

RESPONSE TO LATE FOLIAR NITROGEN APPLICATION IN SOYBEAN PRODUCTIVITY

ABSTRACT: To achieve high productivity in soybean crop, a balanced fertilization is fundamental, therefore, it is needed appropriate management during the period in which the plant requires larger amounts of nitrogen, since this element is very extracted by the plant. This study evaluated the response to late nitrogen fertilization using ammonium sulfate applied on soybean leaves. The experiment was conducted in 2015/2016 crop in the state of Piauí, Brazil. Nitrogen was applied at doses D1 - zero kg ha⁻¹ (control); D2 - 3 kg ha⁻¹; D3 - 6 kg ha⁻¹; D4 - 9 kg ha⁻¹; D5 - 12 kg ha⁻¹; D6 - 15 kg ha⁻¹ at the early grain-filling stage (R5). The experiment was conducted in a randomized block design with four replications, consisting of 10 rows, five meters long, 0.5 m spaced apart. Analyses were made for number and length of pods, thousand seed weight and yield. The results showed no significant difference in grain yield. It was noted that there is no response from soybean plant to late nitrogen application.

Keywords: *Glycine max*, plant nutrition, foliar application, yield.

1. INTRODUCTION

Soybean are an important source of protein and important for food and feed. Soybean production has been growing over the years and the harvest of 2014/15 Brazilian production reached a record 96.24 million tons.

Nitrogen is part of most organic compounds as proteins, chlorophyll, hormones, nucleic acids and amino acids making it essential for plant life (MALAVOLTA, 2006). The increased demand for nutrients is observed at the flowering period and when there is the maximum volume of grain at stages between R1 and R6 (LAMOND & WESLEY, 2001; MAEHLER *et al.*, 2003). Much of nitrogen required by the crop comes from fixation and through the symbiont *Bradyrhizobium* bacteria, the remainder is obtained via soil, by mineralization of organic matter (AMADO *et al.*, 2010). However, several factors hamper the fixation process, for example, water deficit or excess, acidity, soil temperature, fertility, competition with wild strains and presence of excess nitrate (PURCELL *et al.*, 2004; SINCLAIR *et al.*, 2007).

Nitrogen fertilization represents an alternative to complement the biological fixation process, therefore, ammonium sulfate {(NH₄)₂SO₄} is often used; the second most widely used source in Brazil (ANDA, 2006). This formula shows 21% nitrogen and also has, on average, 24% sulfur (S), in addition, it has advantages, such as low hygroscopicity, low loss by volatilization of N, low nitrification and good physical properties, and increases phosphorus solubility and soil manganese through the

38 sulfur (COLLAMER [et al.](#), 2007). Given the above, this study evaluated soybean production according
 39 to the late foliar application of different ammonium sulfate doses.

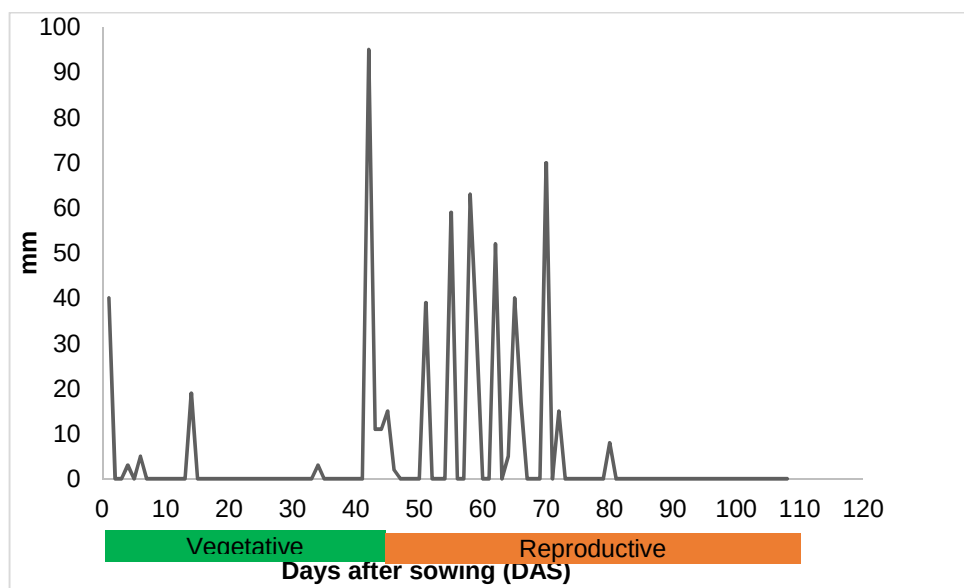
40

41 2. MATERIAL AND METHODS

42 The research was conducted in soybean crops at the São João Farm, in the agricultural
 43 frontier region with the Brazilian Cerrado, state of Piauí (9° 3'25.69" S and 44° 33'12.89" W), 570 m
 44 altitude. The study was conducted between December 2015 and March 2016. The climate is
 45 classified as warm tropical Aw, according to Köppen classification, with rainy and hot summer.
 46 Rainfall and average monthly temperatures were monitored during the study period; from November
 47 2015 to April 2016, rainfall was 746 mm, as shown in figure 1, and the average temperature was 26.5
 48 °C.

49

50



51

52 **Fig. 1.** Rainfall, in millimeters, from November 2015 to April 2016.

53

54 Fertilization was based on soil analysis (table 1) and recommendation for the culture. Seeds
 55 were treated and inoculated with *Bradyrhizobium* bacteria at 5×10^9 colony forming unit.

56

57 **Table 1.** Soil analysis of the experimental area at different depths.

Depth	pH	OM	P	K	Ca	Mg	Al	SB	SAND	CLAY	SILT
cm	CaC ₂	g/dm ³	mg/dm ³	-----mmolc/dm ³ -----				-----g/kg-----			
0-10	4.8	26.4	30.3	3.8	38.3	7.6	0	49.7	660	280	60
10-20	4.2	20.5	11.1	1.4	14.4	2.9	5	18.7	610	300	90
20-40	3.1	14.3	6.3	0.7	1	0.9	12	2.6	590	330	80

Depth = soil depth; pH = potential of hydrogen; OM = organic matter; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; Al = aluminum; SB = base saturation.

Sowing of soybean was made in late November 2015, the cultivar presented a determinate growth habit, 77 cm average height, 110 days average cycle, 8.6 maturity group. This cultivar has a high yield potential and good adaptation to regions with less than 600 meters altitude. The experimental design was a randomized block design, using six doses of ammonium sulfate $\{(NH_4)_2SO_4\}$: D1 - control, 0 kg ha⁻¹; D2 - 3 kg ha⁻¹; D3 - 6 kg ha⁻¹; D4 - 9 kg ha⁻¹; D5 - 12 kg ha⁻¹; D6 - 15 kg ha⁻¹, with 4 replications.

Each plot had 10 rows, 5 meters long, 0.5 m spaced apart, totaling 25 m². The useful area of the experimental unit was formed by the three central rows, excluding 0.5 m from each end of the rows. Ammonium sulfate (21% N and 24% S) was used as a source of fertilizer. For the application of N in liquid form, we used a knapsack sprayer of 20 liters in the period from the end of the pod formation stage (R4) to the beginning of the grain filling stage (R5). For the assessments, plants were collected only in the useful area of the plot. Harvest was done manually, when the plants have reached the R8 developmental stage, when 95% of the pods had the typical color of mature pod. For the assessment of yield components of the crop, we evaluated:

Soybean yield: plants of the useful area of the plot were measured for total weight of the grains of the collected plants. The result was presented in kg ha⁻¹ (with moisture adjusted to 13%).

Thousand seed weight: eight samples of 100 seeds were taken at random from each plot, and each sample was weighed on a scale and then applied the formula described in Brasil (2009). The results were expressed in grams.

Number of pods per plant: five plants of each plot were collected, and we counted the number of pods and later calculated the average of 5 plants.

Length of pods: of the five plants collected for determining the number of pods, 10 pods per were taken plant to measure the length, using a digital caliper and then obtaining the average per plant.

Data were tested by analysis of variance (ANOVA) by applying the F-test and processed by the R software (version 3.2.3).

3. RESULTS AND DISCUSSION

Table 2 lists the results of the analysis of variance. For the number of pods, there was no significant difference, showing that the different doses applied to leaves of soybean plants at R4-R5 stages had no significant influence on this variable. This result differs from that reported by Zocca and Fancelli (2013), who tested N foliar applications in soybeans, which had a significant increase in the number of pods per plant compared to the control.

For the length of pods, the result was also non-significant. According to the authors mentioned above, this result may be related to lack of biological nitrogen fixation at the final stage of the crop.

Table 2: Analysis of variance for number of pods (NP), length of pods (LP), thousand seed weight (TSW) and yield.

Source of variation	Degrees of freedom	NP (unit/plant)	LP (cm)	TSW	YIELD
Dose	5	147.94 ^{ns}	3.07 ^{ns}	35.16 ^{ns}	126.69 ^{ns}
Blocks	3	116.02 ^{ns}	0.09 ^{ns}	27.99 ^{ns}	25.89 ^{ns}
Residue	15	164.85	1.54	17.31	92.73
Coefficient of variation (%)		23.08	2.82	6.77	30.18

^{ns}: non-significant

For TSW (table 2), significant differences were not detected, this may have occurred because of high water stress in the region during the grain filling period (R5), thus providing pods with malformed grains and low weight. Sohrabi *et al.* (2012), in Iran, conducted an experiment with urea and observed that the treatments with application of 50 kg ha⁻¹ and 100 kg ha⁻¹, at the R1 and R5 stages, caused no significant difference in 1000 grain weight between treatments, thus demonstrating that late applications caused no significant response.

Yield, in kg ha⁻¹ (table 2), was also not affected by the late application of ammonium sulfate. These results contradict Zocca and Fancelli (2013), who verified a production of 3890.50 kg ha⁻¹ and 3940.50 kg ha⁻¹ using foliar application of N (25%) at a dose of 10 L ha⁻¹ at the stage of R5 and R1 + R5. However, Pasqualli and Pittelkow (2014), in an experiment with nitrogen (32%) as nitrate, ammonium and amidic in the same fertilizer applied on soybean noted an increase in yield at doses of 3 and 5 L h⁻¹, however the results were not significantly different. Rosa *et al.* (2015) also reported that the application of foliar N (30%) at the R4 and R5 reproductive stages have not increased yield when used in two doses of 4 L ha⁻¹.

Table 3. Average number of pods (NP), length of pods (LP), thousand seed weight (TSW) and yield of different nitrogen doses applied.

DOSE	NP Unit/plant	LP Cm	TSW g	YIELD kg/ha ⁻¹
0	58.35	42.45	95.85	1750.20
3	63.15	44.84	95.63	2406.10
6	49.85	43.82	93.75	1667.97
9	61.00	43.63	88.38	1406.29
12	52.95	44.15	91.63	2013.47
15	48.45	44.76	90.58	2139.71

For application via foliar, we observed toxicity symptoms at doses of 6, 9, 12 and 15 kg ha⁻¹, only the dose of 3 kg ha⁻¹ caused no symptoms, but the plants were able to recover and complete their cycle. According to Rosolem & Boaretto (1989), the foliar application of considerable levels of

nitrogen may cause toxicity, which can be minimized by the choice of the nutrient source, the nozzle and spray volume, as well as the time of application.

Discussion has taken place about the inefficiency of nitrogen fixation to supply the demand at the grain filling stage (R5). Nevertheless, it should be noted that some practices and chemicals used for seed treatment are incompatible with N_2 fixing bacteria, leading to the death of them (Ferreira *et al.*, 2011) and thus impairing the final production. The mineral forms of N, NH_4^+ and NO_3^- , affects not only the biological fixation, but also the nodulation of the plants, for inhibiting the formation of nodules or causing senescence of those already formed (BOTTOMLEY & MYROLD, 2007).

4. CONCLUSION

The application of $\{(NH_4)_2SO_4\}$ ammonium sulfate did not increase yield, compared to the control, when applied at the grain filling phase (R4 and R5).

5. REFERENCES

1. Amado TJC, Schlindwein, Fiorin JE. Manejo do solo visando à obtenção de elevados rendimentos de soja sob sistema plantio direto. In: Thomas AL, Costa JÁ, editors. Soja - Manejo para alta produtividade de grãos. 1th ed. 2010. Portuguese.
2. Anda. Anuário estatístico do setor de fertilizantes. São Paulo. 2006:162. Portuguese
3. Brasil. Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Mapa/ACS, 2009:399. Portuguese
4. Bottomley PJ, Myrold DD. Biological N inputs. In: Paul, EA, editors. Soil microbiology, ecology and biochemistry. 3th ed. Oxford: Academic Press; 2007.
5. Collamer JD, Gearhart M, Monesmith FL. Sulfato de Amônio. Informações Agronômicas. 2007;10:7-8. Portuguese
6. Conab. Acompanhamento safra brasileira de grãos. 2015;2:1-134. Accessed 22 November 2016. Available. http://www.conab.gov.br/OlalaCMS/uploads/arquivos/15_09_11_08_57_48_boletim_graos_setembro_2015.pdf. Portuguese.
7. Ferreira E, Nogueira MA, Fukami J, Conceição RB, Hungria M. Nova legislação, recomendação de doses de inoculantes e pré-inoculação: riscos ao sucesso da contribuição da fixação biológica do nitrogênio para a cultura da soja. Embrapa Soja, 2011;358. Portuguese.
8. Lamond RE, Wesley TL. Adubação nitrogenada no momento certo para soja de alta produtividade. Informações Agronômicas. 2001;95:6-7. Portuguese.
9. Maehler AR, Costa JÁ, Pires JLF. Qualidade de grãos de duas cultivares de soja em função da disponibilidade de água no solo e arranjo de plantas. Revista Ciência Rural. 2003;33:213-218. Portuguese.
10. Malavolta E. Manual de nutrição de plantas. Editora Agronômica Ceres. 2006;638. Portuguese.

- 163 11. Pasqualli RM, Pittelkow FK. Efeito da aplicação de ubyfol n-32 na cultura da soja. Fundação
164 de Pesquisa e Desenvolvimento Tecnológico Rio Verde. 2015. Portuguese.
- 165 12. Purcell LC, Rachid S, Thomas R & D. Soybean N₂ fixation estimates, ureide concentration,
166 and yield responses to drought. Crop Science. 2004;44:484-492.
- 167 13. Rosa LS, Silva AP, Jesus VV, Kolesk AL, Petean LP. Influência da utilização de nitrogênio
168 aplicado via foliar na fase reprodutiva da soja. 2015:1983-7178. Portuguese.
- 169 14. Rosolem CA, Boaretto AE. Avaliação do estado nutricional das plantas cultivadas. In:
170 Boaretto AE, Rosolem CA, editors. Adubação foliar. 1th ed. Campinas: Fundação Cargill;
171 1989. Portuguese.
- 172 15. Sinclair TR, Urcell LC, King CA, Sneller CH, Chen P, Vadez V. Drought tolerance and yield
173 increase of soybean resulting from improved symbiotic N₂ fixation. Field Crops Research.
174 2007:101:68-71.
- 175 16. Sohrabi Y, Habibi A, Mohammadi K, Sohrabi M, Heidari G, Khalesro S, Khalvandi M. Effect of
176 nitrogen (N) fertilizer and foliar-applied iron (Fe) fertilizer at various reproductive stages on
177 yield, yield component and chemical composition of soybean (*Glycine max* L. Merr.) seed.
178 African Journal of Biotechnology. 2012;11:9599-9605.
- 179 17. Zocca TN, Fancelli AL. Incremento de produtividade da soja pelo uso de nitrogênio foliar.
180 ESALQ/USP. 21º SIICUSP: Simpósio Internacional de Iniciação Científica da USP.
181 Piracicaba. 2013. Portuguese.