D), which highlights the importance of the cover crops and the mulch in recycling the nutrient in the system. Cover crops can act in the system in two ways: preventing K leaching below 60 cm, and bringing up some K from deeper soil layers, in both cases releasing K from the straw during early growth of soybean to match the K demand and avoiding nutrient loss. Therefore the K accumulated in the winter cover crops was paramount as a nutrient source for the following soybean crop and for the sustainability of the system.

Media summary

Potassium accumulated in the winter cover crops was paramount as a nutrient source for the following soybean crop and for the sustainability of the system.

Key words

Black oat, cropping systems, nutrient cycling, pearl millet, potassium

Introduction

No till systems are characterized by maintenance of plant residues on the soil surface. It is very important in tropical regions because soil loss is reduced and water and nutrients are conserved. The straw kept over the soil is a considerable reserve of nutrients like K and contributes to the nutrition of the following crop. Large agricultural areas of Brazil present relatively low K contents. K fertilization is usually recommended considering K contents in the first 20 cm of the soil profile. On the other hand, non-exchangeable K can contribute to soybean nutrition. Potassium fertilization of soybeans in Brazil is estimated to have a cost of around US$ 30 million. A well managed K fertilization program can avoid nutrient losses and soil K depletion, thus minimizing costs.

Material and Methods

An experiment was performed to evaluate the contribution of the potassium from straw, and exchangeable and non-exchangeable soil K on K balance in the soil-plant system during two years when soybean was grown in rotation with no-till. The experiment was conducted in Botucatu, S?o Paulo State, Brazil in a Red Distroferric Latosol, sandy loam (770 g kg^{-1} of sand, 10 g kg^{-1} of silt and 220 g kg^{-1} of clay), planted to soybean and kept under no-till for the two preceding years. Soil samples were taken in August, 2000 (Table 1). In September, millet (*Pennisetum glaucum)* was planted in lines 2.0 m apart, using 20 kg ha^{-1} of P_2O_5 and 15 kg ha^{-1} of N, over black oat (*Avena strigosa)* straw. Millet yielded 4.5 t ha^{-1} of dry matter. In December/2000, millet was desiccated using 4 L ha^{-1} of Glyphosate and soybean was planted over millet straw, in lines 0.45 m apart at a population of 47 plant m^{-2}, using 60 kg ha^{-1} of P_2O_5. Average soybean yield was 3570 kg ha^{-1}. In April 2001 black oat was planted without fertilizer, in lines 0.20 m apart. Black oat yielded 7.3 t ha^{-1} of dry matter. In September 2001 black oat was desiccated using 2.0 L ha^{-1} of Glyphosate and millet was planted over the remaining straw. Millet yielded 13.3 t ha^{-1} of dry matter. In December 2001 millet was desiccated using 4.0 L ha^{-1} of Glyphosate and soybean was again planted at a population of 51 plants m^{-2}. Soybean average yield was 3050 kg ha^{-1}.

Treatments consisted of 0, 30, 60 and 90 kg ha^{-1} of K_2O as KCl applied either at millet or soybean planting, in a factorial design in complete randomized blocks with four replications. Plant residues laying over the soil surface were sampled right before soybean planting and at soybean harvest, oven-dried a 60 ^oC for 72 h and K content was determined. A grain sample was taken from each plot, oven-dried and K content was also determined. Soil samples were taken from depths of 0-5, 5-10, 10-20, 20-40 and 40-60 cm. Exchangeable (resin) and non-exchangeable K (hot HNO_3 1.0N) were determined. Potassium balance in the system was calculated after soybean harvest, considering as K additions the fertilizer, the soil K at soybean planting down to 60 cm and the K content in the straw; and K removal as soybean grain K, K in content in the straw at soybean harvest and soil K at soybean harvest. Anova was performed in the results and equations were fitted according to the highest determination coefficient.

Profundidade	pH_{CaCl_2}	M.O.	P_{resina}	H+Al	K	Ca	Mg	SB	CTC	V
(cm)		g dm^{-3}	mg dm^{-3}	---------------------------$mmol_c$ dm^{-3}---------------------------						(%)
0-5	5,2	21,0	18,4	27,3	2,7	21,0	13,0	36,7	64	57,3
5-10	5,2	18,1	16,2	28,2	0,7	17,0	11,0	28,7	56,9	50,4
10-20	4,6	18,9	5,3	34,1	0,6	8,0	5,8	14,4	48,5	29,7
20-40	4,0	18,2	2,9	44,8	0,7	5,0	2,6	8,3	53,1	15,6
40-60	3,8	15,3	1,9	66,0	0,3	3,0	1,2	4,5	70,5	6,4

Table 1. Chemical characteristics of the soil at the time the experiment was started.

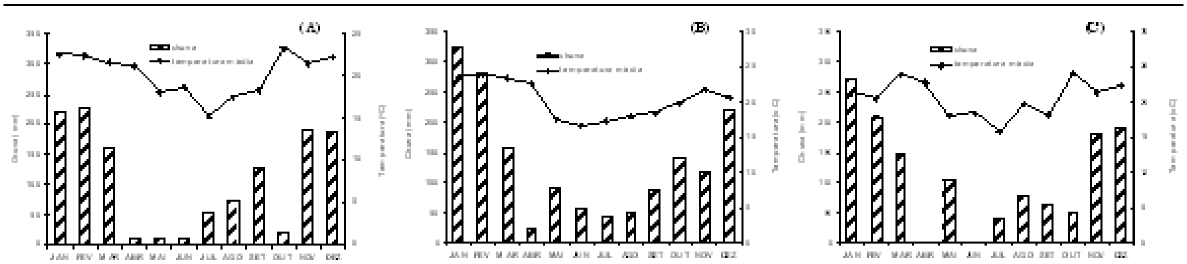

Figure 1. Amount of rain and monthly average temperature during the experiment.

Results and discussion

The application of 129 kg ha^{-1} of K_2O was required to make K balance in the system equal zero in the soybean-millet rotation (Fig 2-A). In other words, considering plant residues plus the exchangeable K down to 60 cm as K sources in the first year, it was necessary to apply a high rate of K fertilizer to meet the system demand. Considering the initial soil K content, the fertilizer recommendation for S?o Paulo State would be 50 kg ha^{-1} of K_2O, what would lead to an important depletion in soil K in the system and soil K exhaustion with time.

When non-exchangeable K was added to exchangeable K in the calculations, in the first year, there was no K depletion in the system, even when no K was applied as fertilizer (Fig 2-B). Therefore, non-exchangeable K presented a considerable contribution to K balance in the system, justifying, in part, the lack of soybean response to K in several Brazilian soils.

Assuming there was no straw on soil surface and exchangeable K as the sole K source (Fig 2-C), the application of 180 kg ha^{-1} of K was not enough to balance K demand by the system. Therefore the K accumulated in the winter cover crops was paramount as a nutrient source for the following soybean crop and for the sustainability of the system.

In the second year of the experiment, with no K fertilization, there was a K deficit when exchangeable (Fig 3-A) and also when exchangeable and non-exchangeable were considered in the calculations (Fig 3-B).

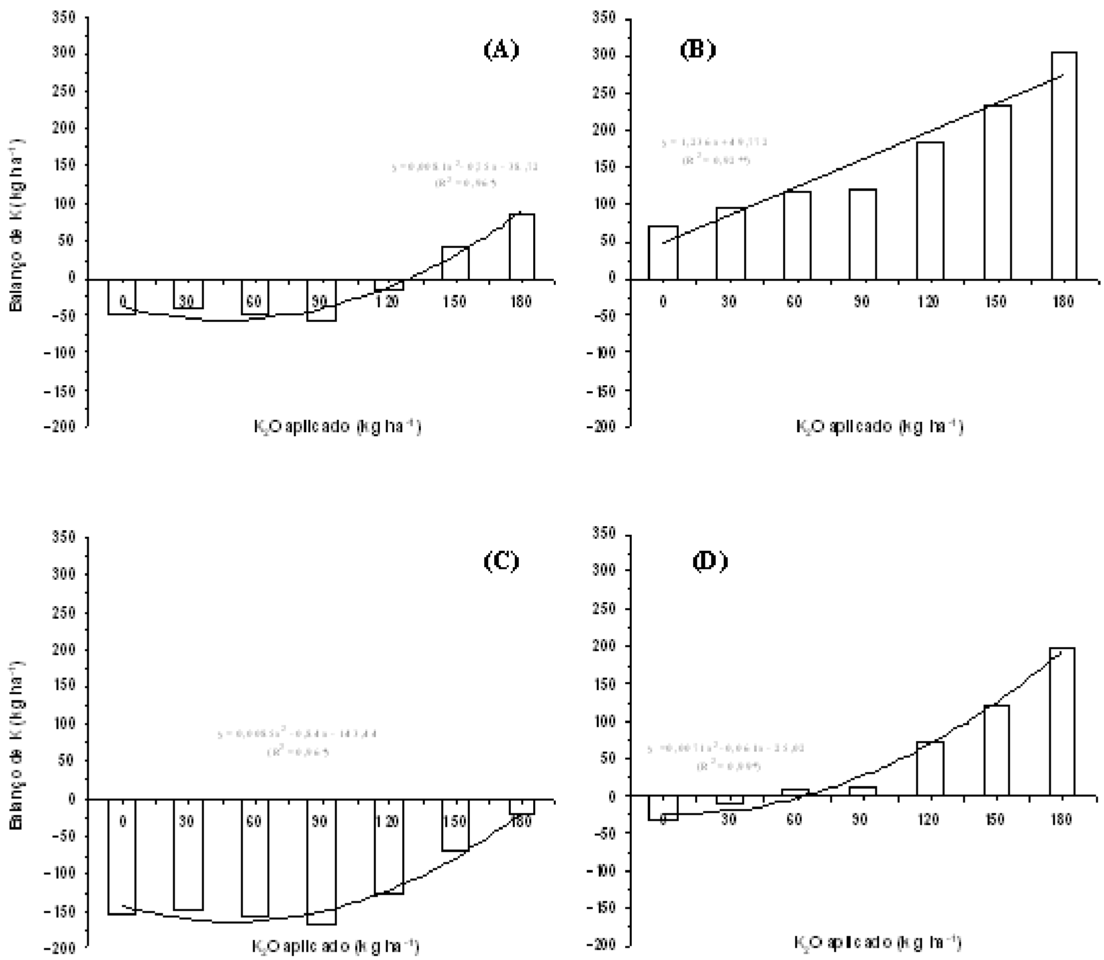

Figure 2. K balance at soybean harvest as affected by K fertilizer management, in the first year:
(A) **[(exchangeable K at soybean plantitng + K in the straw at soybean planting + fertilizer K) - (exchangeable K at harvest + K in the straw at harvest + grain K)].**
(B) **[(exchangeable + non-exangeable K at planting + K in the straw at planting + fertilizer K) - (exchangeable + non-exangeable K at harvest + K in the straw at harvest + grain K)].**
(C) **[(exchangeable K at planting + fertilizer K) - (exchangeable K at harvest + straw K at harvest + grain K)].**
(D) **[(exchangeable + non-exangeable K at planting + fertilizer K) - (exchangeable + non-**

exangeable K at harvest + straw K at harvest + grain K)].
*** and ** significant (P<5% and < 1%, respectively; n.s. non-siginificant.**

This was true even when K contents in straw was added in the balance. In this way, in the second year non-exchangeable K reserve of the soil was not enough to provide an adequate amount of the nutrient for soybean. After two years of the rotation millet-soybean-oat in no till there was a depletion of 31 kg ha^{-1} of the exchangeable K in the system, when no K fertilizer was applied. In this case, considering exchangeable and non-exchangeable K total depletion reached 31 kg ha^{-1} (Fig 3-A and 3-B).

These results showed that to maintain K levels in the system relatively stable, it was necessary the application of, at least, 38 kg ha^{-1} of K_2O per year (Fig 3-a). If K contents in the straw is not taken into account, in two years K deficit in the system would amount to over 180 kg ha^{-1} (Fig 3-C and 3-D), what highlights the importance of the cover crops and the mulch in recycling the nutrient in the system. Cover crops can act in the system in two ways: preventing K leaching below 60 cm and bringing up some K from deeper soil layers and releasing K from the straw during early growth of soybean, matching K demand and avoiding nutrient loss.

Soybean dependence on K fertilizer was increased when non-exchangeable K was not considered as a K source in the balance sheet. K source-sink equilibrium in the system where soybean was grown in rotation with pearl millet and black oat, in no-till, depended more on K amounts accumulated in the straw than on soil non-exchangeable K, which was more important than fertilizer K, in two years of rotation.

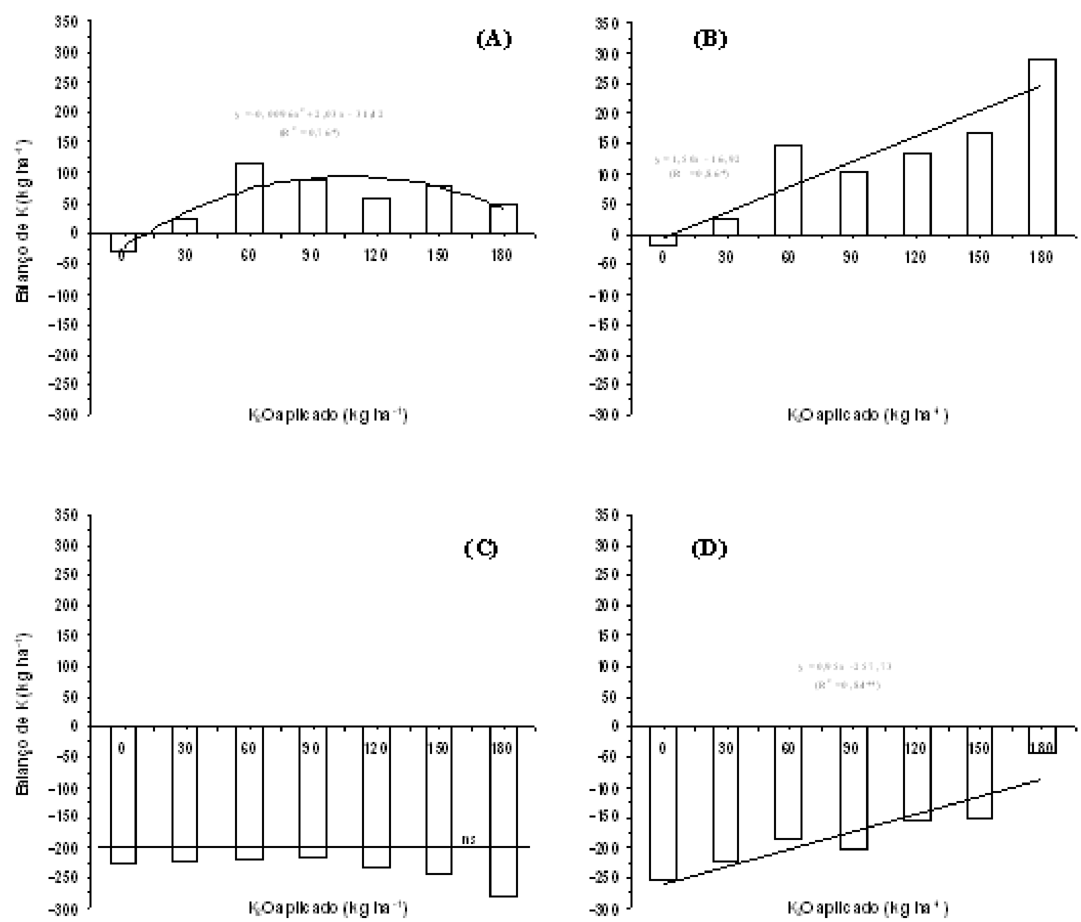

Figure 3. K balance at soybean harvest as affected by K fertilizer management, in the second year:
(A) [(exchangeable K at soybean plantitng + K in the straw at soybean planting + fertilizer K) - (exchangeable K at harvest + K in the straw at harvest + grain K)].
(B) [(exchangeable + non-exangeable K at planting + K in the straw at planting + fertilizer K) - (exchangeable + non-exangeable K at harvest + K in the straw at harvest + grain K)].
(C) [(exchangeable K at planting + fertilizer K) - (exchangeable K at harvest + straw K at harvest + grain K)].
(D) [(exchangeable + non-exangeable K at planting + fertilizer K) - (exchangeable + non-exangeable K at harvest + straw K at harvest + grain K)].
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