International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 14, No. 1, p. 437-443, 2019

INNSPUB

RESEARCH PAPER OPEN ACCESS

Behavior of soy cultivation (*Glycine max* L.) with foliar application of molybdenum, cobalt and boron

Diosnel Amarilla M.[1*], Albino Zaracho[1], Ever Maidana C.[2], Milciades Melgarejo A.[2], Miguel Bogado C.[2], Walter Vera[2], Rafael Franco S.[2]

Departament of Phytotechni, National University of Canindeyú (UNICAN), Faculty of Agricultural and Environmental Sciences (FCAA), Katuete -Paraguay

Key words: *Glycine max*, Foliar fertilization, Cobalt, Molybdenum, Boron.

http://dx.doi.org/10.12692/ijb/14.1.437-443 Article published on January 31, 20199

Abstract

Soy is an oilseed of great economic importance in Paraguay. Foliar fertilization is a fundamental practice to meet the nutritional needs of the crop, therefore, the objective of this work is to evaluate the effect of the foliar application of cobalt (Co), molybdenum (Mo) and boron (B) with different doses and combinations in the soybean crop, the experiment was carried out in Curuguaty, the design used was randomized complete blocks with factorial arrangement of 9 treatments and 3 blocks, treatments were CoMo (0, 150 and 250 mL ha^{-1}) and B (0, 500 and 1000 mL ha^{-1}) applied via foliar during stage V8 of the crop. The following were evaluated: height of the plant, number of nodules, number of pods, yield and weight of 1,000 grains. For plant height, T7 had a greater height with 80.3 cm over 71.83 cm of the control, for the number of pods the T6 obtained a greater quantity with an average of 79.1 pods, while the Witness reached 64.4 pods per plant, the number of nodules in the interaction showed significant differences, being the T4 that presented greater amount, with 66.05 on 55.13 of the control, the yield of the crop showed increases with the application of the micronutrients, the best was the T4 with 2305 kg ha^{-1}, compared to 1923 kg ha^{-1} of the control, and in weight of 1,000 grains there was a highly significant difference in the interaction, with T4 achieving 124.2 gr over 107.43 gr of the control; that is, the application of micronutrients such as cobalt, molybdenum and boron increases the yield of soybeans according to the result, so the application is recommended taking into account the cost benefit.

* **Corresponding Author:** Diosnel Amarilla M. ✉ lionelms@hotmail.com

Introduction

The soybean is an oilseed that is varied in growth, habit and height, can grow from 0.20 m to 2 m in height, the pods, stems and leaves are covered by fine brown or gray hairs, the leaves are trifoliate, these fall before the seeds are ripe, the flowers are born in the armpit of the leaf and are white, pink or purple, the fruit is a hairy pod, the pods are about 3 to 8cm in length and usually contains 2 to 4 seeds (MAG, 2010).

It requires nutrients either macro or micronutrients, often the limiting factors are micronutrients and in some cases they are found in the soil at a low level of what the crop needs, so foliar fertilization with micronutrients is a fundamental practice to fulfill with the nutritional needs of the crop. The foliar fertilizers are used for the growth and development of the plants, the Cobalt (Co) and Molybdenum (Mo) are elements that help fixing microorganisms to capture nitrogen from the atmosphere, meanwhile, the Boron (B) acts in the formation of the pollen tube and it is also a nutrient that stimulates cell development, and due to inadequate fertilization and little use of foliar fertilizers the cultivation of soy has lowered its yield (Cubilla, 2014).

Foliar fertilizers are an alternative to supplement the nutrition of soybean and other extensive crops, currently the diagnosis of response to foliar fertilization is more accurate, making the analysis of soil and tissues for more information of eventual deficiencies (Fontanetto, Keller, & Albrecht, 2009). Foliar application of fertilizers is a widely used practice to cover deficiencies of micronutrients, the advantage of this practice is the possibility of providing the most uniform elements directly on the leaves thus preventing the interaction of micronutrients with the soil avoiding reducing their bioavailability (Prystupa, 2012).

Boron acts in the transport of sugars, internal regulation of growth by plant hormones, in fertilization, water absorption, synthesis of nucleic acids (Jiménez *et al.*, 2010). With the foliar application of B they found an increase in yield, especially in a soil of low fertility. Gambaudo *et al.*, (2010).

The Co and Mo are elements of relevance in the fabaceae family because they are part of the nitrogenase enzyme, synthesized by bacteria during the process of biological nitrogen fixation by symbiosis, these elements increase in yield (Deuner *et al.*, 2016). The application of Co and Mo presents a good amount of nodules in the root, obtains favorable responses with the treatments carried out on the seed and applied via foliar. Masgrau (2006).

The objective of this work is to evaluate the agronomic characteristics of soybean with the foliar application of nutrients such as cobalt, molybdenum and boron. In order to achieve greater productivity by observing all the agronomic characteristics of the plant (a better growth rate in height of cultivation, greater presence of nodules in the root system and higher yield).

Materials and methods

Location and installation of the experimental plot

The experiment was conducted in Santa Librada district of Curuguaty, department of Canindeyú, 18 km northwest of the same city whose geographical coordinates are 7°305`320 "S and 626°089` W, on a soil classified as Rhodic Paleudult(López *et al.*, 1995). For the installation of the parcel, 10 subsamples from 0 to 0.20m of the surface were collected for the determination of the chemical characteristics and granulometry of the soil, the result of which is as follows: pH (CaCl2) = 5,40; O.M = 19.38 g dm-3; P (Mehlich I) = 11.45 mg dm^{-3}; K + = 0,27 cmol dm^{-3}; Ca ++ = 3,45 cmolc dm^{-3}; Mg ++ = 0,61 cmolc dm^{-3}; V = 57,63%; Sand = 83,40% of granulometry; silt = 4,55% and clay = 12,05% respectively, The region has a mesothermal humid subtropical climate with an average temperature of 23°C and 1,300 mm of annual rainfall (DGEEC, 2002). During the development of the crop, the following meteorological data were obtained (Fig. 1) whose result was provided by the Fecoprod station located in Curuguaty-Paraguay.

Measurement of the experimental area

Ten days before sowing, a desiccation with glyphosate of 3.5 L ha^{-1} was carried out, then the land was marked, the experimental area had a total dimension of 396.2 m^2, 28.3 m long and 14 m wide, totaling 27 experimental units, each experimental unit were separated by 0.60 m and obtained an area of 2.70 m wide and 4 m long (10.8 m^2), and the blocks were separated from each other at 1 m , for the useful parcel, 0.5 m of edges was eliminated for each experimental unit, and the useful area of 5.1 m2 was left.

Sowing of soybeans

Seeding was done manually by depositing two seeds in the soil at each 0.11 m with a spacing between lines of 0.45 m, the variety used was 5909 RG, prior to sowing the seeds were inoculated with the Rhizobium spp. treated with insecticide (fipronil) and fungicide (thiran + carbendazim).

Fertilization and handling of the crop

The crop obtained a basic fertilization with phosphorus (60 kg ha^{-1}) and potassium (50 kg ha^{-1}) according to the soil analysis, the weed control was carried out with the application of glyphosate until the soybean plants cover the soil in the whole, for the control of pests and diseases the following products were used: carbendazim, tebuconazole, as preventive treatments since there was not much incidence of pathogens, azoxystrobin + pyraclostrobin was used, and for the control of insects was applied cypermethrin and fipronil.

Experimental design

The design used in the trial was randomized complete blocks with bi-factorial arrangement of 3×3 totaling 9 treatments and 3 blocks. The treatments were applied via foliar in vegetative stage eight (V8) with backpack sprayer as shown in Table1, on combinations of doses and nutrients.

Harvest

The harvest was made manually in its entirety of the useful plot, then put in a burlap bag giving hits for the shelling and finally with a fan separated the grains of impurities from each experimental unit.

Variables studied

The variables evaluated were:

A). Height of the plant, 10 plants were taken at random from the useful plot and were measured with a tape measure each plant from the base of the stem to the tip of the apex, the measurements obtained was expressed in cm.

B). Amount of pod per plant, in which 10 plants of each experimental unit were randomly chosen, then pods were counted per plant and the result was averaged of the total of each experimental unit.

C). Number of nodules per plant, 10 plants were extracted in the reproductive stage three (R3), with all its root system using a shovel for its extraction with care not to break the nodules, and to scatter the particles of the soil the roots were shaken and were washed for better visualization of the nodules.

D). Yield of the crop, all the useful plot of the crop was harvested manually, after this it was placed in a burlap bag and threshed in manual form, the weighing was carried out with a precision balance, converting the yield to kg ha-1 .

E). Weight of 1000 grains, four samples of 100 grains were extracted at random from each useful plot, each sample was weighed to obtain the average between them, and then multiplied by 10 to obtain the weight of 1,000 grains in grams.

For the analysis of the data the analysis of variance (ANOVA) was used, and the software called Assistat version 7.7 was used, for the comparisons of the means the Tukey test was used at a 5% error probability.

Results and discussion

Plant height

For the height of the plant in the analysis of variance (ANOVA) no significant differences were observed between the treatments performed (p> 0.05) for the doses of factor 1 (Co, Mo) and factor 2 (B) as a sample in the (Table 2). When applying boron via foliar, there were no variations in plant height despite the fact that there was a slight increase between the factors, which is consistent with the work carried out by Aguayo *et al.* (2015), as well as applying Co, Mo via foliar although there was an increase between the doses, no significant differences were found, being the result similar to the work done by (Deuner *et al.*, 2016).

Table 1. Combination of treatments.

Treatment (T)	CoMo (mL ha^{-1})	B (mL ha^{-1})
T1	0	0
T2	0	500
T3	0	1000
T4	150	0
T5	150	500
T6	150	1000
T7	250	0
T8	250	500
T9	250	1000

Table 2. Height of the plant according to the factors.

Levels	Factor 1 Co Mo		Factor 2 B	
	Dose	Medium in cm	Dose	Medium in cm
L1	0 ml ha^{-1}	73.08 a	0 ml ha^{-1}	77.10 a
L2	150 ml ha^{-1}	75.45 a	500 ml ha^{-1}	74.67 a
L3	250 ml ha^{-1}	77.30 a	1000 ml ha^{-1}	74.06 a

*Values with the same letter, do not differ statistically from each other according to the Tukey test at 0.05.

Number of pods per plant

In number of pods per plant, significant differences were observed between the treatments at (p≤ 0.05), the result in factor 1 (Co, Mo) showed a highly significant difference, in level 2 of the dose (150 mL ha^{-1}) and level 3 doses of (250 mL ha^{-1}) presented better results than the level 1 dose (0 mL ha^{-1}), in factor 2 (B) there were no significant differences as observed in (Table 3), but if in the treatments, the one that presented more pods per plant was T6, with 79 pods on the control that reached 64 pods per plant; Although there was a very slight increase, there was no significant difference with the application of boron via foliar, this result agrees with what was said by Ballvé, Bengolea and Ratto, (2015), therefore when applying Co, Mo via foliar presented differences highly significant reaching 75 sheaths treated, over 66 control pods, this result agrees with what was said by Stuart and Ledesma, (2009).

Table 3. Amount of pods per plant according to the factors.

Levels	Factor 1 CoMo		Factor 2 B	
	Dose	Average in quantity	Dose	Average in quantity
L1	0 ml ha^{-1}	66.38 b	0 ml ha^{-1}	72.84 a
L2	150 ml ha^{-1}	74.90 a	500 ml ha^{-1}	71.72 a
L3	250 ml ha^{-1}	75.00 a	1000 ml ha^{-1}	71.72 a

*Values with the same letter, do not differ statistically from each other according to the Tukey test at 0.05.

The variables, number of pods per plant, were influenced positively and significantly by the application of Co and Mo via foliar, concordant with Stuart and Ledesma, (2009), which argues that these elements are effective means to improve and increase the productivity of crops.

Number of nodules per plant

For the variable quantity of nodule per plant, a non-significant result is observed at (p> 0.05) between the levels of factor 1 (Co, Mo) and factor 2 (B) as shown in (Table 4), but in the interaction between the factors was significant at 1% probability of error, as indicated by (Fig.2), in the interaction between the factors shows that there are differences in the nodulation of the soybean root, treatments 4 and 7 were those that presented higher nodules, being the first with 66.05 and the second with 63 nodules respectively, this work agrees with what was done by (Fontanetto *et al.*, 2006), that with the fertilization with Co, Mo, they obtained answers like; increase of nodules in the root.

Table 4. Number of nodules per plant according to the factors.

Levels	Factor 1 CoMo		Factor 2 B	
	Dose	Average in quantity	Dose	Average in quantity
L1	0 ml ha^{-1}	57.45 a	0 ml ha^{-1}	61.39 a
L2	150 ml ha^{-1}	60.05 a	500 ml ha^{-1}	59.53 a
L3	250 ml ha^{-1}	61.48 a	1000 ml ha^{-1}	58.06 a

* Values with the same letter, do not differ statistically from each other according to the Tukey test at 0.05.

Table 5. Yield of the crop in kg ha^{-1} according to dose of the factors.

Levels	Factor 1 Co Mo		Factor 2 B	
	Dose	Medium in kg ha^{-1}	Dose	Medium in kg ha^{-1}
L1	0 ml ha^{-1}	1858.22 a	0 ml ha^{-1}	2089.11 a
L2	150 ml ha^{-1}	1981.33 a	500 ml ha^{-1}	1780.00 b
L3	250 ml ha^{-1}	1965.44 a	1000 ml ha^{-1}	1935.88 ab

* Values with the same letter, do not differ statistically from each other according to the Tukey test at 0.05.

Yield of the crop

For the yield of the crop, the result was observed with a statistically insignificant difference (p> 0.05) between the doses of factor 1 (Co, Mo), but highly significant in factor 2 (B), in F2, level 1 showed a slight increase in relation to level 3, the one that presented the lowest result was level 2, as shown in (Table 5).

Table 6. Weight of 1,000 grains of each treatment according to factor levels.

Levels	Factor 1 Co Mo		Factor 2 B	
	Dose	Medium in gram	Dose	Medium in gram
L1	0 ml ha^{-1}	112.84 b	0 ml ha^{-1}	117.10 a
L2	150 ml ha^{-1}	116.92 a	500 ml ha^{-1}	114.80 a
L3	250 ml ha^{-1}	118.14 a	1000 ml ha^{-1}	116.01 a

* Values with the same letter, do not differ statistically from each other according to the Tukey test at 0.05.

The obtained result shows that when applying Boro*n* via foliar the cultivation of the soybean presents significant differences what agrees with the work done by (Fontanetto *et al.*, 2009), when applying Co Mo via foliar in spite of not showing significant differences there was a slight increase in production this agrees with what was sustained by Masgrau, (2006), the treatments that came to obtain better results are T4 and T7, the first achieved an increase of up to 2305 kg ha^{-1} and the second 2038 kg ha^{-1} this agrees with the work done by (Ceretta *et al.*, 2005), on the other hand Deuner *et al.,* (2016) mention that with the application of Co and Mo soybean productivity can increase up to 7%, these results indicate the importance and benefits of treatment with Co and Mo.

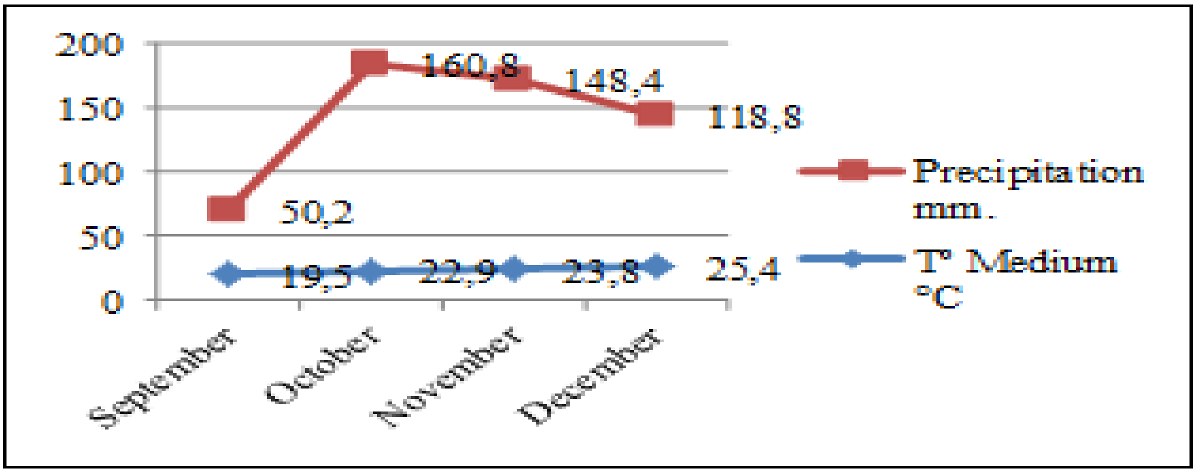

Fig. 1. Meteorological data during the stage of soybean cultivation.

Weight of 1,000 grains

For the variable weight of a thousand grains it is observed that in factor (F1 Co, Mo) showed a highly significant difference to ($p \leq 0.05$), dose 2 of (150 ml ha-1) and dose 3 (250 ml ha- 1) presented better results than dose 1 (0ml ha-1), while in factor 2 (F2 B) the results were not significant as indicated in (Table 6), when applying B via foliar there were no statistical differences as for the weight of a thousand grains that agrees with what Fontanetto *et al.* (2009) said, while Aguayo *et al.*, (2015) in a study with the application of B via foliar during the reproductive stage, found that there was an increase in the number of pods, higher yield and the weight of 1,000 grains varies according to the doses applied; However, when Co Mo was applied, significant differences were found in the variable weight of a thousand grains in this work and it is in agreement with the work done by Gambaudo (2010), with the application of Co and Mo resulted in a good response to the cultivation of the soy.

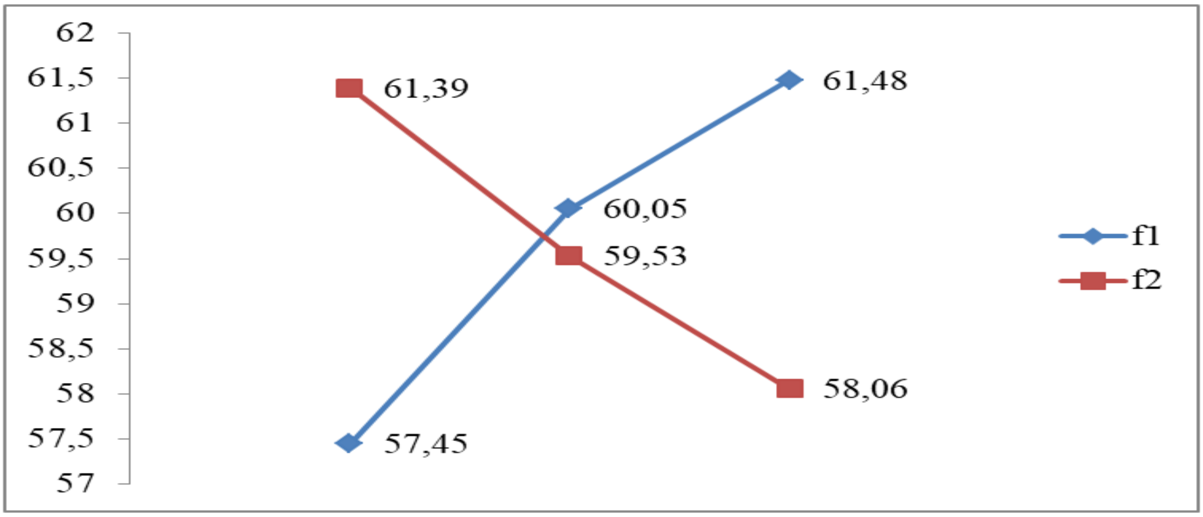

Fig. 2. Interaction of factors between factor 1 and factor 2 respectively on the amount of nodule per plant.

Conclusion

The application of Co, Mo and B with the interaction of these elements gave a positive result in yields and other agronomic characteristics such as height of the plants, weight 1,000 grains, number of nodules and number of pods per plant. In the height of the plant the result shows that there are no significant differences but presented a slight increase; in the number of pods per plant, the result showed that there are significant differences being the T6 that achieved the highest number of pods with 79.1 on the control that obtained 64.4 pods per plant; On the other hand, the number of nodules in the interaction showed significant differences, in the yield of the crop, despite not showing differences in the interaction, an increase was observed between the treatments, the one with the highest yield was T4, with 2305 kg ha^{-1} while the witness managed to reach 1923 kg ha^{-1}; and in weight of 1,000 grains the result showed a highly significant difference in the interaction between the factors and between treatments, reaching 124.2 g (T4), over 107.43 g (T1) of the control. On this side, it is observed that the application of Co Mo and B micronutrients influences the increase in crop yield, but a cost-benefit analysis must be made to know whether it is appropriate or not to apply even if the yield increases.

References

Aguayo S, Rasche J, Britos C, Karajallo J, González A. 2015. Fertilización foliar con boro en el cultivo de la soja Foliar fertilization with boron on soybean crops. Nota de Investigación **17(2),** 129–137. http://doi.org/10.18004/investig.agrar.2015.diciembre.129-137.

Ballvé Bengolea B, Ratto SE. 2015. Ensayo de fertilización y rendimiento del cultivo de soja en la pampa ondulada: ¿boro o nitrógeno? **35(1),** 29–35.

Ceretta CA, Pavinato A, Pavinato PS, Moreira ICL, Girotto E, Trentin ÉE. 2005. Micronutrientes na soja: produtividade e análise econômica Micronutrients in soybean: productivity and economic analysis. Ciencia Rural **35(3),** 576–581.

Cubilla M. 2014. Manejo del suelo , fertilidad y nutrición de la soja para aumentar la capacidad productiva en la región oriental del Paraguay. Testing Operation Manager – Monsanto, Paraguay, 2–6.

Deuner C, Pereira RSD, Borges CT, Rosa MP, Castellanos CIS, Meneghello GE. 2016. Desempeño fisiológico de semillas de soja y fríjol tratadas con dos micronutrientes. Investigación Agraria **18(1),** 8–14.

DGEEC (Dirección General de Estadistica, Encuestas y Censos). 2002. Canindeyú Orografía. Atlas Censal Del Paraguay, 189–197.

Estuardo S, Ledesma L. 2009. & quot;Evaluación de varios Bioestimulantes Foliares en la producción del Cultivo de Soja (Glycine max L.), en la zona de Babahoyo Provincia de Los Ríos & quot.

Fontanetto H, Keller O, Albrecht J. 2009. Efecto de la fertilización foliar con boro y nitrógeno sobre el cultivo de soja. Informaciones Agronómicas **47,** 19–22.

Fontanetto H, Keller O, Negro C, Belotti L, Giailevra D. 2006. Inoculación y fertilización con cobalto y molibdeno sobre la nodulación y la producción de soja. Publicación Miscelánea Nº, 106.

Gambaudo S, Madoery M, Fontanetto H. 2011. Respuesta al agregado de micronutrientes en el cultivo de soja en suelos de diferente aptitud agrícola. Informaciones Agronómicas **3,** 1–4.

Jiménez PGS, Marotta JJL, Criado SR, García MN. 2010. Guía práctica de la fertilización racional de los cultivos en España. Retrieved from http://www.060.es

López OG, Erico EG, Llamas P, Molinas A, Franco E, García S, Ríos E. 1995. Estudio de reconocimiento de suelos, capacidad de uso de la tierra y propuesta de ordenamiento territorial preliminar de la región oriental del Paraguay.

MAG(Ministerio de Agricultura y Ganaderia). 2010. Producción de soja en el paraguay: Zafra 2008/2010.

Masgrau A. 2006. Ensayo de fertilización con Cobalto y Molibdeno en Soja., 63–66.

Prystupa P, Duggan MT, Ferraris G. 2012. tecnología de aplicación de micronutrientes en la región pampeana argentina. Tecnoagro S.R.L., 2–8.