# Influence of CAN Fertilizer and Seed Inoculation with NS Nitragin on Glycine *max* Plant on Pseudogley Soil Type

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## Summary

Soybean [*Glycine max* (L.) Merr.] is the most important legume because it is an essential source of dietary protein and oil for animal feed and food production. Good soil with well-planned program of fertilization is the main factor of soybean production. Soybean yield will be reduced when essential nutrients are deficient. Sufficient soil fertility combined with a well-planned fertilization program is a main component for high soybean production.

The aim of this investigation was to estimate the effects of fertilization and seed inoculation on height of soybean plant in humid year. Two factors were tested: 1. CAN fertilization and 2. seed inoculation. Four treatments of CAN fertilization were tested: control - 0 kg N $ha^{-1}$; 50 kg N $ha^{-1}$; 100 kg N $ha^{-1}$ and 150 kg N $ha^{-1}$. Two factors of seed inoculation (SI) were tested: without SI and with SI. Results showed that fertilizers and seed inoculation significantly increased the values of soybean productivity. Cost effective is the application of 50 kg N $ha^{-1}$ and it is recommended on the basis of this study.

## Key words

soybean, plant, fertilization, seed inoculation, pseudogley

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## Introduction

Soybean [*Glycine max* (L.) Merr.] is one of the oldest oilseed crops in the world. According to the Food and Agricultural Organization data, soybean is cultivated worldwide, generating 276,406,003 tones, of which almost 30% is obtained in the United States of America. Worldwide, the economic value of soybean is 119,516 million US dollars, owing to the versatile use in many fields of industry. It alleviates some chronic diseases (Kahraman, 2017), and it is an essential source of dietary protein, oil and minerals for humans and animals.

Soybean is the most important oilseed and livestock feed crop, which accounts for 58% of the total world oilseed production and 69% of protein meal consumption by livestock. The contributing factor is its high level of proteins (almost 40% of seed weight) as well as the content of valuable oil and mineral compounds. Soybean proteins represent a major source of amino acids. Soybean proteins are also a good source of various bioactive peptides and have unique health benefits, which are used for the prevention of age-related chronic disorders, such as cardiovascular disease, obesity, impaired immune function and cancer. Soybean foods are also rich in vitamins and minerals. Recent research suggests that owing to the valuable nutritional content, soybean may decrease the risk of prostate, colon and breast cancers, osteoporosis and other bone degenerative diseases, and alleviates hot flashes associated with menopause (El-Shemy, 2011). Soybean seeds contain satisfactory amounts of calcium, iron and zinc, i.e. elements whose intake is marginal in some population groups distinguished by social vulnerability. Soybean seeds contain relatively higher amounts (5%) of minerals than cereal seeds (1%) (Board, 2012).

The oil content of soybeans is nearly 20%. It has a good composition of of lipids, which are classified as polyunsaturated oil, including about 15% of saturates, 24% of monounsaturates and 61% of polyunsaturates, of which 53.2% is linoleic acid and 7.8% linolenic acid. Basically, soybean oil consists of five predominant fatty acids: palmitic, stearic, oleic, linoleic and linolenic acids. As it is reported by many studies involving human clinical trials and investigations, this composition has nutritional advantages and promotes regulation of the plasma lipids and biosynthesis of eicosanoids. Studies show that soybean oil is effective in decreasing the serum cholesterol and LDL levels and has a big potential for being used as a hypocholesterolemic agent to prevent atherosclerosis and heart diseases (Kummerow et al., 2007).

It has been demonstrated that a soybean crop yielding 2.5 t seed removes about 125 kg nitrogen, 23 kg phosphorus, 101 kg potassium, 22 kg sulphur, 35 kg calcium, 19 kg magnesium, 192 g zinc, 866 g iron, 208 g manganese and 74 g copper per hectare from the soil. Concerning fertilization, major causes of low productivity of soybean are multi-nutrient deficiencies (e.g. of nitrogen, phosphorus, sulphur, zinc, iron, boron) as farmers tend to supply only nitrogen and phosphorus to major crops, and often at lower doses than recommended, whereas sulphur deficiency is due to the preference by farmers of diammonium phosphate (DAP) as a source of phosphorus rather than single superphosphate (SSP). The relative uptake of nitrogen, phosphorus and potassium by indeterminate soybean under field conditions was studied in some earlier research (Kahraman 2017).

Soybean is the most important legume in Republic of Serbia and Bosnia and Herzegovina with regard to food production. Irrational use of the soil and its production properties can be significantly reduced if the properties of the soil are known, especially the plots on which the intensive agricultural production is conducted. Determination of the necessary agro-technical measures that will increase soil fertility and improve agricultural production should be based on the obtained research data (Popovic et al., 2013a; 2013b; 2015; 2016; 2017; Đekić et al., 2014; Glamočlija et al., 2015; Živanović and Popović, 2016; Stevanović et al., 2016; 2017). Yields will be reduced when essential nutrients are deficient. Sufficient soil fertility coupled with a well-planned fertilization program is main component of producing high soybean yields. Therefore, profitable fertilizer programs must be developed to maximize yields. Soybeans proper fertilization programs have long been ignored. However, high soybean prices and interest in the production of ultra-high soybean yields have stimulated interest in maximizing soybean yields via proper fertilization.

Soybean seed should be inoculated with the proper *Rhizobia* on land where soybeans have not been grown in the previous three to five years or where previous soybean crops have had poor nodulation. There are recomendations for addition of inoculant to seed that will be planted in fields that were previously flooded. If poor nodulation causes a lack of nitrogen, application has to be carried out. If the lack of nitrogen, caused by poor nodulation, was disclosed in soybeans, application of a minimum of 40 to 60 lb N/acre can stimulate growth and increase yield. Additional N applications may be needed. Nodules should be present on soybean root systems and fixing N by the V2 to V3 growth stage. Molybdenum (Mo) is an essential micronutrient that is especially important for legumes and required by the bacteria (*Rhizobia*) that form nodules on soybean roots and fix atmospheric N2 gas into a form that can be used by the plant (biological N fixation). Unlike most other micronutrients, the availability of Mo increases as soil pH increases. Molybdenum deficiencies are most likely to occur on acidic soils. On low fertile acidic soils, soybean yield response to recommended P and K fertilizer may be limited if Mo is not applied. With adequate Mo, recommended rates of P and K fertilizer have a greater chance of increasing soybean yields. When lime cannot be applied to sandy or silt loam soils with pH values below 5.8, treating seed with Mo is recommended. Treating seed with Mo is a low-cost practice that may be beneficial whenever the pH is $< 7.0$, if lime has been applied within the last year or in fields with a wide range of soil pH values. On some clayey soils with a pH below 5.8 responses to Mo are nearly as good as response to lime alone or a lime and Mo combination. The application of Mo to soybean seed should not be used as a substitute for maintaining the soil at an optimal pH using a proper liming program. When needed, the application of 0.2 to 0.4 oz Mo/acre is recommended. These Mo sources can also be sprayed onto the soil if application to the soybean seed is not feasible. Some fungicide seed treatments used on soybean contain Mo. A Mo deficiency will cause stunted soybeans with leaves that are pale green or yellow, giving the same appearance as nitrogen (N) deficiency (Kahraman, 2017). Molybdenum-deficient plants will have few or no nodules on the root system (Popović et al., 2011; Dozet et al., 2016; Kahraman, 2017).

Some of actions that were used for achievement of high and stable yields are the correct nitrogen fertilization and inoculation of soybean seed. The aim of this study was to investigate the influence of nitrogen fertilization and seed inoculation with NS Nitragin on the growth of soybean plants.

## Materials and methods

The trial was conducted in order to investigate the effect of CAN fertilization and seed inoculation on soybean plant height, at the site of Brezovo Polje in Brčko, on pseudogley soil type. Tested soybean variety was 'Bačka' (Maturity group, 0), created in Institute of Field and Vegetable Crops, Novi Sad, Serbia, in the three replications (Stevanović et al., 2016). The plant densities were 500,000 plants $ha^{-1}$. Plot size was 10 $m^2$, and the row-to-row spacing was 50 cm. A standard cultivation practice for soybean was applied, with the exception of studied factors. Soybean preceding crop was corn. Sowing was done in early April. As fertilization was planned, CAN was applied just before sowing. The seed was inoculated with biofertilizer NS Nitragin just before sowing.

The experiment was set up as a two factorial split plot method (split-plot):

**1. Fertilization - F.** Four treatments of fertilization were tested:

I - control 0 kg N $ha^{-1}$; II - 50 kg N $ha^{-1}$; III - 100 kg N $ha^{-1}$ and IV - 150 kg N $ha^{-1}$

**2. Inoculation of seed - SI.** Two treatments of seed inoculation were tested:

I - without seed inoculation and II - with seed inoculation.

Before the harvest, mature samples were taken from 10 plants in each repetition and their plant height was determined. The resulting data were analyzed using mathematical and statistical analysis of variance and evaluation of the obtained difference of the height by LSD test.

The experiment was conducted on pseudogley soil type. Soil pH was strongly acidic, poor in humus, with traces of carbonate, with medium status of $P_2O_5$ and good status of $K_2O$.

## Results and discussion

### Meteorological conditions

Meteorological conditions have a major impact on plant growth (Popović, 2010; 2015; Ikanović et al., 2014; Vasileva and Ilieva, 2015; Popovic et al., 2016b; Đekić et al., 2014). Meteorological data were obtained from the meteorological station, Brčko, Bosnia and Herzegovina, in humid year (Table 1). Soybean grows the best when there is optimal quantity of precipitation and optimum temperature. Water need in total is 450 mm, 1-5 mm daily, and for some months are: April 50 mm; May 75 mm; June 90 mm; July 90 mm; August 95 mm, and September 30 mm (Glamočlija et al., 2015; Popović et al., 2016a; 2016b). Optimum precipitation for soybean is 450 mm (Table 1).

In the study year average recorded temperature was 18.2°C and it was higher than the optimal temperature for 1.17°C. The total amount of rainfall during the growing period was 930 mm, and it was for 480 mm higher than soybean productivity need is (Table 1, Fig. 1).

Sufficiency/Deficiency

**Table 1.** Temperature (T) and precipitation (P) in tested year and optimum T and P for soybean

| Mounth | IV | V | VI | VII | VIII | IX | Average/Total |
|---|---|---|---|---|---|---|---|
| Temperature | 11.0 | 18.7 | 18.7 | 22.2 | 23.3 | 15.3 | 18.2 |
| *Optimum** | *12* | *15* | *20* | *20* | *21* | *16* | *17.33* |
| *Difference* | *-1* | *+3.7* | *-1.3* | *+2.2* | *+2.3* | *-0.7* | *+1.17* |
| Precipitation | 108.2 | 111.0 | 262.0 | 96.0 | 16.5 | 336.5 | 930.2 |
| *Optimum** | *50* | *75* | *90* | *90* | *95* | *30* | *450* |
| Difference | +58.2 | +36.0 | +172.0 | +6.0 | -80.5 | +306.5 | 480.2 |

Source: Popović et al., 2016;

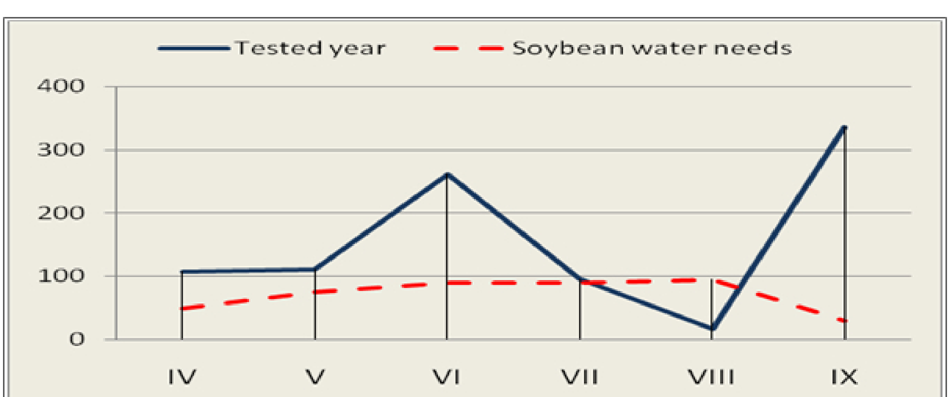


**Figure 1.** Soybean water needs and precipitation in tested year

Good soil with well-planned program of fertilization is the main factor of soybean production. Soybean production will be reduced when essential nutrients are deficient. Results showed that fertilizers and seed inoculation significantly increased the values for productivity traits of soybean. The tested factors, fertilization, seed inoculation and interaction of tested parameters (F x SI), in the humid year had a statistically significant effect on the growth of soybean plants. Values of these traits were higher with 50 and 150 kg $ha^{-1}$ N (117.25 cm and 117.08 cm) (Table 2).

Significantly higher plants were, on average, at treatments with the seed inoculation compared to the tretment without seed inoculation. Average height of soybean plants was 115.3 cm. The height ranged from 114.9 cm in the treatments without inoculation to 115.8 cm in the treatments with seed inoculation with the microbiological fertilizer NS Nitragin.

In the treatments without inoculation the highest plants (117.8 cm) were with the application of 50 kg N $ha^{-1}$ ($2^{nd}$ treatment), while in the treatments with seed inoculation the highest plants were 117.3 cm with the application of 150 kg N $ha^{-1}$ ($4^{th}$ treatment) and 117.1 cm with 50 kg N $ha^{-1}$ ($2^{nd}$ treatment).

On average, for all tested factors, for two treatments of inoculation and four treatments with the fertilization, best results for the tested factors were obtained with application of 50 kg N $ha^{-1}$ ($2^{nd}$ treatment) and with the application of 150 kg N $ha^{-1}$ ($4^{th}$ treatment). Cost effective is the application of 50 kg N $ha^{-1}$ (Table 2, Fig. 2).

The interaction between studied factors of soybean, seed inoculation and fertilizer treatments, had significant effect on plant height, (Fig. 3).

Many researchers have reported that foliar fertilization treatments significantly increase plant height (Prijić et al., 2003; El-Abady et al., 2008; Yildirim et al., 2008; Ranđelović, 2009; Popović et al., 2013b;), first pod height (Ranđelović, 2009), number of nodes per plant (Odeleye et al., 2007; Ranđelović, 2009; Popović et al., 2017), number of pods per plant (El-Abady et al., 2008; Yildirim et al., 2008; Ranđelović, 2009; Popović et al., 2018), number of grain per plant (Odeleye et al., 2007; El-Abady et al., 2008; Ranđelović, 2009), grain yield per plant (Kaiser et al., 2007; El-Abady et al., 2008; Ranđelović, 2009, Popović et al., 2013a; 2013c; 2018) and 1000-grain weight (Ranđelović, 2009; Popović et al., 2013b, Stevanovic et al., 2016; 2017).

Popović et al. (2013c) reported that NS soybean varieties 'Galina' (maturity group 0), 'Victoria' and 'Tea' (maturity group I) had higher yield and 1000 grain weight in the variant with foliar fertilization with fitofert (composition: 12% N, 4% $P_2O_5$, 6% $K_2O$, 0.013% Mn, 0.010% Fe, 0.008% B, 0.006% Cu, and 0.005% Zn) than in the control. On the contrary, in earlier research Popovic et al. (2011; 2013b) reported obtaining significantly higher yields of soybean grain as a result of foliar dressing with an increased nitrogen fertilizer rate. According to the same authors, increased soybean yields are a result of an improved balance between the macro and micro-nutrients necessary for proper plant metabolism, i.e. for enzymatic processes affecting the formation of yield and grain quality in the crop. Since the 1970s, investments in studies on the genetic improvement of cultivars, fertilizers and pesticides for soybean production in Brazil have increased and improved productivity (Nelson and Centurion, 2014). The protein content, Mg, Mn, palmitic, linoleic and linolenic acids showed an increasing tendency with the increased doses of phosphorus. Additionally, protein, Cu, Zn, palmitic, linolenic, gadoleic, eicosadienoic and docohexaenoic acids showed an increasing tendency with the increased doses of sulphur. Consequently, the response of soybean plants to foliar application of S and especially P during the flowering period entailed significant changes, especially in protein and essential fatty acids. The results can be used in nutritional medicine and by farmers, food companies, breeders, etc. (Kahraman, 2017).

**Table 2.** Effect of nitrogen fertilization and seed inoculation on soybean plant height

| Fertilization of soybean, kg $ha^{-1}$ | Seed inoculation | | | | |
|---|---|---|---|---|---|
| | Without seed inoculation | With seed inoculation | $\overline{X}$ | Std. Dev. | Std. *Err.* |
| Control, 0 | 109.7 | 110.8 | 110.3 | 0.778 | 0.318 |
| 50 | 117.8 | 116.4 | *117.1* | 0.820 | 0.335 |
| 100 | 117.0 | 116.4 | 116.7 | 0.521 | 0.212 |
| 150 | 115.1 | 119.4 | 117.3 | 2.372 | 0.968 |
| *Average* | *114.9* | *115.8* | *115.3* | 3.220 | 0.657 |
| Std. Dev. | 3.285 | 3.238 | - | - | - |
| Std. Err | 0.948 | 0.934 | - | - | - |

| Parameters | | Seed inoculation - SI | Fertilization - F | SI x F |
|---|---|---|---|---|
| LSD | 0.5 | 0.364 | 0.515 | 0.729 |
| | 0.1 | 0.502 | 0.709 | 1.003 |

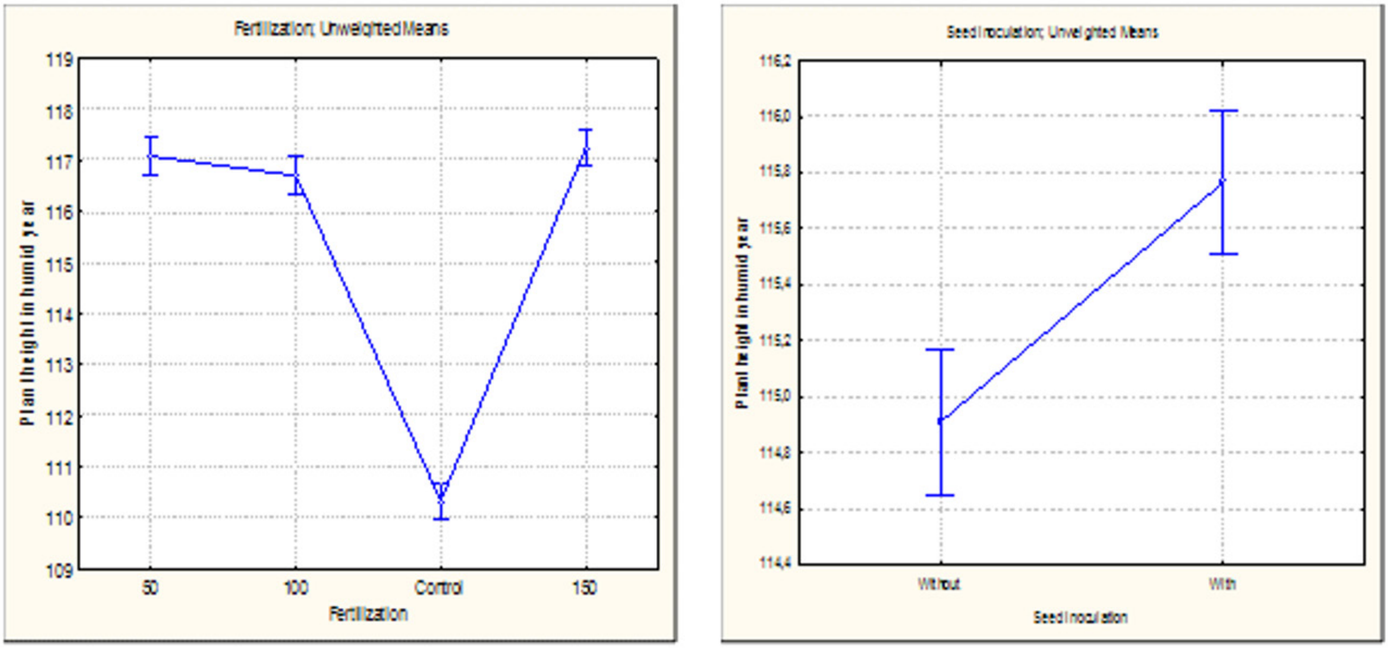


**Figure 2.** Effect of CAN fertilization and seed inoculation on soybean plant

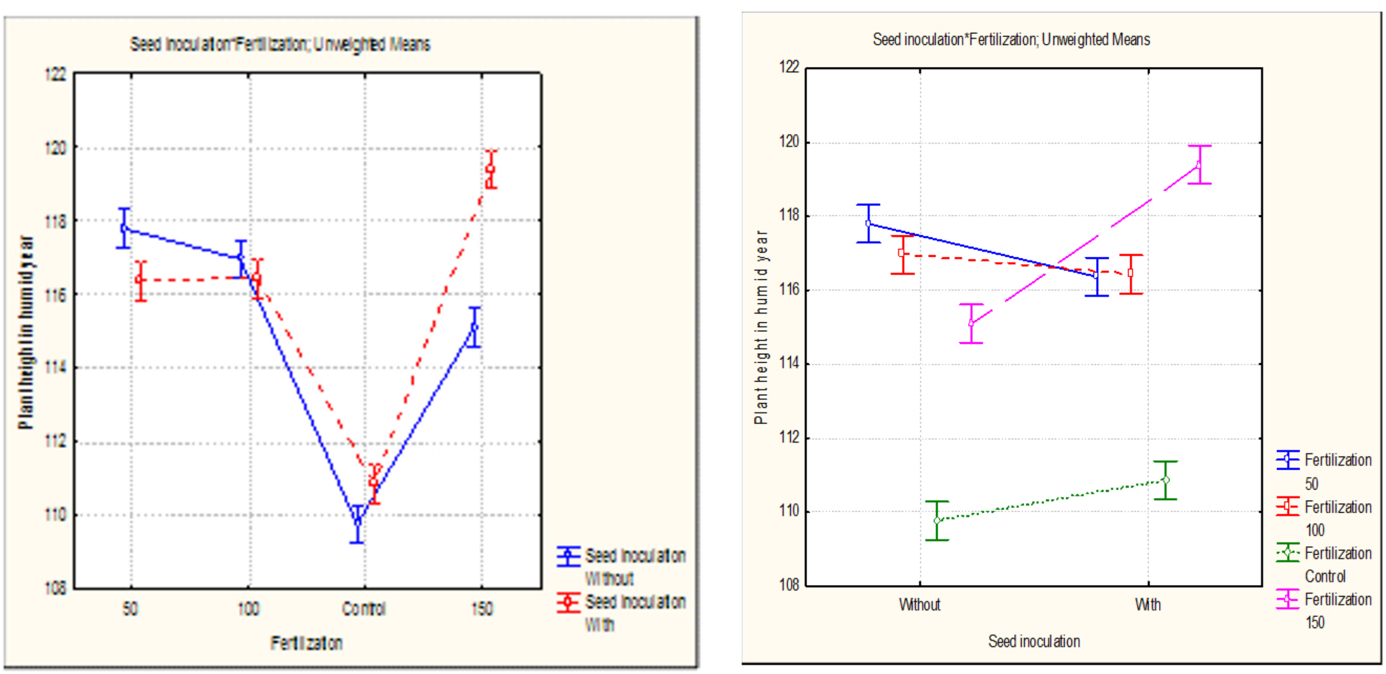


**Figure 3.** Interaction of CAN fertilization and seed inoculation on soybean plant height

Soil acidity affects nutrient availability, deficiency and toxicity of chemical elements (Soratto & Crusciol, 2008) and activity of beneficial microorganisms (Moreira & Siqueira, 2006). Limestone is the most commonly used material for acidity correction in Brazil. Due to its limited mobility in soil, liming has major effects in superficial soil layers, mainly in nonmobilized areas, such as under no tillage system (Soratto & Crusciol, 2008). Calcium and magnesium silicates also have neutralizing properties and can be used as liming material even more advantageously (Corrêa et al., 2007). Currently, slag is the main source of calcium and magnesium silicate used in agriculture (Demattê et al., 2011). Because of their similar neutralizing power, particle size, and effective correction capacity (ECC) (Alcarde & Rodella, 2003), slag and limestone have the same recommendation methods. However, calcium silicate is 6.78 times more soluble than limestone (Alcarde & Rodella, 2003), and therefore a good option for superficial application in the no tillage system (Corrêa et al., 2007). Some advantages of silicates include a high reaction rate and mobility in the soil profile (Castro et al., 2013), and the fact that silicon is a beneficial element for plant nutrition, which decreases water losses through evapotranspiration (Ma & Yamaji, 2006) and increases tolerance to pests and diseases (Berni & Prabhu, 2003), toxicity of heavy metals and aluminum (Prabagar et al., 2011), and lodging. Moreover, Si turns plants more erect and improve their photosynthetic efficiency (Pulz et al., 2008). Ma & Yamaji (2006) reported that Si supply may improve crop yield stability as a consequence of the higher tolerance to biotic and abiotic stress. Most part of that area (46%) consists of Oxisols in central Brazil, characterized by low fertility, high aluminum saturation, and high P fixation. However, rainfall, temperature, and topography are generally favorable for agriculture. Soil correction did not influence N, K, Mg, and S levels in the dry matter of Congo signal grass cropped after soybean (Castro and Crusciol, 2013).

## Conclusion

Investments in studies on the genetic improvement of cultivars and improvement of fertilizers for soybean production have increased and improved productivity.

The tested factors, fertilization, seed inoculation and interaction of tested parameters (F x SI), in the humid year had a statistically significant effect on the growth of soybean plants.

Significantly higher plants on average were with treatments with the seed inoculation compared to the treatments without inoculation of seeds.

Average height of soybean plants was 115.3 cm. The tested parameter ranged from 114.9 cm, in the variants without inoculation, up to 115.8 cm, in the variants with seed inoculation with the microbiological fertilizer.

Cost effective is the application of 50 kg $ha_{-1}$ N and it is a recommendation on the basis of these studies.

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