

Responses of IPR Campos Gerais and BRS Estilo bean cultivars to different nitrogen fertilizer rates in corn (*Zea mays* L.) succession

Respostas das cultivares de feijão IPR Campos Gerais e BRS Estilo à diferentes doses de adubo nitrogenado na sucessão do milho (*Zea mays* L.)

Respuestas de los cultivares de frijol IPR Campos Gerais y BRS Estilo a diferentes tasas de fertilizantes nitrogenados en la sucesión del maíz (*Zea mays* L.)

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Abstract

Among the nutrients, nitrogen (N) is the element required in greater quantity by the bean plant. Depending on the cultivar, it has greater or lesser N-fixing capacity. The aim of this work was to evaluate the performance of two common bean cultivars under nitrogen topdressing in corn succession, on yield components and yield. The experiment was carried out in randomized blocks in a 2x5 factorial scheme, the first factor being the common bean cultivars (IPR Campos Gerais and BRS Estilo) and the second factor the nitrogen rates (0, 30, 60, 90 and 120 kg ha⁻¹), with four repetitions. At harvest, plants were collected in one meter, in the useful area of each subplot to determine: number of plants per meter; number of pods/plant; number of grains/plant; number of grains/pods; mass of a thousand grains and productivity. The cultivars differed regarding the number of pods per plant, grains per plant and yield, but they were equivalent for the number of plants per meter, grains per pod and mass of a thousand grains. Comparing the production component number of pods per plant and grain yield, it is concluded that the cultivar that produced the highest number of pods per plant and showed the highest yield was BRS Estilo. There were differences between the treatments for the two cultivars, only in the yield obtained. The highest yield averages were obtained in treatments with doses above 60 kg ha⁻¹ of N.

Keywords: *Phaseolus vulgaris*; Productivity; Cultural practice.

Resumo

Entre os nutrientes, o nitrogênio (N) é o elemento requerido em maior quantidade pelo feijoeiro. Dependendo da cultivar apresenta maior ou menor capacidade de fixação do N. O objetivo deste trabalho foi avaliar o desempenho de duas cultivares de feijão à adubação nitrogenada de cobertura na sucessão do milho, sobre os componentes de rendimento e a produtividade. O experimento foi conduzido em blocos ao acaso em esquema fatorial 2x5, sendo o primeiro fator as cultivares de feijão (IPR Campos Gerais e BRS Estilo) e o segundo fator as doses de nitrogênio (0, 30, 60, 90 e 120 kg ha⁻¹), com quatro repetições. Na colheita, foram coletadas as plantas em um metro, na área útil de cada subparcela para determinação do: número de plantas por metro; número de vagens/planta; número de grãos/planta; número de grãos/vagem; massa de mil grãos e a produtividade. As cultivares diferiram com relação ao número de vagens por planta, grãos por planta e produtividade, porém foram equivalentes para o número de plantas por metro, grãos por vagem e massa de mil grãos. Comparando o componente da produção número de vagens por planta e a produtividade de grãos, conclui-se que a cultivar que produziu o maior número de vagens por planta e apresentou maior produtividade foi BRS Estilo. Houve diferença entre os tratamentos para as duas cultivares, apenas

na produtividade obtida. As maiores médias de produtividade foram obtidas nos tratamentos com doses superiores a 60 kg ha⁻¹ de N.

Palavras-chave: *Phaseolus vulgaris*; Rendimento; Prática cultural.

Resumen

Entre los nutrientes, el nitrógeno (N) es el elemento requerido en mayor cantidad por la planta de frijol. Dependiendo del cultivar, tiene mayor o menor capacidad de fijación de N. El objetivo de este trabajo fue evaluar el comportamiento de dos cultivares de frijol común bajo cobertura de nitrógeno en sucesión de maíz, sobre componentes de rendimiento y rendimiento. El experimento se realizó en bloques al azar en un esquema factorial 2x5, siendo el primer factor los cultivares de frijol común (IPR Campos Gerais y BRS Estilo) y el segundo factor las tasas de nitrógeno (0, 30, 60, 90 y 120 kg ha⁻¹), con cuatro repeticiones. En la cosecha, las plantas se recolectaron en un metro, en el área útil de cada subparcela para determinar: número de plantas por metro; número de vainas / planta; número de granos / planta; número de granos / vainas; masa de mil granos y productividad. Los cultivares difirieron en cuanto al número de vainas por planta, granos por planta y rendimiento, pero fueron equivalentes en el número de plantas por metro, granos por vaina y masa de mil granos. Comparando el componente de producción número de vainas por planta y rendimiento de grano, se concluye que el cultivar que produjo el mayor número de vainas por planta y mostró el mayor rendimiento fue BRS Estilo. Hubo diferencias entre los tratamientos para los dos cultivares, solo en el rendimiento obtenido. Los mayores promedios de rendimiento se obtuvieron en tratamientos con dosis superiores a 60 kg ha⁻¹ de N.

Palabras clave: *Phaseolus vulgaris*; Actuación; Práctica cultural.

1. Introduction

In Brazil, the social and economic importance of the bean crop (*Phaseolus vulgaris* L.) is evidenced by representing a protein source in the population's diet and by the contingent of small producers involved in its production, although there has been an increase in recent years. interest of producers from other classes of agribusiness, adopting advanced techniques, including irrigation and mechanized harvesting (Viçosi & Pelá, 2020).

The world production per year is around 12 million tons, supplying the basic food of about 400 million people (CIAT, 2019). Latin America concentrates the largest number of countries with the highest production and consumption, highlighting Brazil that occupies the first place in the world production ranking (FAOSTAT, 2019), with production of 122,225.2 thousand tons in the 2019/2020 harvest (CONAB, 2020).

However, among the main factors limiting crop productivity in the country, those related to the low technical level employed by producers and the cultivation of beans in low fertility soils, especially poor in N, a very important nutrient for plants, stand out. part of many compounds, such as amino acids and chlorophyll (Pereira et al., 2019).

Nitrogen is the element required in the greatest quantity by the bean plant. The main sources of N for the crop are the soil, through the decomposition of organic matter, the application of nitrogen fertilizers and the biological fixation of atmospheric N₂, through the association of common bean with bacteria of the rhizobia group (Stocco et al., 2008). Depending on the cultivar, it has greater or lesser capacity to fix atmospheric nitrogen by the action of N₂ fixing bacteria, present in nodules formed in the root system (Bordin et al., 2003).

Beans and a legume of the Fabaceae family, with the ability to perform symbiosis with bacteria of the rizophium genus, to perform biological nitrogen fixation (FBN) these bacteria are present in the soil or through inoculation. With the help of these bacteria, the N fixation process becomes more effective (De Araujo et al., 2017). However, FBN is not effective in fully meeting the N needs, in many cases the use of nitrogen fertilizers is necessary to meet the physiological needs (Silva et al., 2017).

Nitrogen fertilization is a cultural practice commonly used by bean producers. However, in addition to the high economic cost, the use of nitrogen fertilizers in tropical soils has an additional ecological cost. It is considered that the losses of nitrogen fertilizers applied are around 50%, mainly caused by leaching, in the form of nitrate and surface runoff, caused by rainwater and/or irrigation (Sangoi et al., 2003).

The N lost in this process is highly polluting and, once transported to the water table, it causes the contamination of underground aquifers, rivers and lakes. Other losses of applied N occur in gaseous forms, which return to the atmosphere, mainly through denitrification and volatilization processes (Lorensini et al., 2012).

In this context, the proper management of nitrogen fertilization represents one of the main difficulties of the bean crop, since the application of excessive doses of N, in addition to increasing the economic cost, can promote serious risks to the environment, and its use in insufficient quantities it can limit its productive potential, even if other production factors are optimized (Pelegri et al., 2009).

The amount of nitrogen to be used in the fertilization of the common bean may depend on the type of cover plant (grass or legume) that is cultivated in the area, in a no-tillage system. Species used as green manure, mainly legumes, despite having a lower C/N ratio, can also be included in the crop rotation plan in a no-tillage system, as they have short-term advantages, such as the release of nutrients during decomposition (Giacomini et al., 2003).

In material with a high C/N ratio (greater than 20), characteristic of most grasses, there is greater nitrogen immobilization for its decomposition (Alvarenga et al., 2001). Residues with a higher C/N ratio (carbon/nitrogen) tend to have a slow decomposition of residues, that is, greater N immobilization in organic matter (Calegari et al., 1993), requiring a greater amount of this nutrient to obtain satisfactory results in the bean harvest.

However, there are still doubts about which dose to use for the supply of this nutrient in coverage to the crop, in the no-tillage system, in succession to the corn crop (high C/N ratio), especially since each bean cultivar may present greater or lesser ability to hold atmospheric N. Within this context, the objective of this study was to evaluate different doses of nitrogen fertilizer in two common bean cultivars (IPR Campos Gerais and BRS Estilo), sown in succession of corn, in the Campos Gerais region.

2. Methodology

The experiment was a field research as considered by Pereira et al. (2018), and was conducted in the municipality of Carambeí-PR, in a private property with a total area of 18 ha under no-tillage, in the succession of corn. The local climate is humid subtropical, classified as Cfb, according to Köppen. The average annual precipitation is approximately 1550 mm.

Two bean cultivars, IPR Campos Gerais and BRS Estilo, were used. Sowing took place on 02/03/2021, spacing between rows of 0.50 m, 12 seeds per linear meter. The experimental design used was a randomized block design in a 2x5 factorial scheme, the first factor being the two bean cultivars (IPR Campos Gerais and BRS Estilo). The second factor was the five doses of nitrogen (0, 30, 60, 90 and 120 kg ha⁻¹), applied in the phenological stage (V4), with four replications.

The phenological stage V4 begins when the third trifoliate leaf is completely open (Fernandez et al., 1992). In evaluations like these, the 3 basic principles of experimentation are used, which are local control, randomization and repetition, with this it is expected to observe the influence of different doses represented in each subplot.

For fertilization at planting, Yara basa and TS with derosal and shelter were used. In stage V4, cover fertilization with N was carried out. The plots had a dimension of 5x5 m, totaling 25 m² of total area. During the development of the culture, the other cultural and phytosanitary treatments recommended for the culture of beans were carried out.

At harvest (05/09/2021 for the cultivar IPR Campos Gerais and 05/16/2021 BRS Estilo), the plants were collected in a linear meter, this collection was in a predetermined location, in the useful area of each subplot, for determination of : number of plants per meter; number of pods/plant, determined by the relation total number of pods/number of plants; number of grains/plant, evaluated by the relation total number of grains/number of plants; number of grains/pod, obtained by the relation total number of grains/total number of pods; mass of one thousand grains, determined by randomly collecting and weighing

two samples of one thousand grains from each subplot.

The plants in the useful area of each subplot were pulled out and left to dry in full sun. After drying, they were submitted to mechanical threshing, and the grains were weighed and the data, transformed into kg ha⁻¹ (13% wet basis). Statistical analysis of data was performed using the free Sasmi agri program. Data were subjected to analysis of variance (ANOVA), and discrimination between treatments was performed by Tukey's test at 5% probability.

3. Results and Discussion

There was no difference for the application of different doses of nitrogen (N) fertilizer in the cultivars IPR Campos Gerais and BRS Estilo for the component of yield plants per meter (Table 1). In the present experiment, the number of plants per meter was below the recommended for the two cultivars, ranging from 7.51 to 9.71.

According to the Instituto Agrônômico de Campinas, in the bean crop, it is recommended the use of row spacing of 50 cm and 10 to 12 plants per linear meter, totaling around 240 thousand plants per hectare (IAC, 2021). Embrapa researchers report that the best yields have been obtained with spacing of 40 to 60 cm between rows and with 10 to 15 plants/m (EMBRAPA, 2021).

Proper plant density for an area is important. Less than adequate amounts of plants mean crop failures. Higher amounts, on the other hand, can reduce production, given the dispute between plants for water, light and nutrients. In the case of common bean, the adequate planting density is one in which the plants, when in flowering period, can cover the entire area. Density reflects the spacing between lines and the number of plants per linear meter (Melo, 2009).

Table 1. Plants per meter and number of pods per plant, as a function of N doses in common bean, cultivars IPR Campos Gerais and BRS Estilo. Carambei/PR, 2021 harvest.

Treatments	Plants per meter		Number of pods per plant	
	IPR Campos Gerais	BRS Estilo	IPR Campos Gerais	BRS Estilo
Witness	9.50 aA*	8.80 aA	8.85 aA	13.92 aB
30 kg ha ⁻¹	8.52 aA	8.21 aA	9.15 aA	14.93 aB
60 kg ha ⁻¹	7.51 aA	8.01 aA	10.78 aA	15.48 aB
90 kg ha ⁻¹	9.71 aA	7.54 aA	9.61 aA	16.32 aB
120 kg ha ⁻¹	9.23 aA	9.25 aA	9.60 aA	15.88 aB
CV	12.06	13.70	24.79	17.39

*Averages followed by the same lowercase letter in the column and uppercase in the row, do not differ by Tukey test at 5% significance; Original data; CV = coefficient of variation. Source: Djalma Cesar Clock.

Regarding the number of pods per plant, there was no difference within the cultivars for the N doses, however there was a difference between the cultivars (Table 1). BRS Estilo features higher number of pods per plant. Comparing, in the control, the cultivar IPR Campos Gerais obtained 8.85 and the cultivar BRS Estilo 13.92 pods per plant. According to De Souza Lima et al. (2020), the number of pods per plant is a genetic characteristic of each cultivar. There is genetic variability between the two cultivars, despite both being from the commercial group in Rio de Janeiro (Table 1).

The component grains per pod ranged from 3.75 to 4.97, but there was no interaction and difference for the application of different doses of nitrogen (N) fertilizer in the two cultivars (Table 2). For Zilio et al. (2011), higher number of pods per plant and number of grains per pod in common bean efficiently contributed to the identification of the most promising genotypes for grain yield.

Table 2. Grains per pod and grains per plant, as a function of N doses in common bean, cultivars IPR Campos Gerais and BRS style. Carambeí/PR, 2021 harvest.

Treatments	Grains per pod		Grains per plant	
	IPR Campos Gerais	BRS Estilo	IPR Campos Gerais	BRS Estilo
Witness	3.75 aA*	3.74 aA	37.40 aA	51.76 aB
30 kg ha ⁻¹	4.51 aA	4.08 aA	40.65 aA	60.81 aB
60 kg ha ⁻¹	4.97 aA	3.98 aA	41.81 aA	59.78 aB
90 kg ha ⁻¹	4.24 aA	4.10 aA	42.10 aA	65.62 aB
120 kg ha ⁻¹	4.47 aA	4.21 aA	45.03 aA	61.92 aB
CV	19.45	26.48	35.63	30.37

*Averages followed by the same lowercase letter in the column and uppercase in the row, do not differ by Tukey test at 5% significance; Original data; CV = coefficient of variation. Source: Djalma Cesar Clock.

As for the component grains per plant, there was no difference within each cultivar, for the application of N doses, however there were differences between the cultivars, with the cultivar BRS Estilo superior (Table 2), a fact justified by the data in Table 1, which presents superiority of this cultivar in the number of pods per plant, since the number of grains per pod is statistically equal (Table 2).

There was no difference between N doses and between cultivars for the mass of one thousand grains (Table 3). The lowest and highest values obtained occurred in the cultivar IPR Campos Gerais, 299.01 and 396.92 g, respectively. De Souza Lima et al. (2020), in Aquidauana (MS), used the cultivar BRS Estilo and obtained number of pods per plant of 17.00 and number of grains per pod of 5.00 and mass of one thousand grains of 313.50 grams and productivity of 689, 53 kg ha⁻¹, values similar to those obtained in the present experiment, except for yield, which the lowest obtained in the present experiment was 2700.00 kg ha⁻¹, higher than that obtained in Aquidauana.

Table 3. Mass of a thousand grains (grams) and productivity (Kg ha⁻¹) as a function of N doses in common bean, cultivars IPR Campos Gerais and BRS Estilo. Carambeí/PR, 2021 harvest.

Treatments	Mass of a thousand grains (grams)		Productivity (Kg ha ⁻¹)	
	IPR Campos Gerais	BRS Estilo	IPR Campos Gerais	BRS Estilo
Witness	299.01 aA*	320.20 aA	1890.00 aA	2700.00 aB
30 kg ha ⁻¹	335.78 aA	338.01 aA	1925.00 aA	3150.00 aB
60 kg ha ⁻¹	359.74 aA	378.51 aA	2825.00 bA	3325.00 bB
90 kg ha ⁻¹	348.14 aA	360.52 aA	2600.00 bA	3500.00 bB
120 kg ha ⁻¹	396.92 aA	370.82 aA	2800.00 bB	3430.00 bB
CV	19.94	30.00	20.84	14.65

*Averages followed by the same lowercase letter in the column and uppercase in the row, do not differ by Tukey test at 5% significance; Original data; CV = coefficient of variation. Source: Djalma Cesar Clock.

According to De Souza Lima et al. (2020), the mass of a thousand grains is a characteristic that, although genetically controlled, is greatly influenced by environmental factors, which justifies different results for the same genotypes when cultivated in different environmental conditions. The characters number of pods per plant and mass of a thousand grains showed a high degree of association with the productivity character (Coimbra et al., 2000).

Regarding productivity (Table 3), there was a difference between treatments for the two cultivars. Both in the cultivar IPR Campos Gerais and in the cultivar BRS Estilo, the lowest values obtained were in the control and in the treatment with 30 kg ha⁻¹ of N. Higher yields were obtained in the treatments with doses above 60 kg ha⁻¹ of N. Comparing the cultivars, BRS style presents superior potential for productivity, even in the control (Table 3).

Brito et al. (2011), worked with common beans (cultivar Carioca), and concluded that beans need a dose equal to or greater than 40 kg ha⁻¹ of N, to obtain economically acceptable productivity. Oliveira et al. (2003), in an experiment with different N doses in cowpea beans, reached maximum yield values at doses of 64, 6 and 59 kg ha⁻¹, respectively. Gitti et al. (2012) with the bean cultivar IPR Juriti, with nitrogen doses in topdressing (0, 15, 30, 45, 60 and 90 kg ha⁻¹), concluded that nitrogen doses positively influenced the leaf chlorophyll index, the leaf nitrogen content, number of pods and grains per plant and yield.

The average yield of edible beans in the 2019/2020 crop in the state of Paraná was 1068.00 kg ha⁻¹ and the Brazilian average, the same crop of 1636.00 kg ha⁻¹ (CONAB, 2021). In the present experiment, from the control to the highest N doses, the two cultivars obtained yield values higher than the Paraná and national averages (Table 3). The average productivity obtained in the present experiment, despite being above the Paraná and national average, is still low, especially when it is known that the crop has the potential to produce in excess of 4000.00 kg ha⁻¹ (Barbosa & Gonzaga, 2012).

De Souza Lima et al. (2020), consider that the productivity of the common bean is the product of three primary components of production, namely, number of pods per plant, number of grains per pod and grain mass. For Gonçalves et al. (2017), only the number of grains per pod and mass of a thousand grains have genetic causes in the correlation of grain yield increase, the other characters have greater environmental influence and can either increase or decrease productivity.

Zilio et al. (2011) report that the number of pods per unit area is determined by the population of plants, the production of flowers per plant and the number of flowers that actually develop pods. In the present work, as can be seen in Tables 1, 2 and 3, the cultivars differed in relation to the number of pods per plant, grains per plant and yield, not differing in relation to the number of plants per meter, grains per pod and mass. of a thousand grains.

Comparing the production component number of pods per plant and grain yield, it can be concluded that the cultivar that produced the highest number of pods per plant (BRS Estilo) had the highest grain yield (Tables 1 and 3). In Brazil there are a large number of cultivars and genotypes with distinct characteristics of the most varied commercial groups (black, carioca, purple and others), however, bean plants from the Mesoamerican group are preferred by the population, and this preference is given by the carioca grain types it's black.

The cultivar IPR Campos Gerais, belonging to the commercial group from Rio de Janeiro, has an average cycle of 88 days, grains with beige color with light brown stripes with an average pod production of 14 pods with 5 seeds and with an average yield of 2902.00 Kg ha⁻¹, besides being resistant to some diseases such as rust and powdery mildew (IDR, 2021).

The cultivar BRS Estilo, also belonging to the commercial group from Rio de Janeiro, has uniformity of color and grain size, average mass of 100 grains of 26 grams, average productivity of 2072.3 kg ha⁻¹ and cooking time of 26 minutes, with resistance under artificial inoculation, is resistant to common mosaic (EMBRAPA, 2021).

With the increased demand for food arising from the growing increase in the world population, it creates a challenge for the producer to produce more in the same space (Gabardo et al., 2020; Macoski et al., 2021; Clock et al., 2021). Alternative techniques and management come as a solution to this problem, one of them is the rational use of fertilizers to increase productivity and reduce costs.

4. Conclusion

There was no difference in the application of different doses of nitrogen fertilizer in the cultivars IPR Campos Gerais and BRS Estilo for the yield components: plants per meter, grains per pod and mass of a thousand grains.

There were differences among cultivars for the number of pods per plant, grains per plant and yield. The cultivar BRS Estilo presented the highest averages in these parameters.

There was a difference between N doses for the two cultivars only for yield. The highest values were obtained in the highest N doses. Comparing the cultivars, BRS Estilo has higher yield potential than IPR Campos Gerais.

Future experiments will be carried out, with more cultivars and sowing times, contributing to the maximization of productivity and maintenance of agriculture.

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