DOI: 10.5433/1679-0359.2022v43n2p855

Weed coexistence in carioca bean inoculated with *Rhizobium tropici* or nitrogen-fertilized

Convivência das plantas daninhas no feijão carioca inoculado com *Rhizobium tropici* ou com adubação nitrogenada

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Highlights

Coexistence with weeds reduces the yield of carioca bean.
Nitrogen fertilization management can be used in integrated weed management.
The ability of carioca bean to coexist with weeds was greater with N topdressing.
Inoculation provided carioca bean with similar yield to mineral N fertilization.

Abstract

The supply of nitrogen (N) to the carioca bean plant via inoculation with *Rhizobium tropici* can prevent competition with the weed community by allowing the crop to absorb the nutrient available in the soil. On this basis, this study proposes to examine the period before weed interference (PBI) in the carioca bean plant following inoculation with *R. tropici* or N topdressing. The experiments were carried out under field conditions during the summer seasons of 2014 and 2015. A randomized-block experimental design with four replicates was adopted, in a 2 × 11 factorial arrangement (common bean plant inoculated or topdressed with N × 11 periods of coexistence with weeds, namely, 0, 7, 14, 21, 28, 35, 42, 49, 56, 63, or 90 days after emergence [DAE]). Nitrogen topdressing increased the crop's tolerance to coexist with weeds from 6 to 14 DAE, compared with inoculation with *R. tropici* The PBI for the inoculated common bean plant was 24 and 16 DAE in the years 2014 and 2015, respectively. For the N-topdressed plant, the PBI was 30 DAE in both years.

Key words: Competition. *Phaseolus vulgaris.* Plant nutrition. Weed interference.

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Received: Aug. 25, 2021 - Approved: Dec. 16, 2021

Resumo

O fornecimento do nitrogênio ao feijoeiro carioca via inoculação com *Rhizobium tropici* pode evitar a competição com a comunidade de plantas daninhas pela absorção do nutriente disponível no solo. Portanto, o objeto deste estudo foi avaliar o período anterior à interferência (PAI) no feijoeiro carioca com inoculação com *R. tropici* e com adubação nitrogenada em cobertura. Os experimentos foram conduzidos em condições de campo durante as safras de verão de 2014 e de 2015. O delineamento experimental foi de blocos casualizados com quatro repetições em esquema fatorial 2x11 (feijoeiro com inoculação ou com adução nitrogenada em cobertura x 11 períodos de convívio com as plantas daninhas: 0, 7, 14, 21, 28, 35, 42, 49, 56, 63 e 90 dias após a emergência (DAE). A adubação nitrogenada em cobertura aumentou a capacidade da cultura em conviver com as plantas daninhas de 6 a 14 DAE quando comparada a inoculação com *R. tropici.* O PAI para o feijoeiro inoculado foi de 24 e 16 DAE em 2014 e 2015, respectivamente. Para o feijoeiro com adubação nitrogenada em cobertura o PAI foi de 30 DAE em ambos os anos.

Palavras-chave: Competição. Matointerferência. Phaseolus vulgaris. Nutrição de plantas.

Introduction

When grown in environments with a limited amount of nutrients in the soil, the common bean crop exhibits intense competition with weeds, which culminates in a significant reduction in its development and yield. Losses stemming from weed interference in the crop can reach around 40 to 60% of shoot dry matter (K. C. Araújo et al., 2018) and 30 to 70% of yield (Borchartt, Jakelaitis, Valadão, Venturoso, & Santos, 2011).

Because they are naturally selected in the production environment, weeds are generally more efficient in using available natural resources. Among the factors that provide weeds with competitive advantages over crops, their more developed and aggressive root system stands out. In compacted soils, soybean plants absorbed 75% less nitrogen (N) than in uncompacted soils, while the *Senna obtusifolia* and *Amaranthus palmeri* weeds reduced its N uptake by 8% and 35%, respectively (Place, Bowman, Burton, & Rufty, 2008). Procópio, Santos, Pires, Silva and Mendonça (2004) tested the response of two crops (soybean and common bean) and weeds to increasing N rates and found that when 80 kg N ha^{-1} were applied, weeds showed a 237.3% increase in total dry biomass relative to the control (without N), whereas common bean had an increase of only 16.0%.

Blackshaw et al. (2003) compared the response of the wheat plant (*Titicum aestivum* L.) with that of 23 weed species to increasing rates of N and observed that at the highest level (240 mg/kg of soil), 15 weed species were more responsive than wheat in shoot dry matter yield, eight in root dry matter yield, 17 in N accumulation in the shoots, and 12 in N accumulation in the root. These results led the authors to conclude that the N fertilization strategy generates significant interference with the crop/weed ratio, which must be considered when devising fertilization methods.

The hypothesis that nitrogen fertilization interferes with the competitive capacity of N-responsive weeds in the soil was corroborated in a new trial by Blackshaw and Brandt (2008). In their experiment, wild oat (*Avena fatua*) performed better than wheat (*T. aestivum* L.) in an environment with a high level of N, which suggests that fertilization strategies that favor the crops at the expense of weeds should be prioritized.

Legume plants, such as common bean, have the ability to establish a symbiotic relationship with diazotrophic bacteria whereby the bacteria supply the plants with N extracted from air, reducing their dependence on N present in the soil (Hungria & Kaschuk, 2014).

Nitrogen-fixing bacteria (diazotrophic bacteria) especially some strains of *Rhizobium tropici,* used in commercial products, can supply the common bean plant with all the N it needs during its development cycle (Pelegrin, Mercante, Otsubo, & Otsubo, 2009), reducing the competition for soil N by weeds. This statement was supported by the results of Bettiol et al. (2021), who found that N topdressing at the rates of 45 and 90 kg ha^{-1}, in common bean plants inoculated with *R. tropici,* did not provide an increase in yield compared with the common bean that was only inoculated, without complementary N fertilization besides the 16 kg ha^{-1} provided at sowing.

In this way, by applying N fertilizers to increase the productive performance of the common bean crop, one may also increase the competitiveness of weeds in relation to the crop and, consequently, compromise weed control measures. Theoretically, this problem could be solved by replacing N fertilization with inoculation with diazotrophic bacteria (Hungria & Kaschuk, 2014), which could provide the common bean with greater tolerance to coexistence with the weed community and allow a longer period before weed interference (PBI) (Schiessel et al., 2019; Lacerda et al., 2020).

The hypothesis investigated in the present study is supported by the premise that inoculation in common bean could constitute an exclusive and efficient source of N, making the crop more competitive in relation to the weed community. Thus, the objective was to evaluate the PBI for common bean inoculated with *R. tropici* or topdressed with N.

Material and Methods

The experiments were carried out in the municipality of Marechal Cândido Rondon, western region of the state of Paraná, Brazil (24°31’58.68” S and 54°01’04.04” W, 395 m above sea level). The soil was identified as a typic eutroferric red oxisol, according to the Brazilian Soil Classification System (Santos et al., 2014). Soil particle size analysis indicated 687 g kg^{-1} clay, 258 g kg^{-1} silt and 55 g kg^{-1} sand.

The experiments were established in the 2014 and 2015 harvests, in two distinct areas, whose soil chemical characteristics are described in Table 1. The areas had their base saturation corrected to 70% before the implementation of the experiment. In the 2014 experimental area, 4,000 kg ha^{-1} of dolomitic limestone were applied in August 2014, whereas in the 2015 area, 2,500 kg ha^{-1} of calcitic limestone were applied in February 2015.

Table 1
Results of chemical analyses of the soil in the areas where the experiments were established before the correction of soil base saturation

Year	P	OM	pH $CaCl_2$	H+Al	Al^{3+}	K+	Ca^{2+}	Mg^{2+}	SB	CEC	BS	Al
	mg dm^{-3}	g dm^{-3}		----------------- cmolc dm^{-3} -----------------							---- % ----	
2014	25	23.2	4.6	7.52	0.40	0.41	4.74	1.36	6.51	14.10	46	6
2015	42	21.9	4.9	5.06	0.30	0.48	2.89	1.85	5.22	10.28	51	5

OM - organic matter; SB - sum of bases; CEC - cation-exchange capacity; BS - base saturation.

In both harvests, the areas were desiccated with the application of 1.44 kg ha^{-1} of glyphosate 30 days before the common bean was sown. Additionally, the dry weight of straw remaining from desiccation was determined on the day of sowing (2,200 and 2,600 kg ha^{-1} for the years 2014 and 2015, respectively). The fertilizer management followed the recommendations proposed by Rosolem & Marubayashi (1994).

In the first experiment, sowing took place on 09/12/2014, adopting a density of 23 seeds m^{-1}. Base fertilization consisted of 269 kg ha^{-1} of the N-P-K 02-20-18 formula. Sowing in the second experiment took place on 09/16/2015, with a density of 12.3 seeds m^{-1}, and 300 kg ha^{-1} of the N-P-K 04-24-12 formula were used as base fertilization. In both experiments, the common bean variety used was 'IPR-Tangará' (carioca commercial group, type-II growth habit, white flower, and average cycle of 87 days).

The experiment was laid out in a randomized-block design with four replicates, in a 2×11 factorial arrangement corresponding to two N fertilization managements (inoculation or N topdressing) and 11 periods of coexistence between weeds and the common bean. Each experimental plot was composed of five 5-m-long rows spaced 0.5 m apart, totaling 12.5 m². The usable area of the plot consisted of two central lines, disregarding 0.5 m at each end, which totaled 6 m².

The seeds were inoculated with *Rhizobium tropici,* without supplementation with N fertilizers (inoculation treatment); or topdressed with 120 kg N ha^{-1} and not inoculated (N-topdressing treatment). Seed inoculation was carried out immediately before sowing, using the Masterfix Feijão® commercial peat-based inoculant (minimum guaranteed content of 5×10^9 bacteria mL^{-1}), at a rate of 100 g of the product for 60 kg of seeds, with the addition of 10% of sugar to the mixture. The seeds did not receive any chemical treatment with insecticides or fungicides, to avoid negative effects on the rhizobia, as recommended by F. F. Araújo, Carmona, Tiritan and Creste (2007).

Nitrogen topdressing was carried out only in the treatments in which the seeds had not been inoculated with rhizobium. Fertilization was split into two applications of 60 kg N ha^{-1} each. The first application was performed at the V4 stage, which occurred 29 days after emergence (DAE) of the crop in 2014 and at 21 DAE in 2015; and the second at the R5 stage, which took place at 49 DAE in 2014 and at 43 DAE in the years 2014 and

2015, respectively. Urea (44% N) was used as N fertilizer.

The periods of coexistence of weeds with the crop were 0, 7, 14, 21, 28, 35, 42, 49, 56, 63, and 90 days after emergence (DAE) in both years. The plots whose coexistence period ended were cleaned periodically, through manual weeding, approximately every seven days, until harvest. The coexistence period of 0 DAE was established as no interaction with the weeds during the entire cycle. The coexistence period of 90 DAE was defined as coexistence with the weeds throughout the common bean cycle.

The weed community was characterized by the inventory method, by randomly throwing a 0.25-m² frame (0.5 × 0.5 m) on the plot at the end of each coexistence period. The weeds present in each frame were identified as to family, genus, and species. Sorensen's Similarity Coefficient between the areas and the evaluated treatments was determined at the end of the experiments (Sorensen, 1948), as shown in Formula 1:

Similarity Coefficient (SC) = (2a/b+c) × 100 .... (1)

where a = number of species common to both areas; b, c = total number of species in the two compared areas.

At the end of each coexistence period, weed dry weight (kg ha^{-1}) was determined. For the crop, shoot dry weight (kg ha^{-1}), plant population (plants ha^{-1}), and grain yield (kg ha^{-1}) were measured.

Data were subjected to normality analysis using the Lilliefors and Kolmogorov-Smirnov methods, as well as combined analysis of variance of the experiments using R statistical software. Quantitative data were subjected to regression fitting using SigmaPlot 11.0 statistical software.

To determine the period before interference (PBI), the acceptable loss criterion was defined, which referred to the point at which the cost of control is equivalent to the economic damage generated by weed interference, as proposed by Vidal, Fleck and Merotto (2005). Therefore, the control cost (CC), in R\$ ha^{-1}, was converted to kilograms of yield loss (kg ha^{-1}) by dividing it by the product value (PV) in this case, the price of the carioca bean in R\$ kg^{-1}, according to Formula 2:

$$Acceptable\ loss = \frac{CC}{PV} = \frac{US\$\ ha^{-1}}{US\$\ kg^{-1}} = \frac{US\$}{ha} . \frac{kg}{US\$} = \frac{\cancel{US\$}\ kg}{\cancel{US\$}\ ha} = \frac{kg}{ha}\ or\ kg\ ha^{-1} \qquad (1)$$

Control cost was defined as the sum of the herbicide and application costs, as proposed by Vidal et al. (2005). The cost of herbicide (a post-emergence graminicide [cletodim] and a post-emergence broadleaf herbicide [fomesafen]) was determined based on consultations with local retailers and the rates recommended in the package inserts. The application cost was based on that expected when using a 90-hp tractor with auxiliary front wheel drive at an average working speed of 7 km h^{-1} and a pull-type sprayer with a capacity of 2,000 L and bar width of 18 m, used on a farm with an average utilization of 70% of the worked hours. The empirical model used to calculate depreciation was described by Cosentino (2004). The useful life of the machinery was determined according to data presented by Piacentini, Souza, Uribe-Opazo, Nóbrega and

Milan (2012) and the prices of agricultural equipment were obtained from the website of the Departamento de Economia Rural [DERAL] (2020). Thus, a CC of 32.84 US$ ha^{-1} was determined.

The PV was defined as the mean of the national average price from January 2009 to December 2019, obtained from the Agrolink website (2020), which was 0.89 US$ kg^{-1}. Based on these data, an acceptable grain yield loss of 36.90 kg ha^{-1} was defined. The dollar exchange rate used in this study was US$ 1.00 = R$ 2.75.

Results and Discussion

Overall, the weed community that coexisted with the common bean during its entire cycle in both years of cultivation consisted of 25 species belonging to 11 families (Table 2). The families with the highest number of species were *Asteraceae* and *Poaceae,* mainly in 2014. In the plots where the common bean was only inoculated, the weed community showed a similarity coefficient of 56.3%, whereas in the plots with N topdressing, the similarity coefficient was 58.1%, when the two years of cultivation were compared.

The characterization of the weed community population revealed high species similarity between the evaluated treatments, with coefficients of 82.1% and 83.3% for the years 2014 and 2015, respectively. These results indicate that the competitive effect of weeds on the crop was similar between the evaluated years and the treatments, since there were no changes in the specific composition of the weed community.

Weed dry matter accumulation was 13.7% and 43.2% higher in the inoculated common bean, compared with the N-topdressed plants, in 2014 and 2015, respectively (Figure 1). Shoot dry matter accumulation with inoculation was 2.6% and 37.4% lower than with N topdressing, in 2014 and 2015, respectively (Figure 2). Similarly, Bressanin, Nepomuceno, Martins, Carvalho and Alves (2013) evaluated the effect of N fertilization in interference periods in common bean and observed a lower initial weed dry weight accumulation after providing 160 kg N ha^{-1} as topdressing. Ahmadvand, Mondani and Golizardi (2009), on the other hand, found that the greater shoot dry matter accumulation in the potato crop correlated positively with the closing speed of the crop's rows and negatively with the development of weeds, which was also reported by Balbinot and Fleck (2005) in the maize crop.

These results indicate that inoculation with *R. tropici* could not provide all the N required by the crop. This was particularly true in the climatic conditions of the year 2015, which caused lower growth and biomass accumulation in the crop, consequently allowing greater growth of the weed community.

Table 2
Characterization of the weed communities present and similarity coefficient between the treatments evaluated in the experiments carried out in 2014 and 2015

Treatment	Family	2014	2015
Inoculation	*Amaranthaceae*	*Amaranthus* spp.	*Amaranthus* spp.
	Asteraceae	*Conyza* spp.	---
	Asteraceae	*Sonchus oleraceus*	---
	Asteraceae	*Bidens pilosa*	*Bidens pilosa*
	Asteraceae	*Emilia sonchifolia*	---
	Asteraceae	*Achyrocline satureoides*	---
	Brassicaceae	*Raphanus raphanistrum*	*Raphanus raphanistrum*
	Brassicaceae	---	*Brassica napus*
	Brassicaceae	*Crambe abyssinica*	---
	Commelinaceae	*Commelina benghalensis*	*Commelina benghalensis*
	Convolvulaceae	*Ipomoea grandifolia*	*Ipomoea grandifolia*
	Malvaceae	*Sida* spp.	*Sida* spp.
	Poaceae	*Digitaria insularis*	*Digitaria insularis*
	Poaceae	*Brachiaria plantaginea*	---
	Poaceae	---	*Brachiaria* spp.
	Poaceae	*Digitaria horizontalis*	*Digitaria horizontalis*
	Poaceae	*Avena* spp.	---
	Poaceae	*Sorghum bicolor*	---
	Poaceae	*Lolium multiflorum*	---
	Poaceae	*Cenchrus echinatus*	*Cenchrus echinatus*
	Rubiaceae	*Richardia brasiliensis*	*Richardia brasiliensis*
	Solanaceae	*Solanum americanum*	---
Similarity coefficient between the years = 56.3%			
N tropdressing	*Amaranthaceae*	*Amaranthus* spp.	*Amaranthus* spp.
	Amaranthaceae	---	*Chenopodium quinoa*
	Asteraceae	*Conyza* spp.	---
	Asteraceae	*Sonchus oleraceus*	---
	Asteraceae	*Bidens pilosa*	*Bidens pilosa*
	Asteraceae	*Achyrocline satureoides*	---
	Brassicaceae	---	*Brassica napus*
	Brassicaceae	*Raphanus raphanistrum*	*Raphanus raphanistrum*
	Commelinaceae	*Commelina benghalensis*	*Commelina benghalensis*
	Convolvulaceae	*Ipomoea grandifolia*	*Ipomoea grandifolia*
	Malvaceae	*Sida* spp.	---
	Phyllanthaceae	*Phyllanthus niruri*	---

continue...

continuation...

Poaceae	*Brachiaria plantaginea*	---
Poaceae	---	*Brachiaria* spp.
Poaceae	*Digitaria insularis*	*Digitaria insularis*
Poaceae	*Sorghum bicolor*	---
Poaceae	*Avena* spp.	---
Poaceae	*Lolium multiflorum*	---
Poaceae	*Digitaria horizontalis*	*Digitaria horizontalis*
Rubiaceae	*Richardia brasiliensis*	*Richardia brasiliensis*
Solanaceae	*Solanum americanum*	*Solanum americanum*
Urticaceae	*Urera baccifera*	---
Similarity coefficient between the years = 58.1%		
Similarity coefficient between treatments in each year	82.10%	83.30%

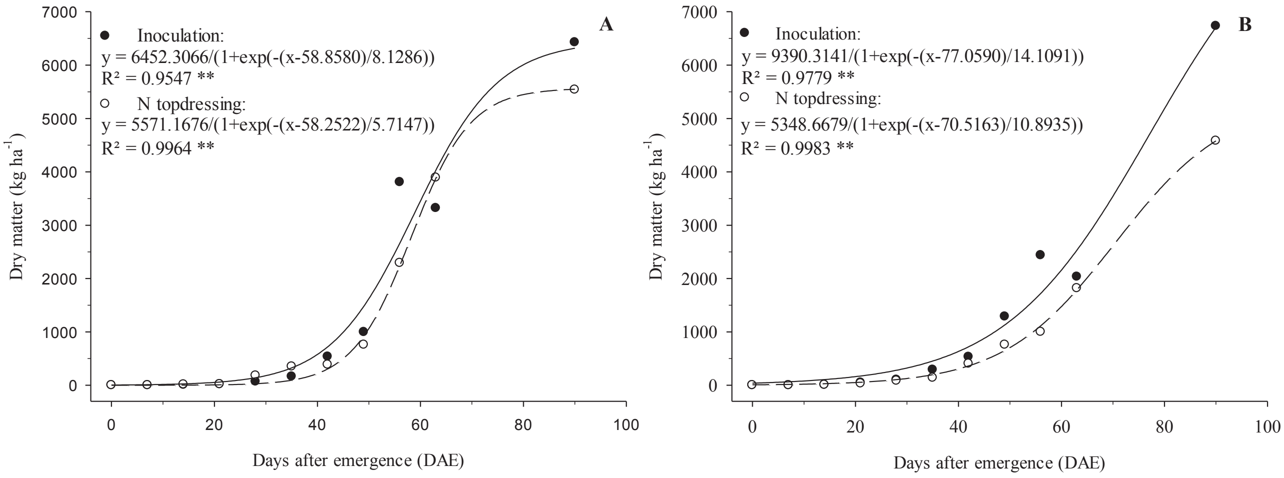

Figure 1. Dry matter accumulation of weeds in coexistence with common bean inoculated and topdressed with nitrogen (N), in the years 2014 (A) and 2015 (B). ** Regression model significant at 1% probability by the F test.

The possible reason why inoculation with *R. tropici* did not provide the full amount of N required by the common bean plant is that some soil-climatic conditions, such as high temperatures and the presence of high populations of native soil-fixing bacteria, can affect the symbiosis between the crop and the bacterium introduced into the system by the inoculant (F. F. Araújo et al., 2007; Hungria & Kaschuk, 2014; Martínez-Romero, 2003; Pelegrin et al., 2009).

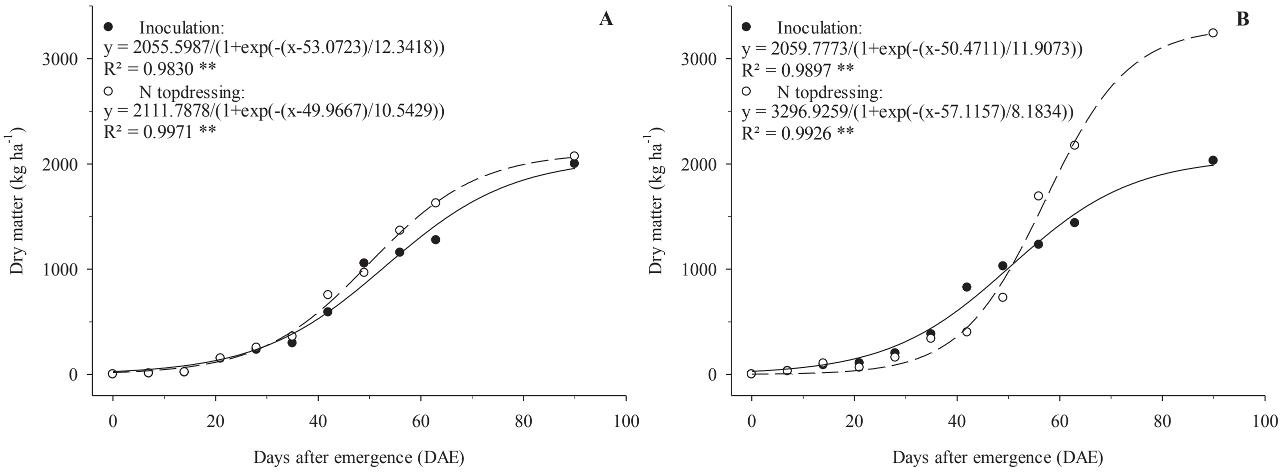

Figure 2. Shoot dry matter accumulation of common bean plants free from coexistence with weeds and inoculated or topdressed with nitrogen (N), in the years 2014 (A) and 2015 (B). ** Regression model significant at 1% probability by the F test.

These arguments are reinforced when we consider that there is a history of other experiments with common bean in the areas where these trials were conducted. The efficiency of diazotrophic bacteria can be compromised in soils previously cultivated with common bean without inoculation with selected strains, as this condition enables the proliferation of symbiotic bacteria native to the soil, which often have low nitrogen fixation efficiency (Vargas, Mendes, & Hungria, 2000). This fact strengthens the native population and prevents the proper establishment of the bacteria introduced by inoculation, reducing their efficiency (Vargas et al., 2000).

The final population of common bean plants correlated negatively with the period of coexistence with the weeds and was significantly affected by the interaction between N fertilization management and the years (Figure 3). In 2014, the daily plant population decrease rates were slightly higher in the inoculated common bean compared with the crop topdressed with N (-0.42 and -0.37, respectively) (Figure 3A). However, in 2015, the rate of plant population decline was 2.7 times higher in the inoculated common bean (-0.57 plants per day of coexistence with weeds) than in the topdressed plant (Figure 3B). This indicates that the inoculated crop underwent greater competition, especially in 2015, corroborating the behaviors shown by weed dry weight and shoot dry weight.

When we analyze the behavior of yield in response to the coexistence periods, we observe gains up to a maximum point, namely, 13 and 3 DAE for the common bean plants inoculated in 2014 and 2015, respectively; and 22 and 18 DAE for the common bean topdressed with N in 2014 and 2015, respectively, as represented by the x0 asymptote in the model (Table 3). After the yield gain phase came the loss phase, which lasted until harvest (Figure 4).

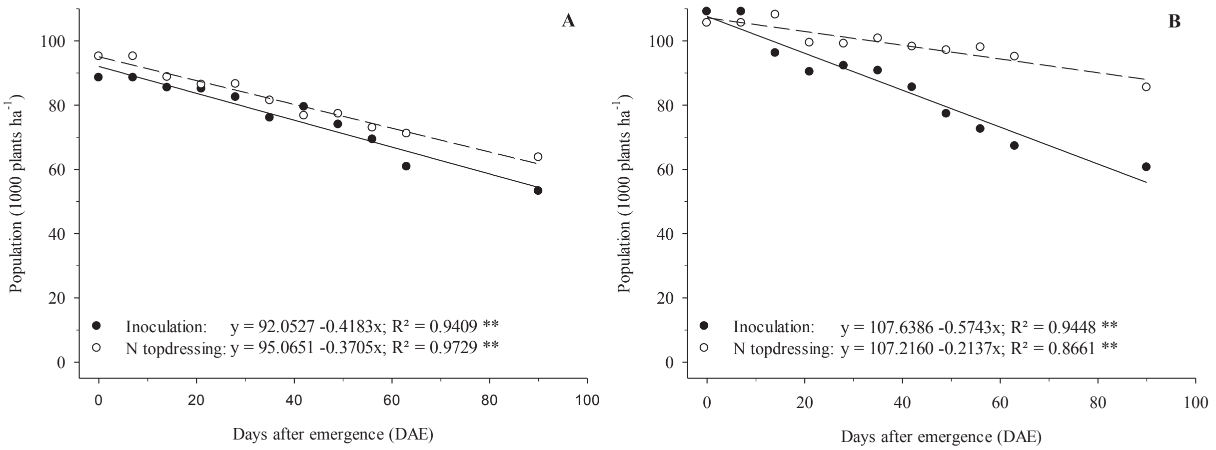

Figure 3. Final population of common bean plants inoculated or topdressed with nitrogen (N), as a function of the periods of coexistence with weeds, in the years 2014 (A) and 2015 (B). ** Regression model significant at 1% probability by the F test.

Table 3
Coefficients of the regression models obtained in the fitting of the common bean yield data displayed in Figure 4

		Model coefficient					
Year	Management	a	b	x0	y0	R²	P
2014	Inoculation	1.176.2207	39.5128	13.6635	289.8269	0.9750	<0.0001
	Nitrogen	588.6859	21.0411	22.1920	1.059.1977	0.7754	0.0113
2015	Inoculation	2.214.1559	72.1583	3.1127	-786.7057	0.9351	0.0002
	Nitrogen	641.5463	35.8588	17.7315	635.2547	0.9723	<0.0001

Model: $f_{(x)} = y_0 + a.e^{\left[-\frac{1}{2}\left(\frac{x-x_0}{b}\right)^2\right]}$.

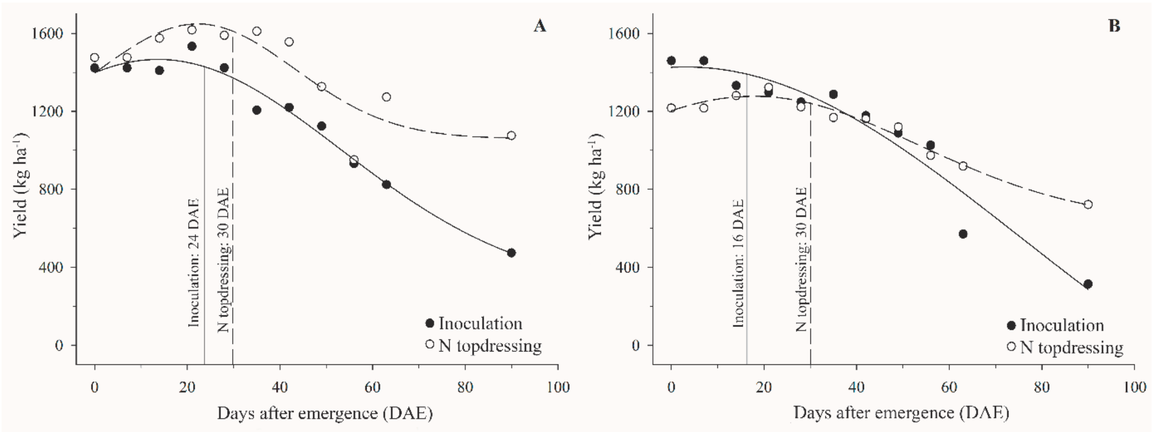

Figure 4. Grain yield of common bean inoculated and topdressed with nitrogen (N), as a function of the periods of coexistence with weeds, in the years 2014 (A) and 2015 (B).

The observed yield peak can be explained by the removal of a large portion of the existing straw on the soil when the plots were weeded. Nunes et al. (2006) demonstrated that the presence of straw on the soil increased the yield of common bean by reducing erosion and soil moisture loss and by releasing nutrients during its decomposition. Therefore, because the accumulation of weed dry matter in the first periods of coexistence was low (Figure 1), the benefit brought by the maintenance of straw compensated for the loss of yield generated by weed interference. Nonetheless, with the advance of the periods, the benefits of maintaining the straw decreased due to decomposition, whereas the damage caused by weed interference increased, beginning the phase of yield decline.

Overall, the yield gain phase in the inoculated common bean plant was shorter and the loss phase was more intense than in the N-topdressed bean plant, resulting in greater yield losses (Figure 4). In 2014, the coexistence with weeds throughout the cycle of the common bean inoculated and topdressed with N caused grain yield decreases of the orders of 73.5% and 35.6%, respectively (Figure 4A). In 2015, yield decreases were 91.2% and 47.5% for the common bean inoculated and topdressed with N, respectively (Figure 4B).

Nitrogen topdressing at the V4 stage of common bean prevented an eventual nutrient deficit in the soil due to immobilization during the decomposition of the remaining straw from the previous crop (Silva et al., 2006). Therefore, it provided the crop with greater tolerance to competition due to the readily available N. This hypothesis is reinforced when we consider the crop's shoot dry matter accumulation curve (Figure 2), which showed greater crop development under N topdressing. These results are in agreement with those described by Kabba, Knight and Van Rees (2011), who found that increasing N rates reduce the competition between the crop and weeds for the nutrient, allowing greater N uptake and, consequently, further development of the plant.

The form of N supply to the common bean crop also influenced the determination of PBI. Thus, considering 36.9 kg ha-1 as an acceptable loss of grain yield, it was possible to determine PBI of 24 and 30 DAE for the year 2014 for the common bean plants inoculated and topdressed with N, respectively. Similar results were obtained in 2015, with PBI of 16 and 30 DAE for the plants inoculated and topdressed with N, respectively.

The supply of N to the crop via chemical fertilizer increased its tolerance to the coexistence with weeds from 6 to 14 DAE. Likewise, Bressanin et al. (2013) compared the effect of N fertilization on PBI in common bean and also observed that N topdressing extended the PBI by 20 days, relative to the control. Evans, Knezevic, Lindquist, Shapiro and Blankenship (2003) examined the effect of N rate on the critical period of weed control (CPWC) and found that higher N rates applied to the crop resulted in lower CPWC and higher yields, which mainly due to the longer PBI.

Overall, the use of N topdressing in the common bean crop proved to be advantageous and can be adopted in the development of integrated weed management strategies, as it increased the capacity of common bean to compete with weeds, especially in the period of greatest demand for N by the crop (reproductive phase). However, inoculation can also provide yields as high as those provided by fertilization with N fertilizers, especially in the absence of weed interference.

It is noteworthy that the use of the inoculation practice must be carefully evaluated, as it may require a greater number of weed control interventions. On the other hand, inoculation can allow substantial savings by replacing the use of N fertilizers. In this case, the decision to adopt only inoculation or N topdressing should take into account the technological level employed by the producer, the desired yield, the cost of controlling weeds, and the price of the product.

Conclusions

Nitrogen topdressing provided greater weed tolerance in common bean, compared with rhizobium inoculation. The period before interference for the inoculated common bean plant was between 16 and 24 days after emergence, whereas for the common bean topdressed with nitrogen, the period before interference was 30 days after emergence.

Acknowledgments

This study was supported by the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Finance Code 001.

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