

YIELD AND ECONOMIC VIABILITY IN A SOYBEAN CROP (*Glycine max* L. Merrill) WITH THE APPLICATION OF AMINO ACIDS

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ABSTRACT: Soybean (*Glycine max* (L.) Merrill) is a crop that has a high demand for all the essential macronutrients. To be used efficiently, these should be at sufficient levels and balanced. The application of amino acids can influence the efficiency of nitrogen fertilisation. The aim of this study was to evaluate the productivity and economic viability of the 'M-6410 IPRO®' soybean under different doses of the amino-acid complex, Torped Gold®. Different doses of the organo-mineral class-A fertiliser complexed with amino acids (Torped Gold®) were used. The treatments were arranged in a randomised block design of five treatments with four replications for a total of 20 experimental units. T₁ - water applied as control (0.0%), T₂ - 80% of the manufacturer's recommended dose (80%), T₃ - 100% of the recommended dose (100%), T₄ - 20% more than the recommended dose (120%) and T₅ - Double the recommended dose (200%). The lowest production was found for T₁ (control), with a productivity of 1495 kilograms per hectare. The manufacturer's recommended dose (100%), 20% more than the recommended dose (120%) and double the dose (200%) gave a productivity of 1873, 1883 and 1905 kg ha⁻¹ respectively. There was an increase in productivity of the order of 6 bag ha⁻¹ and there was no need to adjust the dose recommended by the manufacturer.

KEYWORDS: Amino acids. Foliar fertilisation. Productivity.

RENDIMENTO E VIABILIDADE ECONÔMICA NA CULTURA DA SOJA (*Glycine max* (L.) Merrill) COM APLICAÇÃO DE AMINOÁCIDOS

RESUMO: A soja (*Glycine max* (L.) Merrill) é uma cultura muito exigente em todos os macronutrientes essenciais. Os quais devem estar em níveis suficientes e equilibrados para um aproveitamento eficiente. A aplicação de aminoácidos pode influenciar na eficácia da adubação nitrogenada. O objetivo do trabalho foi avaliar a produtividade e a viabilidade econômica da soja M-6410 IPRO® em diferentes dosagens do complexo de aminoácido Torped Gold®. Foram utilizadas diferentes dosagens do fertilizante organomineral classe A, complexados com aminoácidos (Torped Gold). Os tratamentos foram dispostos em delineamento de blocos casualizados, sendo cinco tratamentos com quatro repetições totalizando 20 unidades experimentais. T₁: aplicação de água como controle (0,0%); T₂: 80% da dose recomendado pelo fabricante (80%), T₃: dose recomendada (100%), T₄: 20% a mais, que a dose recomendada (120%) e T₅: o dobro da dose recomendada (200%). Constatou-se menor produção no T₁ (controle), com produtividade de 1495 quilogramas por hectares. Dosagens recomendada pelo fabricante (100%), 20% a mais que a dose recomendada (120%) e o dobro da dose (200%), proporcionaram produtividades, de 1873, 1883 e 1905 kg ha⁻¹, respectivamente. Houve incremento na produtividade na ordem de 6 (seis) sacas ha⁻¹, não havendo necessidade de ajustar a dose recomendada pelo fabricante.

PALAVRAS-CHAVE: Adubação Foliar. Aminoácidos. Produtividade.

RENDIMIENTO Y VIABILIDAD ECONÓMICA EN EL CULTIVO DE SOJA (*Glycine max* (L.) Merrill) CON APLICACIÓN DE AMINOÁCIDOS

RESUMEN: La soja (*Glycine max* (L.) Merrill) es un cultivo muy exigente en todos los macronutrientes esenciales. Los cuales deben estar en niveles suficientes y equilibrados para un uso eficiente. La aplicación de aminoácidos puede influir en la eficacia de la fertilización con nitrógeno. El objetivo del estudio ha sido evaluar la productividad y viabilidad económica de la soja M-6410 IPRO® en diferentes dosis del complejo de aminoácidos Torped Gold®. Se utilizaron diferentes dosis de fertilizante organomineral clase A, complejados con aminoácidos (Torped Gold). Los tratamientos se organizaron en un diseño de bloques al azar, siendo cinco tratamientos con cuatro repeticiones totalizando 20 unidades experimentales. T₁: aplicación de agua como control (0.0%); T₂: 80% de la dosis recomendada por el fabricante (80%), T₃: dosis recomendada (100%), T₄: 20% más que la dosis recomendada (120%) y T₅: dos veces la dosis recomendada (200%). En T₁ (control) se encontró menor producción, con una productividad de 1495 kilogramos por hectárea. Las dosis recomendadas por el fabricante (100%), 20% más que la dosis recomendada (120%) y el doble de la dosis (200%), proporcionaron rendimientos

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de 1873, 1883 y 1905 kg ha⁻¹, respectivamente. Hubo un aumento de productividad del orden de 6 (seis) sacos ha⁻¹, sin necesidad de ajustar la dosis recomendada por el fabricante.

PALABRAS CLAVE: Fertilización foliar. Aminoácidos. Productividad.

Introduction

Soybean (*Glycine max* (L.) Merrill) is a crop with a high demand for all the essential macronutrients. These should be at sufficient levels and in a balanced ratio, so that the crop can utilise them efficiently. The insufficiency or imbalance of these mineral nutrients (nitrogen, phosphorus and potassium) can result in the poor uptake of some and the excessive uptake of others, and for this reason, they need to be monitored in the soil and in the leaves (DOMINGOS *et al.*, 2015).

Grain production in Brazil is constantly expanding. Each year, productivity increases, so that Brazil can continue to affirm the phrase "Brazil, granary of the world", used as a national slogan during the Vargas dictatorship (1937-1945), since it meets the needs of both the internal and external markets. Brazil is the world's second largest producer of the grain, behind only the USA; but is the largest exporter of products derived from the plant, such as the grain, bran and oil (MAPA, 2016).

According to the ninth survey carried out by Conab (2017) during the 2016/2017 harvest, 113.9 million tons were produced in an area of 33.9 million hectares; this result is a reflection of the large investment in the technology employed, emphasising, by level of importance and use, soil correction, base fertilisation, cover fertilisation and foliar fertilisation.

Although there is not a lot of data on the absorption of amino acids via the leaf, Castro (2009) reports their importance in the absorption and transport of mineral nutrients across the cell membrane, since amino acids play various roles in plants and can act as stress-reducing agents, as sources of nitrogen and as hormone precursors (DELILLE; SEHNKE; FERI, 2011; MAEDA; DUDAVERA, 2010; ZHAO, 2010).

According to Boaretto; Muraoka and Boaretto (2003), foliar fertilisation is a process by which plant nutrition is carried out via the shoots, especially the leaves. In foliar application, after penetrating the cuticle, the nutrient

reaches the cell cytoplasm through the tonoplast, arriving at the vacuole; or can translocate to other cells by means of the plasmodesmata, until reaching the vein phloem, where it is transported to consumption sites, forming the compounds that are part of the plant organism. The effect of foliar fertilisation depends on the speed of nutrient uptake by the leaves and their translocation in the plant.

The aim of this study therefore was to evaluate the productivity and economic viability of the 'M-6410 IPRO' soybean under different doses of the amino-acid complex, Torped Gold®.

Material and Methods

Site of the experiment

The experiment was set up in the district of Marabá in the town of Tuneiras do Oeste in the State of Paraná, at -23.79159°S and -52.75898°O, in a commercial area of 36.3 ha⁻¹ owned by José Nilson Xavier dos Anjos. The experiment was conducted in the field during the 2016/2017 agricultural year.

Climate Characteristics

According to the Köppen classification (1949), the predominant climate in the area is of type Aw, with a mean annual temperature of 28.0°C, mean annual rainfall of 1,100 mm and mean annual relative humidity of 50 to 70%.

Soil Characteristics

The soil in the experimental area is classified as a quartzarenic Neosol, a soil with very low cation exchange capacity (CEC) and low suitability for agriculture. According to the new Brazilian System of Soil Classification, quartzarenic Neosols are very sandy soils (EMBRAPA, 2005). As they are very sandy, with a low capacity for particle aggregation and conditioned by the low levels of clay and organic matter, such soils are very susceptible to erosion (NEGREIRO, 2002). The chemical characteristics of the soil at the time of analysis can be seen in Table 1.

Table 1: Chemical characteristics of the soil where the experiment was set up

Level	pH		P	Zn	Mn	K ⁺	CEC	V
	CaCl ₂	H ₂ O						
0-20	5.69	6.26	45.92	4.21	176.57	0.14	4.78	58.16
20-40	4.81	5.49	25.59	2.40	154.27	0.10	4.34	38.70

Soybean Variety or Cultivar

The variety used was M-6410 IPRO, of maturity group 6.4, with a purple-coloured flower, grey pubescence,

resistant to lodging, of indeterminate growth habit, an imperfect-black hilum, a mean plant height of 86 cm and a cycle of 125 days. Planting took place on 6 december 2016.

Table 2: Characterisation of the seed batch used

Physical Purity (%)	Percentage Germination (%)	Emergence in the Field (%)	Size	1000-seed weight (g)
99	91	90	6,5	195

Characteristics of Torped Gold®

The commercial branded fertiliser used in the study, Torped Gold®, is characterised as a Class-A organo-mineral fertiliser (free of sodium (Na⁺), heavy metals, and synthetic and toxic compounds) containing 6% organic carbon, enriched with macro- and micronutrients (5% N, 8% P, 8% K, 1.5% Ca, 0.5% Mg, 0.5% B, 0.2% Cu, 0.5% Mn, and 1% Zn) and containing amino acids. In addition to containing organic carbon, macro- and micronutrients, and being enriched with amino acids, there are three ways of using the product, i.e. it can be applied via the leaves, by fertigation or by drenching (via the soil).

Conducting the Experiment

Soybean seed from the MONSOY 6410 IPRO variety was used in the area, of size 6.5 and industrially processed (Standak Top + Drying Powder + Polymer + Inoculant). Seeding was carried out mechanically, at a density of 13 seeds per linear metre, as per the company's recommendation. For the base fertiliser, 330 kg ha⁻¹ NPK formulation 04-30-10 (N-P₂O₅-K₂O) + 50 kg micronutrients (+ 0.2% Mn + 0.3% Zn) was used. A cover fertilisation of 124.0 kg ha⁻¹ potassium chloride was also applied 30 days after planting (DAP).

For the treatments, different doses of organo-mineral class-A fertiliser with organic carbon were used, highly soluble at any pH, containing macro- and micronutrients complexed with amino acids (Torped Gold®). For each treatment, the applied solution was made up of a different concentration of product + adjuvant + water.

The following doses were used for the test: T₁ - water applied as control (0.0%), T₂ - 80% of the recommended dose, T₃ - recommended dose, 100%, T₄ - 120% of the dose (adding 20% more product) and T₅ - twice the recommended dose (200%).

The dose recommended by the manufacturer is 1.5 l per 10,000 m² (1 ha), diluted in 0.50 l ha⁻¹ orange oil (OROBOR N1™) and 124 l ha⁻¹ water to facilitate product absorption by the plant. For the plot of 25 m² where the recommended dose was used, 36.2 ml of the product was applied, diluted in 5 ml adjuvant and 3.0 l water.

The first application was made at 30 (DAP), when the soybean was at the V3 and V4 vegetative stages, i.e. with around 3 to 4 trifoliolate leaves, with a second application at 70 days, when the soybean was at the R1 reproductive stage.

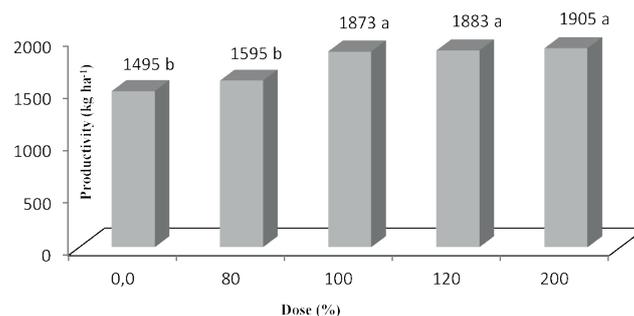
In the experiment, 5 x 5 metre plots were used as the experimental unit, comprising four planting rows of five metres in length, at a spacing of one metre between plots. A randomised block design with four replications was adopted. The treatments were arranged in a scheme of 5 treatments with 4 replications, for a total of 20 experimental units. The data were analyzed using an analysis of variance (ANOVA) with significance determined at $p \leq 0.05$. The means were compared using the Tukey test ($p \leq 0.05$). All analyses were performed using the SISVAR software version 5.6 (FERREIRA, 2011).

Results

When analysing the productivity of the 'MONSOY 6410 IPRO' soybean (Figure 1), it was seen that the doses

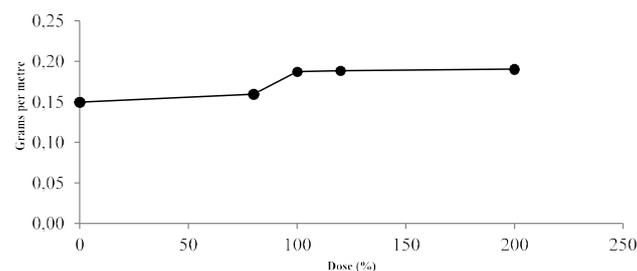
of Torped Gold® recommended by the manufacturer (100%), 20% more than the recommended dose (120%) and double the recommended dose (200%) gave a productivity of 1873, 1883 and 1905 kg per hectare respectively, with no statistical difference between treatments 3, 4 or 5; however, these values were higher when compared to treatments 1 and 2, which gave a productivity of 1495 and 1595 kilograms per hectare.

Figure 1: Productivity of the 'MONSOY 6410 IPRO' soybean in kilograms per hectare within the different concentrations of Torped Gold®. Similar letters do not differ statistically by Tukey's test at 5% probability. Coefficient of variation: 3.29%.



According to Figure 2, production in the experimental units showed a statistical difference in productivity, and it was possible to find different production values in the area; however, at the recommended dose (100%), 20% more than the recommended dose (120%), and at double the recommended dose (200%), there was a significant result for production of 0.19 grams per sample in the three treatments. This low production may be related to the type of soil in the area.

Figure 2: Quantity of soybeans of the MONSOY 6410 variety in grams, within the different amounts of Torped Gold®. Coefficient of variation: 3.29%.



Discussion

Machado (2015) studied the nutritional quality and yield components of soybean grain as a function of the period of application of different foliar fertilisers, with the experiment carried out in the field at three different locations during the 2013/2014 harvest period. In the experiment, eight different foliar fertilisers were tested, applied at two different times, one at R2 (the end of flowering) and the other at R5. The author evaluated productivity and the chlorophyll index, and found that the foliar fertilisers tested, based on N, P, K, S, B, Fe, Mn, Zn, Mo and Cu, did not promote an increase in

soybean productivity; however, an economic analysis of the study showed that when using foliar fertilisers, the application of some products can increase gains for the producer.

Gazola *et al.* (2014), studying the effects of the foliar application of amino acids as a supplement to nitrogen fertilisation in the wheat cultivars Quartzo, IPR Catuara, CD 120 and BRS Gaivotá, found that product based on amino acids applied via the leaves did not alter the productive performance of the wheat cultivars Catuara, Gaivotá or Quartzo; when observing the CD 120 cultivar, increases in the dose of foliar fertilisation based on amino acids, which was applied during the rubber phase of the plants, provided an increase in the number of grains per area, without altering grain yield.

Kikutí and Tnaka (2005) also evaluated the application of amino acids in bean seeds and concluded that the application of amino acids had no positive effect on seed vigour, but resulted in better quality for seeds evaluated by germination test. The results obtained by Albuquerque and Dantas (2002) showed that the application of amino acids in grapes of the Benitaka cultivar promoted more-intense colouring in addition to reducing the acid content, consequently resulting in grapes of a sweeter flavour, with a more-balanced ratio of soluble solids and acidity.

Conclusion

An increase in soybean production of 0.15 to 0.19 grams per sample was found with the application of Torped Gold in the experimental unit.

Double the recommended dose (200%) expressed the best result among the treatments, of 1905 Kg ha⁻¹; however, this result did not produce significant values to justify the investment.

The best three results showed no statistical difference, which in turn made it economically unviable to change the dose recommended by the manufacturer; An economic analysis of the study showed that there was an increase in productivity due to the use of Torped Gold of the order of 6 bg ha⁻¹, and that it was not necessary to adjust the dose recommended by the manufacturer.

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