BEAN RESPONSE TO REINOCULATION WITH RHIZOBIUM STRAINS IN BRAZILIAN CERRADOS SOILS

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Introduction

In the Brazilian Cerrados common bean is a major grain legume. In 2003/2204 around 1867,00 ha were cultivated in the Central-West region, with an average yield of 1506 kg/ha (CONAB, 2004). In small farms where the use of N fertilizer and other fertilizers are limited, the yields are low (around 700 kg/ha). In larger farms, under irrigation, yield averages are greater than 2,000 kg/ha.

The majority of the areas cultivated with common beans (*Phaseolus vulgaris* L.) involve the use of N fertilizer in rates that range from 0 to 100 kg N ha^{-1}. Although indigenous soil population of rhizobia are low, they increase rapidly upon successive bean cultivation (regardless of inoculation) and constitute one of the major limiting factors for the success of inoculation This is one of the reasons that explain why yield responses to inoculation under field conditions is often variable, ranging from no responses to substantial increases.

Increases in soybean yield promoted by yearly reinoculations are well known in Brazil, however few data support the benefits of this practice for common bean.

Objective

The objective of this work was to examine, during a three year period, bean response to annual reinoculation in a clayey Dark-Red Oxisol that had never been cropped with beans.

Materials and methods

Local

The study was carried out at the Embrapa Cerrados Research Center, Planaltina, DF, Brazil, between January 2000 and July 2002, involving four harvests (January/ 2000, July/2000, July/ 2001 and July/ 2002).

Soil

Dark-red oxisol that had never been cropped with bean (indigenous populations of rhizobia able to nodulate common beans of 8,4 cells/g soil, as determined by the plant infection technique).

Experimental Design

Completely randomized block with four replicates.

On the first planting (January 2000), besides an uninoculated control and a nitrogen control (60 kg $N.ha^{-1}$), four distinct strains were introduced in the soil: *Rhizobium tropici* strains CIAT 899 (=SEMIA 4077) and PRF-81 (=SEMIA 4080), and strains BR 868 and BR 53C isolated at Embrapa Agrobiologia.

On the second, third and fourth plantings (June/2000, May/2001 and May/2002, respectively), the main plots (11 m by 5m) were split into two sub-plots of 5m by 5m. One sub-plot was left uninoculated and the other was reinoculated with the same strains introduced in the first cropping.

Inoculant

All treatments were inoculated with a peat inoculant (populations ranging from $2,0 \times 10^8$ up to $2,0 \times 10^9$ cells g^{-1}) in the proportion of 1kg per 40 kg of seeds.

Parameters evaluated

Nodule number and mass at 15 days after the emergence (d.a.e) and at the flowering stage.

Bean yields.

Bean cultivar

Aporé

Results and discussion

In the first experiment a significant increase in the number and dry weight of nodules was observed in all inoculated treatments, however due to a severe disease attack (*Phaeoisariopsis griseola*), occurred at the flowering stage, grain yields were lower and no differences among treatments were observed (data not shown).

The lowest number and dry weight of nodules were observed in the second experiment (Table 1), which might be related to the lower temperatures that occurred at the beginning of the growth cycle. In this experiment no differences in the nodulation were observed among the inoculated and the uninoculated treatments. The only exception was the treatment inoculated in the first and in the second experiment with strain BR 53C, each presented the lowest weight of nodules. Yield differences among treatments were significant. Regardless, of inoculation in the second year, the average yield of the treatments inoculated in the first year with PRF-81 (4,356 kg.ha^{-1}) was significantly greater than the control without inoculation and without nitrogen (3,254 kg.ha^{-1}).

With the exception of strain PRF-81, the grain yields of all treatments with reinoculation were lower than those without reinoculation, which might be a consequence of the lower number of nodules observed in this experiment.

In the third experiment (Table 2), with the exception of the treatments originally inoculated with strain PRF-81, all the others showed significant responses to reinoculation with yield gains in relation to the non-inoculated ones ranging from 179 up to 965 kg/ha. Compared to the treatment left without inoculation and without nitrogen fertilizer, the yield gains observed with reinoculation of strains CIAT 899, PRF 81, BR 868 and BR 53C were of 697, 194, 261 and 517 kg/ha, respectively.

In the fourth experiment (Table 3), reinoculation with strains PRF-81 and BR 868 showed significant responses with yield gains, in relation to their non-inoculated counterparts, of 717 and 560 kg/ha, respectively. Compared to the control treatment the yield gains observed with reinoculation were not statistically significant.

With the exception of the first experiment the N treatments always presented the greatest productivity levels.

Table 1. Effects of inoculation history on bean nodulation and yield, on the 2nd planting (June/2000).

Inoculation treatments		Nodules per plant			Yield (kg/ha)
1st planting (January 00)	2nd planting (June 00)	Number	Number	Weight (mg)	
		15 dae	-------- Flowering -----		
Control	Uninoculated	21	23	19 abc	3254 f
60 kg N.ha^{-1}	60 kg N.ha^{-1}	17	14	5 c	4594 a
	CIAT899	19	26	6 bc	4315 abc
CIAT 899	Uninoculated	20	25	24 a	3963 cde
	CIAT 899	23	26	19 abc	3736 e
PRF-81	Uninoculated	21	23	17 abc	4389 ab
	PRF-81	23	24	17 abc	4322 ab
BR 868	Uninoculated	26	28	30 a	4164 bcd
	BR 868	27	25	22 ab	3762 e
BR 53C	Uninoculated	20	24	20 abc	4166 bcd
	BR 53C	19	16	7 bc	3816 de
CV(%)		25 (ns)	42 (ns)	57	5.8

ns= non significant

Table 2. Effects of inoculation history on bean nodulation and yield, on the 3rd planting (May/2001).

Inoculation treatments			Nodules per plant			Yield (kg/ha)
1st planting (January 00)	2nd planting (June 00)	3rd planting (May 01)	Number	Number	Weight (mg)	
			17 dae	------- Flowering -------		
Control	Uninoculated	Uninoculated	50 ab	41	72 bc	3578 ab
60 kg N.ha^{-1}	60 kg N.ha^{-1}	60 kg N.ha^{-1}	21 c	45	63 bc	4082 a
	CIAT899	CIAT899	32 bc	30	38 bc	4261 a
CIAT 899	Uninoculated	Uninoculated	47 ab	45	100 ab	3311 b
	CIAT 899	CIAT 899	42 ab	40	80 abc	4276 a
PRF-81	Uninoculated	Uninoculated	42 ab	58	90 abc	3961 ab
	PRF-81	PRF-81	49 ab	40	71 bc	3772 ab
BR 868	Uninoculated	Uninoculated	50 ab	63	130 a	3578 ab
	BR 868	BR 868	53 ab	49	54 bc	3839 ab
BR 53C	Uninoculated	Uninoculated	45 ab	51	103 ab	3747 ab
	BR 53C	BR 53C	62 a	39	101 ab	4095 a
CV(%)			29(**)	21 (ns)	38 (**)	10,4 (*)

* = P<0.10 ** = P<0.05; ns= non significant

Table 3. Effects of inoculation history on bean nodulation and yield, on the 4th planting (May/2002).

Inoculação anterior				Nodules per plant			Yield (kg/ha)
1st planting (Jan. 00)	2nd planting (June 00)	3rd planting (May 01)	4th planting (May 02)	Number	Number	Weight (mg)	
				17 dae	---- Flowering ----		
Control	Uninoc.	Uninoc.	Uninoc.	77	55	93	3657 abcd
	60 kg N.ha^{-1}	60 kg N.ha^{-1}	60 kg N.ha^{-1}	73	49	69	3950 ab
	CIAT899	CIAT899	CIAT899	90	44	50	4089 a
CIAT 899	Uninoc.	Uninoc.	Uninoc.	80	49	98	3320 cde
	CIAT 899	CIAT 899	CIAT 899	76	46	78	3784 abc
PRF-81	Uninoc.	Uninoc.	Uninoc.	86	44	105	3216 de
	PRF-81	PRF-81	PRF-81	91	53	114	3933 ab
BR 868	Uninoc.	Uninoc.	Uninoc.	84	58	114	2920 e
	BR 868	BR 868	BR 868	84	50	97	3480 bcd
BR 53C	Sem inoc.	Sem inoc.	Sem inoc.	95	64	121	3592 abcd
	BR 53C	BR 53C	BR 53C	93	45	104	3885 ab
CV(%)				18 (ns)	32 (ns)	37(ns)	9,2 (***)

*** = P<0.001; ns= non significant

Conclusion

Even though maximum yields were obtained with N fertilization, in areas that had never been cropped with beans, bean inoculation also is a profitable practice, which must be carried out every year, specially considering the low costs of the inoculant and the yield increases.

Acknowledgements

To Osmar Teago, Emilio Taveira, Maria das Dores Silva, Odete Justino and Vilderete Alves for their technical assistance. This work was partially financed by CNPq-PRONEX, Group of Excellence in Nitrogen Fixation (41.96.0884.00).