# Nitrogen management for common bean crop in new and established no-tillage systems

Rogério Peres Soratto[A], Adelson Antonio Guidolin Perez[A] and Natália Politti Manzatto[A]

[A]College of Agricultural Sciences, São Paulo State University, Botucatu, São Paulo State, Brazil, Email soratto@fca.unesp.br

## Abstract
The common bean crop has been increasingly cultivated in no-tillage systems, thus it is important to know the responses to nitrogen fertilization in soils under non-conventional management for different periods of time, considering that N availability in affected by the soil management system. This work aimed to evaluate the effects of sidedressed N fertilization rates (0, 30, 60, and 120 kg/ha) on common bean crop cultivated in newly implemented no-tillage system and established no-tillage system, without or with application of 60 kg/ha of N at bean sowing. In both systems (newly and established), N fertilization increased shoot dry matter production and grain yield of common bean; however, N applied at sowing was more efficient in increasing shoot dry matter. Even with the application of 60 kg/ha of N at sowing, common bean yield was increased by sidedressing N fertilization in both newly implemented and established no-tillage system. The efficiency of sidedressing N was greater in treatments receiving N at sowing.

## Key Words
*Phaseolus vulgaris*, nitrogen, soil management system, no-tillage, grain yield.

## Introduction
Brazil is the greatest common bean (*Phaseolus vulgaris* L.) producer in the world (Faoestat 2009). This legume crop is an important source of protein and energy for the nutrition of Brazilian people. Although the association with *Rhizobium* bacteria supplies the bean crop with part of the nitrogen (N), the amount supplied is not sufficient for the crop. Bean plants that are deficient in N show lower development and grain yield (Oliveira *et al*. 1996). Therefore, N supplied at the right time is fundamental for the bean plants to develop appropriately, because plants that are stronger, with more stems and that show more reproductive structures result in higher grain yield.

In tropical regions, no-tillage system is responsible to maintain soil sustainability. In the first years of no-tillage establishment, N immobilization in soil increases. At this time, organic matter works as a N sink, because soil organic matter accumulation exceeds decomposition, mainly if the soil is cropped with grasses. After some years of no-tillage establishment, soil conditions stabilize. As time goes by, residue decomposition increases N in soil, and this will be higher than the amount immobilized by microorganisms (Amado *et al*. 2002), so decreasing N demand. Nevertheless, appropriate management of N fertilization is one of the hardest to achieve.

The objective of this work was to evaluate the effects of N fertilization applied at sowing and/or side dressing on the bean crop cultivated in newly implemented and established no-tillage systems.

## Methods
This work was carried out in 2007/08 and 2008/09, on Lageado Experimental Farm, Botucatu/SP - Brazil (48º 23' W and 22º 51' S, 765 m asl). The soil was a Red Nitosol (Alfisol), with 20.2%, 24.5%, and 52.3% of sand, silt, and clay contents, respectively. The experiment was arranged in a randomized complete block design with split-plots and four replications. Main plots consisted of four treatments: NNT - newly implemented no-tillage system (common bean crop was the first to be cropped in no-tillage system), ENT - established no-tillage system (23 years without soil tillage), NNT+N - NNT with application of 60 kg/ha of N at common bean sowing and ENT+N – ENT with application of 60 kg/ha of N at common bean sowing. Subplots consisted of four sidedressed N rates (0, 30, 60 and 120 kg/ha), applied at common bean V4 stage (third expanded trifoliate leaf) (Fernández *et al*. 1986), 20 days after seedling emergence (DAE). Nitrogen source was ammonium nitrate.

In fall-winter of 2007 and 2008 soil was cropped with yellow oat (*Avena byzantina* C. Koch). In December of 2007, chemical analysis of the soil in the experimental area was carried out, in the depths 0-10 and 10-20 cm (Table 1).

The area was treated about 15 days before bean sowing with the herbicide glyphosate (1.44 kg/ha of the active ingredient). Sowing of the Pérola cultivar was on 17 January 2008 and 06 January 2009, using 15 seeds per meter, in a 45 cm row spacing. At this time, $P_2O_5$ and $K_2O$ were applied in all plots in the rates recommended for the crop. In previously specified plots, 60 kg/ha of N was also applied.
Shoot dry matter production at the time of flowering, N concentration in leaves and grain yield were evaluated. Data were subjected to an ANOVA (average across 2 years). System treatment means were compared by LSD test ($P<0.05$). Sidedressing N rates were analyzed through regression analysis, adopting the magnitude of regression coefficients that were significant at the 0.05 probability level by t-test as criterion for choosing the model.

**Table 1. Soil chemical attributes at the depths 0-10 and 10-20cm. Average of four replications.**

| Prof. (cm) | Soil management | pH ($CaCl_2$) | O.M. ($g/dm^3$) | P (resin) ($mg/dm^3$) | H+Al | K | Ca | Mg | CEC | Base saturation (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($mmol_c/dm^3$) | | | | | |
| 0-10 | NNT | 5.2 | 35.9 | 51.1 | 38.9 | 5.0 | 51.5 | 17.0 | 112.4 | 65 |
| | ENT | 5.3 | 40.2 | 81.5 | 38.3 | 5.7 | 61.6 | 22.6 | 128.2 | 70 |
| 10-20 | NNT | 5.2 | 32.6 | 36.9 | 39.6 | 3.2 | 61.9 | 19.4 | 124.1 | 68 |
| | ENT | 5.3 | 30.5 | 48.4 | 36.4 | 3.1 | 61.7 | 18.7 | 119.9 | 69 |

NNT - newly implemented no-tillage system, ENT - established no-tillage system, CEC - cation exchange capacity.

## Results

Despite the different periods of time under no-tillage system, the soil of the experimental area showed good fertility level in both situations (Table 1).

For the treatments with 60 kg/ha of N at sowing (NNT+N and ENT+N), shoot dry matter production was higher than in the treatments with no N at sowing, even with the application of 120 kg/ha of sidedressing N (Figure 1A). Sidedressed N linearly increased dry matter, but only for the treatments with no N at sowing (NNT and ENT). However, for those treatments, with the sidedressing application of 120 kg/ha of N, dry matter production was lower than with the application of 60 kg/ha of N at sowing. There was no plant response to sidedressing N fertilization whenever N was applied at sowing. The results showed that N supplied at sowing resulted in better use of the fertilizer with effects on biomass production, considering that whenever N was applied at sowing there were higher values of plant dry matter. This emphasizes the importance of N fertilization in the initial stages of the bean crop. Although the maximum absorption of N is between flowering and grain filling (Hungria *et al*. 1985), the results showed that the bean crop requires N for its initial growth (Soratto *et al*. 2006), mainly when cultivated in no-tillage system after grasses.

Bean plants of the treatments with N applied at sowing (NNT+N and ENT+N) showed higher concentrations of this nutrient in leaves, whenever side dressing N was not applied (Figure 1B). Nitrogen applied at sowing increased N uptake by the plants, considering that it also increased shoot dry matter (Figure 1A) and N concentrations in the leaves (Figure 1B). Plants fertilized with 120 kg/ha of side dressing N in the treatment ENT+N showed higher concentrations of the nutrient in the leaves, which indicates higher N availability in soil for the established no-tillage system. Nevertheless, only for the treatments NNT and ENT with no side dressing N, bean plants showed N concentrations in the leaves that were below the optimum range (30-50 g/kg) considered appropriate for this crop (Ambrosano *et al*. 1996).

Irrespective of soil management, both sidedressing N and sowing application increased grain yield (Figure 1C). In the treatment NNT+N, sidedressed N increased bean yield up to the calculated dose of 84 kg/ha. In the other treatments, side dressing N fertilization linearly increased grain yield. However, the treatment ENT+N combined with the highest side dressing rate (120 kg/ha) resulted in higher grain yield (Table 2).

The greater availability of N in the initial stage of the crop, due to N application at sowing, increased the efficiency of sidedressed N, especially in the newly implemented no-tillage system (Table 2).



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

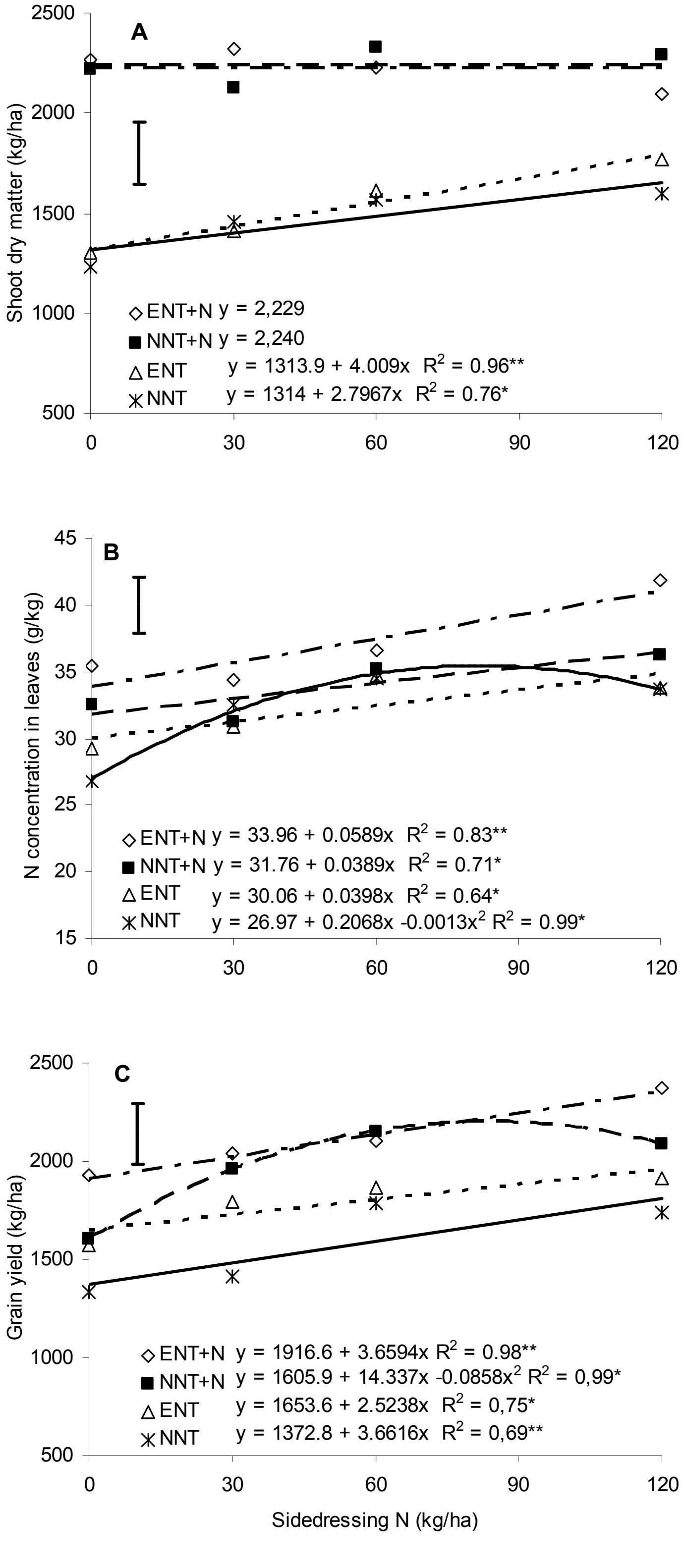


**Figure 1. Shoot dry matter production (A), leaves N concentration (B) and grain yield (C) of common bean crop cultivated in newly implemented no-tillage system (NNT), established no-tillage system (ENT), newly implemented no-tillage system with N application at common bean sowing (NNT+N), and established no-tillage system with N application at common bean sowing (ENT+N) as affected by sidedressing N fertilization. *$P$ <0.05; **$P$ < 0.01. Vertical bars represent LSD values ($P$<0.05).**

**Table 2. Common bean yields without sidedressed N, maximum yield, yield increase with N rate for maximum yield, amount of N for maximum yield and kilogram of common bean yield increased per kilogram of sidedressed N in newly implemented no-tillage system (NNT), established no-tillage system (ENT), newly implemented no-tillage system with N application at common bean sowing (NNT+N), and established no-tillage system with N application at common bean sowing (ENT+N).**

| Treatments | Yield without sidedressed N (kg/ha) | Maximum yield (kg/ha) | Yield increase with N rate for maximum yield (kg/ha) | N rate for maximum yield (kg/ha) | Sidedressed N use efficiency[1] (kg/kg) |
|---|---|---|---|---|---|
| ENT+N | 1926 | 2371 | 445 | 120 | 3.7 |
| NNT+N | 1604 | 2205 | 601 | 84 | 7.2 |
| ENT | 1574 | 1910 | 337 | 120 | 2.8 |
| NNT | 1332 | 1735 | 403 | 120 | 3.4 |

[1] Yield increase with N rate for maximum yield (kg/ha) per N rate for maximum yield (kg/ha)

## Conclusion

In both newly implemented and established no-tillage systems, N fertilization increased shoot dry matter production and grain yield of common bean; however, N applied at sowing was more efficient in increasing shoot dry matter. Even with the application of 60 kg/ha of N at sowing, common bean yield was increased by sidedressing N fertilization in both newly implemented and established no-tillage system. The efficiency of sidedressing N was greater in treatments receiving N at sowing.

## References


Amado TJC, Mielniczuk J, Aita C (2002) Recomendação de adubação nitrogenada para o milho no RS e SC adaptada ao uso de culturas de cobertura do solo, sob sistema plantio direto. *Revista Brasileira de Ciência do Solo*, **26**, 241-248.

Ambrosano EJ, Tanaka RT, Mascarenhas HAA, van Raij B, Quaggio JA, Cantarella H (1997) Leguminosas e oleaginosas. In 'Recomendações de adubação e calagem para o Estado de São Paulo'. (Eds B van Raij, H Cantarella, JA Quaggio, AMC Furlani) 2nd edn, pp.187-203. Boletim Técnico, 100. (Instituto Agronômico e Fundação IAC: Campinas).

Faostat (2009) Production, Crops, (Food and Agriculture Organization of the United Nations for a world without hunger: Rome) faostat.fao.org/site/567/default.aspx#ancor

Fernandez F, Gepts P, Lopes M (1986) Etapas de desarrollo de la planta de frijol (*Phaseolus vulgaris* L.), (Centro Internacional de Agricultura Tropical: Cali)

Hungria M, Neves MCP, Victoria RL (1985) Assimilação do nitrogênio pelo feijoeiro. II. Absorção e translocação do N mineral e do $N_2$ fixado. *Revista Brasileira de Ciência do Solo* **9**, 201-209.

Oliveira IP, Araújo RS, Dutra LG (1996) Nutrição mineral e fixação biológica de nitrogênio. In 'Cultura do feijoeiro comum no Brasil'. (Coords. RS Araújo, CA Rava, LF Stone, MJO Zimmermann) pp.169-221. (Potafos: Piracicaba).

Soratto RP, Carvalho MAC, Arf O (2006) Nitrogênio em cobertura no feijoeiro cultivado em plantio direto. *Revista Brasileira de Ciência do Solo* **30**, 259-265.