2017

APPLICATION RATES OF *RHIZOBIUM* INOCULANT IN THE PLANTING FURROW IN DRY BEAN cv. BRS ESTILO

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INTRODUCTION: One of the limitations of liquid inoculation with rhizobia in the planting furrow in the dry bean crop is the small number of research studies involving this type of inoculation and the establishment of application rates suitable for good performance of biological nitrogen fixation (BNF). Thus, the aims of this study were to evaluate the viability of liquid inoculation in the planting furrow in dry bean BRS Estilo and certify if the increase in the inoculation rate benefits its symbiosis with *Rhizobium* sp.

MATERIALS AND METHODS: A field experiment was carried out in a no-till planting system in the 2014/2015 crop season in a *Latossolo Vermelho distrófico* in the south of Minas Gerais, Brazil, at 986 m altitude, 21º58'S latitude and 45º20'W longitude. The experimental design was randomized blocks with three replications and eight treatments, involving five application rates of liquid inoculant in the planting furrow, seed inoculation, and two controls without inoculation, one without N and the other fertilized with 80 kg ha^{-1} of mineral N.

There were no records of prior inoculation in the dry bean crop in the area. Each experimental unit (14.4 m^2) consisted of six four-meter-length rows, spaced at 0.6 m, and the unit area effectively used was the four central rows. All the plots received base fertilization at the rate of 110 kg ha^{-1} of P_2O_5 and 40 kg ha^{-1} of K_2O mechanically applied during furrowing for planting. In addition, the inoculated plots received 20 kg N-urea ha^{-1} at planting so as to meet the recommendations of Soares et al. (2016). Sowing was manual at the density of 15 seeds per meter, and the cultivar used was BRS Estilo of high yield potential and intermediate resistance to common bacterial blight and to rust (Melo et al., 2010).

The strain used was CIAT 899 of *Rhizobium tropici*. The inoculant was prepared in liquid medium "79" (Fred & Waksman, 1928). Inoculant quality met the minimum legal requirement of 10^9 viable cells of *Rhizobium* per mL of inoculant. The rate of inoculant applied on the seed was 40 mL kg^{-1}, and the seeds were inoculated shortly before sowing. The application rates in the furrow were determined to obtain rhizobia populations of 0, ½, 1, 2, and 3 times the rate of 240 mL ha^{-1} (corresponding to rates of 0, 120, 240, 480, and 720 mL ha^{-1}, respectively). Distribution of the inoculant in the furrow was performed with a manual backpack sprayer, and the spray volume was equivalent to 20 L ha^{-1}.

At flowering, 10 plants were collected from each plot (rows 2 and 3) for determination of the number and dry weight of nodules and shoot dry matter, as well as N concentration and accumulation in the shoots. To meet the requirements of analysis of variance, the nodulation data were first transformed into $(x+1)^{0.5}$. The data were subjected to analysis of variance and the effects of the treatments evaluated by the F test ($p \leq 0.05$). In the cases of significant effect of the treatments, grouping of means was performed by the Scott-Knott test ($p \leq 0.05$).

RESULTS AND DISCUSSION: The treatments significantly affected plant dry matter and shoot N accumulation in dry bean (Table 1). There was good experimental precision in the estimates of the characteristics evaluated, even in relation to the number and dry matter of nodules, the values of which normally prove to be higher in the literature.

Seed inoculation and inoculation in the planting furrow exhibited equivalent nodulations, regardless of concentration of the inoculant. However, the highest values of dry bean growth were

observed in the control fertilized with 80 kg of N-urea ha^{-1} and in some concentrations of liquid inoculation in the planting furrow, even without expressing direct proportionality between concentration and growth. The control without N and without inoculation also had good performance under most of the variables, probably as a result of the expressive nodulation observed, which is indicative of the efficiency of native rhizobia populations. Shoot N accumulation, for its part, followed the shoot dry matter (SDM) (Table 1).

Likewise, other authors, also for soils of the south of Minas Gerais (Fonseca et al., 2013; Figueiredo et al., 2016; Oliveira et al., 2016; Soares et al., 2016), found native rhizobia with nodulating ability and BNF similar to the those of the strain CIAT 899, already recommended by the Brazilian Department of Agriculture (Ministério da Agricultura, Pecuária e Abastecimento) for dry bean. These results are encouraging and represent significant savings on nitrogen fertilizers.

Table 1. Number of nodules (NN) mean nodule dry matter (NDM), shoot dry matter (SDM), shoot nitrogen concentration (SNC), and shoot nitrogen accumulation (SNA) in dry bean cv. BRS Estilo. Spring-summer crop season 2014/2015.

Treatment	NN[1] (plant unit $^{-1}$)	NDM[1] (mg plant^{-1})	SDM (g plant^{-1})	SNC (%)	SNA (mg plant^{-1})
No inoculation in furrow (0 mL ha^{-1})	20 a	248 a	6.96 b	2.90 a	204 b
½X rate inoculation in furrow - ISu (120 mL ha^{-1})	31 a	445 a	6.75 b	2.73 a	184 b
1X rate ISu (240 mL ha^{-1})	19 a	275 a	8.55 a	3.27 a	279 a
2X rate ISu (480 mL ha^{-1})	20 a	345 a	8.09 a	3.03 a	248 a
3X rate ISu (720 mL ha^{-1})	24 a	345 a	6.56 b	3.47 a	221 b
Seed inoculation	20 a	224 a	5.39 b	2.93 a	158 b
Control with N	17 a	209 a	10.70 a	3.03 a	325 a
Control without N	24 a	323 a	8.28 a	3.07 a	257 a
Overall mean	22	302	7.66	3.05	234
Coefficient of variation	19.38	4.21	17.21	10.47	20.69

Mean values followed by the same lowercase letters in the columns belong to the same group by the Scott-Knott test ($P \leq 0.05$). [1]Mean values compared according to transformed data $(x+1)^{0.5}$.

At the application rate of 240 mL ha^{-1}, the method of inoculation in the planting furrow proved to be viable, showing efficiency similar to or even greater than that of seed inoculation, and providing for plant growth and N nutrition equivalent to the values obtained from fertilization with 80 kg ha^{-1} of mineral N. In spite of these results, new studies should be carried out aiming at use of this technique in dry bean, above all in areas without native rhizobia efficient in this symbiosis.

ACKNOWLEDGEMENTS: The authors thank the financial support of CAPES, CNPq and FAPEMIG, and the Empresa de Pesquisa Agropecuária de Minas Gerais (Epamig), for granting use of field area.

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