FERTILIZER WITH RESIDUAL 3.4-PHOSPHATE DIMETILPIRAZOL (DMPP) ON SOYBEAN CULTIVATION IN SUCCESSION TO INDUSTRIAL TOMATO

RESIDUAL DE FERTILIZANTES COM 3,4-DIMETILPIRAZOL FOSFATO (DMPP) NO CULTIVO DA SOJA EM SUCESSÃO AO TOMATE INDUSTRIAL

FERTILIZANTES RESIDUALES QUE CONTIENEN FOSFATO DE 3,4-DIMETILPIRAZOL (DMPP) EN EL CULTIVO DE SOJA EN SUCESIÓN AL CULTIVO INDUSTRIAL DE TOMATE

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Juliano Magalhães Barbosa[1], Cibelle Christine Brito Ferreira[2], Rafael Felippe Ratke[3], Wilson Mozena Leandro[4], João Gabriel Magalhães Barbosa[5], Vitória Beatriz Silva[6], Roberta Zani da Silva[7], Cláudia Fabiana Alves Rezende[8]

ABSTRACT

Aimed to estimate the residual effect of fertilizer application partially covered with polymers and stabilized with 3.4-phosphate dimetilpirazol (DMPP), via soil, for culture of soybean grown in no-tillage system in succession to industrial tomato cultivation. The study was carried out in field condition (latitude 16° 35 ' 48.81" S, longitude 49° 16 ' 41.13"W, altitude of 729 m), under central pivot. The experimental design was of randomized blocks with seven treatments and five replications. The treatments consisted of different combinations of DMPP, NPK (04-30-16), Urea, KCl and foliar fertilizers. It was determined the chemical attributes of the soil, foliar levels and productivity of plants. Soybean culture presents positive relative efficiency index as for increase of productivity for the treatments with greater quantities of fertilizer applied as inhibition of nitrification in residual effect. The application of foliar fertilizer is not efficient for the increase of productivity, either for replacement of base fertilizer.

Keywords: *Glycine Max*. Mineral Nutrition. Nitrification Inhibitors.

RESUMO

Objetivou-se estimar o efeito residual da aplicação de fertilizantes parcialmente recobertos com polímeros e estabilizados com 3,4-dimetilpirazol fosfato (DMPP), via solo, para cultura da soja cultivada em sistema de plantio direto em sucessão ao cultivo de tomate industrial. O estudo foi desenvolvido em condição de campo (latitude Sul 16˚35'48.81", longitude Oeste 49˚16'41.13" e uma altitude de 729 m), sob pivô central. O delineamento experimental foi o

[1] Dr. in Agronomy. Instituto Federal do Tocantins (IFTO). E-mail: juliano.barbosa@ifto.edu.br
[2] Dr. in Plant Production. Universidade Estadual do Tocantins (UNITINS). E-mail: cibelle.cb@unitins.br
[3] Dr. in Agronomy. Universidade Federal do Mato Grosso do Sul (UFMS). E-mail: rafael.ratke@ufms.br
[4] Dr. in Plant Production. Universidade Federal de Goiás (UFG). E-mail: wilsonufg@gmail.com
[5] Specialist in Higher Education. Instituto Federal do Tocantins (IFTO). E-mail: joao.barbosa@ifto.edu.br
[6] Master's student in Biotechnology. Universidade Federal do Tocantins (UFT).
E-mail: vitoria.beatriz@mail.uft.edu.br
[7] Dr. in Agronomy. Centro Universitário Católica do Tocantins. E-mail: roberta.silva@p.catolica-to.edu.br
[8] Dr. in Agronomy. Universidade Evangélica de Goiás (UniEVANGÉLICA). E-mail: claudia7br@msn.com

de blocos casualizados com sete tratamentos e cinco repetições. Os tratamentos consistiram em diferentes combinações de DMPP, NPK (04-30-16), Ureia, KCl e fertilizantes foliares. Determinou-se os atributos químicos do solo, teores foliares e produtividades das plantas. Cultura da soja apresenta índice de eficiência relativa positiva quanto ao incremento de produtividade para os tratamentos com maiores quantidades aplicadas do fertilizante como inibição de nitrificação, em efeito residual. A aplicação de fertilizante foliar não é eficiente para o aumento de produtividade, tampouco para substituição da adubação de base.

Palavras-chave: *Glycine Max*. Nutrição Mineral. Inibidor de Nitrificação.

RESUMEN

Este estudio tuvo como objetivo estimar el efecto residual de la aplicación al suelo de fertilizantes parcialmente recubiertos con polímeros y estabilizados con fosfato de 3,4-dimetilpirazol (DMPP) en soja cultivada bajo un sistema de labranza cero, en sucesión al cultivo industrial de tomate. El estudio se llevó a cabo en condiciones de campo (16˚35'48.81" de latitud sur, 49˚16'41.13" de longitud oeste y una altitud de 729 m) bajo un pivote central. El diseño experimental fue un diseño de bloques completos al azar con siete tratamientos y cinco réplicas. Los tratamientos consistieron en diferentes combinaciones de DMPP, NPK (04-30-16), urea, KCl y fertilizantes foliares. Se determinaron las propiedades químicas del suelo, el contenido foliar y el rendimiento de las plantas. Los cultivos de soja mostraron un índice de eficiencia relativa positivo con respecto al aumento del rendimiento para los tratamientos con mayores cantidades de fertilizante aplicado, como efecto residual que inhibe la nitrificación. La aplicación de fertilizante foliar no es eficiente para aumentar la productividad, ni para reemplazar la fertilización de base.

Palabras clave: *Glycine Max*. Nutrición Mineral. Inhibidor de la Nitrificación.

1 INTRODUCTION

Soybeans are of fundamental importance in the main agricultural production systems in Brazil and have a prominent participation in the country's exports (HEREDIA et al., 2010). In 2015, exports of the soybean complex totaled US$ 27.96 billion, representing 14.6% of total national exports (ABIOVE, 2016).

The advance of soybean cultivation in Brazil was made possible by the combination of scientific advances and the availability of technologies to the productive sector (FREITAS, 2011). Factors associated with mechanization, nutritional practices and the creation of highly productive cultivars adapted to the various edaphoclimatic conditions, combined with the development of technological packages, were fundamental for this advance (FREITAS, 2011).

Soybean is a very nutritionally demanding crop (JOBBÁGY & SALA, 2014). In order for nutrients to be efficiently used by the crop, they must be present in the soil in sufficient quantities and in balanced ratios (BRITTO & KRONZUCKER, 2013; VALICHESKI et al., 2016). It is noteworthy that insufficiency or imbalance between nutrients can result in deficient absorption of some and excessive absorption of other nutrients (EMBRAPA, 2008). Thus, an alternative to increase the efficiency in the use of fertilizers by the crop, and reduce operating costs, is the use of fertilizers with increased efficiency, which promote reduction of losses due to ammonia volatilization, such as DMPP (3,4-dimethylpyrazole phosphate) (REIS JÚNIOR, 2007).

According to TRENKEL (2010), ABALOS et al. (2014) and HU et al. (2014), these fertilizers provide the following advantages: regular and continuous supply of nutrients at the time needed by the plants, with less frequency of applications; reduction of nutrient losses by leaching, denitrification, immobilization and volatilization; elimination of damage caused to seeds and roots due to the high concentration of salts; greater practicality in the handling of fertilizers; reduction of pollution environmental by $NO3^-$, attributing ecological value to agricultural activity (less contamination of groundwater and surface water) and reduction in production costs (by reducing operating costs with the installment of fertilizers). However, there is little research associated with the evaluation of the residual effect of these fertilizers on the successor crop (GAZOLA et al., 2013).

In view of the above, the objective of this study was to estimate the residual effect of the application of fertilizers partially coated with polymers and stabilized with 3,4-dimethylpyrazole phosphate (DMPP), via soil, for soybean cultivation cultivated in a no-tillage system in succession to industrial tomato cultivation.

2 METHODOLOGY

The study was carried out under field conditions (south latitude 16°35'48.81" and west longitude 49°16'41.13" and an altitude of 729 m), under central pivot from December 20 to April 28. The soil of the area corresponded to a dystrophic Red Latosol (EMBRAPA, 2013) with the following textural proportions in the 0-20 cm layer: 45% clay, 23% silt and 32% sand. The main chemical attributes are shown in Table 1.

Table 1

Soil chemical attributes in the 0-0.2 m layer before the installation of the soybean experiment

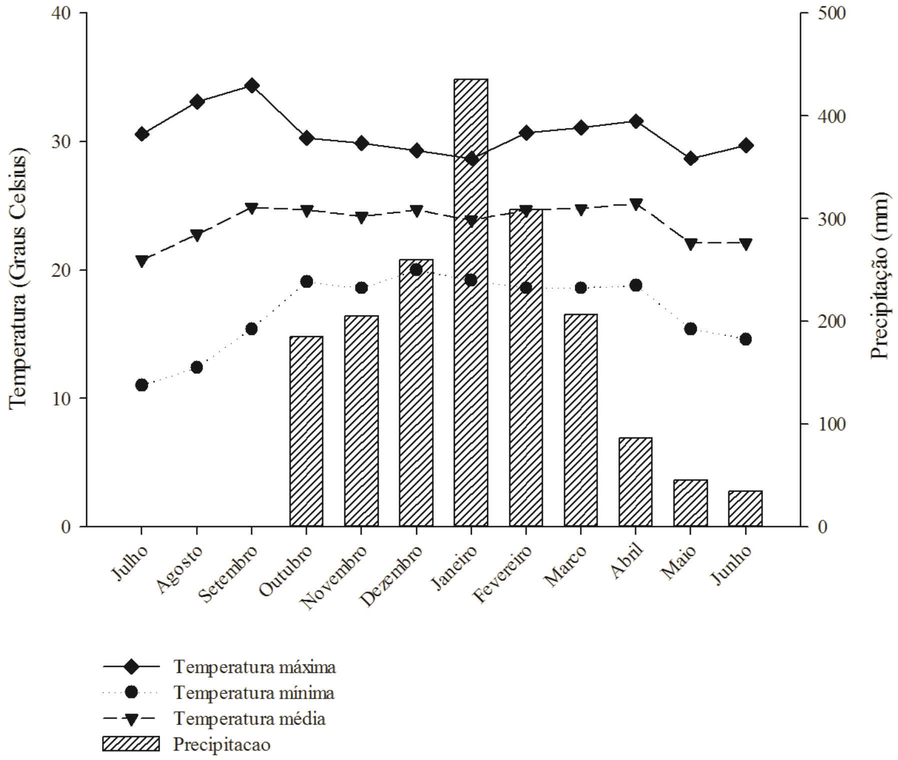
M.O.	V	pH	P(Mel)	K	Ca	Mg	CTC	Cu	Fe	Mn	Zn	Al	H + Al
-----%----		CaCl2	--mg DM-3--		----CMOC DM-3----			------- mg dm-3---------				-CMOC DM-3-	
1,52	47,6	5,02	6,75	95	1,41	0,68	4,75	2,18	27,1	36,4	4,12	0,0	2,43

Note: K, P, Cu, Fe, Mn and Zn = Mehlich extractor 1; Ca, Mg = extraction with KCl mol $^{L-1}$;
Source: Source: Prepared by the authors themselves, 2025

The climate of the region, according to Köppen-Geiger, is humid tropical with a dry season in winter (type Aw). There is a marked seasonality in the rainfall regime, with well-defined rainy (spring and summer) and dry (autumn and winter) seasons (CPRM, 2001). The rainfall and temperatures that occurred during, before and after soybean cultivation (December – April) are described in Figure 1.

Figure 1

Precipitation (mm) and average temperature (º C) during the year of trial driving



Source: Author, 2025

The experimental design was randomized blocks with seven treatments and five replications. Each experimental unit consisted of 5 m long and 6 m wide and spaced 0.45 m apart. A 1 m border was considered around the experimental area.

Before the installation of the experiment, the area had 70% to 90% of vegetation cover and about 80% of the flora was composed of weeds, such as: *Digitaria horizontalis*, *Eleusine indica*, *Cenchus echinatus*, *Cyperus rotundus*, *Commelina benghalensis* and *Bidens pilosa*. Soybean was planted in a no-tillage system, after management with glyphosate (4.0 L $^{ha-1}$). The herbicide application was conducted with a boom sprayer regulated at a flow rate of 200 L $^{ha-1}$.

The implementation of the trial with soybean was carried out in an area with a history of industrial tomato cultivation (planting in May, harvest in October). Different types of fertilizers were used in this crop: fertilizers with granule mixture; Fertilizers with incorporated technology and foliar fertilizers. The products used are reported in Table 2 and the doses and combinations in Table 3.

Table 2

Products used in the cultivation of industrial tomatoes prior to soybean and used for residual effect

Product	N	P	K	Mg	S	Cu	Zn	B	Mn	Mo	Fe
						%					
NPK 04-30-16(1)	4	30	16		1,6	-	-	-	-	-	-
NPK with DMPP in planting	15	15	14	2,1	7	-	-	-	-	-	-
NPK with DMPP On the roof	24	5	5	2	5	-	-	-	-	-	-
Foliar 1	20,0	5,0	5,0	1,7	39,0	0,02	0,02	0,01	0,05	0,001	0,05
Foliar 2	7,0	12,0	40,0	2,0	11,0	0,02	0,02	0,01	0,05	0,001	0,05
Foliar 3	13,0	40,0	13,0	0,1	1,0	0,02	0,02	0,01	0,05	0,001	0,05

Density = 1.0 g $^{cm-3}$; (1) = Granule Mixture.
Source: Prepared by the authors themselves, 2025

Table 3

Different doses of fertilizers used in the cultivation of industrial tomatoes prior to soybean

Fertilizer	Time of application	Treatments (kg $^{ha-1}$)						
		FNS	PMG	DMPP 0.3	DMPP 0.25	DMPP 0.15	DMPP 0.05	DMP P 0.7
NPK with DMPP	Planting	-	-	-	-	-	-	700
NPK 04-30-16(1)	Planting	-	1.500	1.000	1.000	900	600	-
NPK with DMPP	Initial coverage (10 DAT)	-	-	300	250	150	50	-
Urea	Cover (20 to 30 DAT)	-	120	-	-	-	-	-
Kcl	Cover (30 to 40 DAT)	-	300	420	300	200	100	400

(1) = Granule Mixture. FNS – Natural soil fertility, without the addition of fertilizer; PMG – planting with granule mixture (1.5*) + cover with urea (0.12*) and KCl (0.3*) + absence of foliar; DMPP 0.3 – PMG (1.0*) + coverage with DMPP (0.3*) and KCl (0.42*) + foliar; DMPP 0.25 – PMG (1.0*) + coverage with DMPP (0.25*) and KCl (0.3*) + foliar; DMPP 0.15 – PMG (0.9*) + cover with DMPP (0.15*) and KCl (0.2*) + foliar; DMPP 0.05 – PMG (0.6*) + coverage with DMPP (0.05*) and KCl (0.1*) + foliar; DMPP 0.7 – planting with NPK with DMPP (0.7*) + absence of foliar. (*) – Amount of NPK fertilizer in t $^{ha-1}$.
Source: Prepared by the authors themselves, 2025

Fertilizers partially coated with ethylenecrylic polymer and stabilized with 3,4-dimethylpyrazole phosphate (DMPP) have 2NT technology. It is a combination of granules with Tef-N technology (Nitrogen stabilized with nitrification inhibitor 3,4-DMPP) and another with coated granules, so that 25% of the nitrogen is released slowly for three to four weeks (REIS JÚNIOR, 2007).

In the soybean crop trial, fertilization was based on the residual of fertilizers applied in the previous crop (industrial tomato). Only foliar fertilizers at a dosage of 3.0 L $^{ha-1}$ in total area were used at 14, 21 and 28 days after emergence. Thus, the treatments evaluated in this study consisted of the seven combinations presented in Table 3.

Sowing was carried out whenever possible in the same line as tomato planting in a no-tillage system on December 20, with a seeder-fertilizer equipped with a disc soil breaking system. Planting was carried out in 14 rows of 0.45 m between rows, with distribution of 400 thousand seeds $^{ha-1}$.

Soybean seeds (cultivar Syn 07LR901753 RR) were previously treated with fungicide Fludioxonil + Metalaxyl−M (1 mL $^{kg-1}$ seed) and insecticide Pyraclostrobin + Methyl Thiophanate + Fipronil (200 mL $^{ha-1}$). Adhere 60 inoculant was used at a dose of 6 g $^{kg-1}$ seeds, with a concentration of 5,109 g-1 rhizobia. Planting fertilization was not used for soybean cultivation and there was also no liming.

Weed management occurred through the application of post-emergent herbicide Glyphosate Potassium (2.0 L $^{ha-1}$). For pest management, insecticide applications were carried out when the pest presented a level of control and in disease management, preventive applications of specific fungicides were carried out based on the rotation of active ingredients.

During the end of flowering, soil sampling was carried out for chemical analysis, seven simple random samples were collected, at the depths of 0-20 cm and 20-40 cm, six between the rows and one in the planting row, per plot. After mixing them, the samples were quartered and the composite sample was separated.

A volume of 400 g of soil was removed for the composite sample. The composite samples were individualized in plastic bags, labeled, kept in the shade and, later, sent to the laboratory. Particle size analysis was performed using the hydrometer method (EMBRAPA, 2011).

The following soil chemical attributes were determined: pH in CaCl2; micronutrients (Cu, Fe, Mn and Zn); P, K, Ca and Mg available; Al; H + Al (potential acidity) and soil organic matter content. The methodologies used followed the recommendations of EMBRAPA (2011).

For foliar diagnosis, 30 leaves were collected per plot. The third trefoil was removed from the apex at full flowering, as recommended by MALAVOLTA et al. (1997). These samples were placed in paper bags and transported to the laboratory.

In the preparation room, the material was washed with distilled water, placed in paper bags for the drying process in an oven with forced ventilation at 60º C. After reaching the constant dry matter, the leaves were ground, and then submitted to the determinations of the total leaf contents of N, P, K, Ca, Mg, Cu, Fe, Mn and Zn, according to the methodology described by MALAVOLTA et al. (1989).

Soybean harvest was carried out after physiological maturation, in the center of each plot. Five rows of 3 m of planting were considered, and all plants in the marked area were harvested. The useful area for determining productivity corresponded to 7.5 m2 per plot.

The collected samples were identified and packaged to be later tracked. After weighing and moisture determination, the moisture content was corrected to 13% and the calculation was extrapolated to the yield in hectares.

The significance of the treatment effect was determined using the F-test. The means were compared using the Tukey test.

3 RESULTS AND DISCUSSION

Table 4 shows the evolution in the average contents of soil attributes at the depths of 0-20 cm and 20-40 cm. A reduction in the contents of P, K, Ca, Mg and V was observed with the cultivation of soybean in succession to the planting of industrial tomatoes. Although, in some situations, these reductions may be enough to cause deficits in productivity, even elements such as K, Ca and Mg have greater facilities to reach adequate levels of availability in the soils, with the years of cultivation.

Table 4

Average content of chemical attributes in the soil at depths 0 - 20 cm and 20 - 40 cm in soybean crop in succession to industrial tomato cultivation

Crops	P	K	Ca	Mg	M.O.	CTC	V	H + Al
	---------- **0 - 20 cm** ----------							
Industrial Tomato	6,75	95,46	1,41	0,68	1,52	4,75	47,63	2,43
Soy	4,05	66,57	1,15	0,67	1,85	5,26	37,66	3,26
	---------- **20 - 40 cm** ----------							
Industrial Tomato	3,04	89,83	1,04	0,66	1,16	4,52	42,31	2,6
Soy	1,62	63,77	0,84	0,55	1,33	4,7	32,88	3,13

Source: Prepared by the authors themselves, 2025

The chemical attributes of the soil were not affected by fertilization, with the exception of phosphorus. Phosphorus applied to the soil tends to react with some components to form compounds of low solubility, reducing losses, retaining it in the soil and causing the residual effect (FURTINI NETO et al., 2001). However, although the levels vary from 1.17 to 8.75 mg dm-3, the interpretation of the mean (2.84 mg dm-3), according to SOUSA et al. (2004), fell into the very low class.

The average K levels were 65.17 mg dm-3 and, according to the evaluation criteria proposed by VILELA et al. (2004), these levels fall into the adequate class, in which the ranges considered adequate for interpretation of K in cerrado soils are between 51 mg dm-3 and 80 mg dm-3, when the CEC at pH 7.0 is greater than 4 cmolc dm-3. The highest coefficient of variation was obtained for the P content (176.58%) (Table 5). This effect is related to the great variation of nutrient contents in the sampled area. This fact can be attributed to the mode of application and also to the low mobility of this nutrient in the soil (MACHADO et al., 2007). The nutrient P should be managed in the soil, considering the appropriate level, for possible fertilization and to take advantage of the residual effect on subsequent crops from previous plantings (FERREIRA & CARVALHO, 2005).

Calcium and magnesium levels were higher in the 0 to 20 cm layer (Table 5). According to SOUSA & LOBATO (2004), in the Cerrado region, the low levels of calcium and magnesium do not only occur on the surface, but can also occur in the deeper layers. Comparing the average levels of Ca (0.99 cmolc dm-3) and Mg (0.60 cmolc dm-3), it is observed that the nutrients Ca and Mg are low and medium, respectively, according to the class of interpretation proposed by SOUSA & LOBATO (2004). Due to the natural deficiency of magnesium in cerrado soils, it should be considered that the use of dolomitic limestone provides this nutrient to the soil, always observing the minimum content of 0.5 cmolc $^{dm-3}$ of Mg (SOUSA & LOBATO, 2004).

Table 5

Analysis of variance for nutrient concentration as a function of fertilizer applied to the soil for soybean crop in the 2011/2012 harvest

Adub.	M.O.	pH	P	K	Ca	Mg	H + Al	Al	CTC	V	m
	- % -	CaCl2	- mg dm-3 --		---------------- Cmolc DM3 --------					------ % -----	
FNS	1,56 the	5,08 the	1.17 b	60.50 to	1.03 to	0.68 to	3.13 to	0.04 to	5.00 to	36.97 to	2.94 to
PMG	1,58 the	5,06 the	2.63 abs	67.00 to	1.12 to	0.65 to	2.93 to	0.06 to	4.90 to	39.98 to	3.66 to
DMPP 0,30	1,46 the	4,97 the	8.75 to	68.90 to	0.93 to	0.53 to	3.34 to	0.04 to	5.00 to	32.75 to	2.96 to
DMPP 0,25	1,59 the	5,06 the	2.83 abs	69.50 to	1.21 to	0.66 to	3.32 to	0.02 to	5.37 to	37.30 to	1.12 to
DMPP 0,15	1,43 the	4,98 the	1.74 b	61.70 to	1.01 to	0.59 to	3.25 to	0.04 to	5.01 to	34.55 to	2.92 to
DMPP 0,05	1,52 the	5,00 the	1.28 b	63.40 to	0.86 to	0.59 to	3.17 to	0.02 to	4.80 to	33.17 to	1.17 to
DMPP 0,70	2,11 the	5,01 the	1.48 b	65.20 to	0.81 to	0.56 to	3.24 to	0.04 to	4.79 to	33.20 to	2.13 to
					Depth (Prof.)						
0-20	1,85	5,03	4,05	66,57	1,15	0,67	3,26	0,04	5,26	37,67	2,25
20-40	1,33	5,01	1,63	63,77	0,84	0,55	3,14	0,04	4,70	32,88	2,86
					Test F						
Adub.	0,62	0,78	2,87*	2,18	2,02	1,81	1,31	0,56	1,47	2,10	0,59
Prof.	5,23*	0,38	4,08*	2,45	16,56*	14,65*	1,69	0,00	20,99*	10,09*	0,38
CV (%)	59,3	3,1	176,5	11,4	31,5	21,5	12,0	157,6	10,2	17,8	161,3

Note: Means followed by different letters in the column differ by Tukey's test ($p<0.05$) FNS – Natural soil fertility, without the addition of fertilizer; PMG – planting with granule mixture (1.5*) + cover with urea (0.12*) and KCl (0.3*) + absence of foliar; DMPP 0.3 – PMG (1.0*) + coverage with DMPP (0.3*) and KCl (0.42*) + foliar; DMPP 0.25 – PMG (1.0*) + coverage with DMPP (0.25*) and KCl (0.3*) + foliar; DMPP 0.15 – PMG (0.9*) + cover with DMPP (0.15*) and KCl (0.2*) + foliar; DMPP 0.05 – PMG (0.6*) + coverage with DMPP (0.05*) and KCl (0.1*) + foliar; DMPP 0.7 – planting with NPK with DMPP (0.7*) + absence of foliar. (*) – Amount of NPK fertilizer in t $^{ha-1}$.
Source: Prepared by the authors themselves, 2025

The results of the leaf analysis are shown in Table 6. The nutrient contents were not influenced by fertilization. It is observed that the mean values of N (51.6 g $^{kg-1}$) and P (4.3 g $^{kg-1}$) fell into the adequate class, while K (14.0 g $^{kg-1}$) and Mg (2.9 g $^{kg-1}$) were below adequate in both interpretation criteria proposed by MALAVOLTA (2006) and OLIVEIRA (2004). The average value for Ca (5.1 g $^{kg-1}$), according to the reference values for interpretation proposed by MALAVOLTA (2006), was below adequate, but for OLIVEIRA (2004) this content is considered adequate.

Table 6

Average contents of the chemical attributes of leaf analysis of soybean plants cultivated in succession to industrial tomato cultivation

Treatment	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
	------------------ g kg^{-1} ----------------					------------ mg kg^{-1} -------------			
FNS	49,1	4,0	14,4	5,0	3,2	1,2	257,6	69,6	13,8
PMG	52,3	4,4	12,9	6,0	3,0	1,4	254,4	47,0	13,7
DMPP 0.30	53,2	4,2	13,9	4,4	3,0	2,0	266,8	60,0	17,5
DMPP 0.25	51,6	4,2	14,4	5,0	3,2	1,4	283,4	58,8	13,2
DMPP 0.15	49,5	4,6	13,4	4,4	2,6	1,4	270,6	54,4	13,6
DMPP 0.05	52,3	4,4	14,8	5,6	2,8	1,0	257,8	60,0	14,1
DMPP 0.70	53,8	4,4	14,4	5,4	3,0	1,6	242,4	54,4	13,5
Average	51,6	4,3	14,0	5,1	2,9	1,42	261,8	57,7	14,2
Test F	0.46ns	0.57ns	0.68ns	0.53ns	1.19ns	1.51ns	0.77ns	1.26ns	2.07ns
CV %	11,3	14,2	13,2	35,8	14,8	41,1	12,7	24,0	16,1

Note: ns – not significant (p>0.05) FNS – Natural soil fertility, without the addition of fertilizer; PMG – planting with granule mixture (1.5*) + cover with urea (0.12*) and KCl (0.3*) + absence of foliar; DMPP 0.3 – PMG (1.0*) + coverage with DMPP (0.3*) and KCl (0.42*) + foliar; DMPP 0.25 – PMG (1.0*) + coverage with DMPP (0.25*) and KCl (0.3*) + foliar; DMPP 0.15 – PMG (0.9*) + cover with DMPP (0.15*) and KCl (0.2*) + foliar; DMPP 0.05 – PMG (0.6*) + coverage with DMPP (0.05*) and KCl (0.1*) + foliar; DMPP 0.7 – planting with NPK with DMPP (0.7*) + absence of foliar. (*) – Amount of NPK fertilizer in t $^{ha-1}$.Source: Prepared by the authors themselves, 2025

Due to the seed inoculation process, it can be inferred that there was an effect of biological fixation for N, but not very expressive, since the sufficiency ranges for the nutrient were close to OLIVEIRA (2004) and MALAVOLTA (2006).

It is observed that, according to the classes of interpretation of the leaf variables proposed by MALAVOLTA (2006), the mean values of the nutrients Cu (1.42 mg $^{kg-1}$) and Zn (14.21 mg $^{kg-1}$) fell into the class below adequate; the Mn value (57.7 mg $^{kg-1}$) was adequate; the Fe content (261.8 mg $^{kg-1}$) was above the adequate. The order of micronutrient extraction by soybean plants was: Fe>Mn> Zn>Cu, confirming the results proposed by BARBOSA (2010).

There was a reduction in the levels of micronutrients in the leaves (Table 6), even with the increase in the dosages of foliar fertilizers. It can be inferred that there was possibly a "dilution" of the concentration of minerals in the leaf content, which also did not reflect in higher yields. There is great difficulty in obtaining positive results regarding the application of fertilizers with micronutrients.

The average yield of soybeans is presented in Table 7. T3 provided increases of 27.77% in soybean yield in relation to the treatment without fertilizer application.

Table 7

Average yield of soybeans from plants cultivated in succession to industrial tomatoes submitted to fertilizers with DMPP

Treatment	Productivity		Relative productivity
FNS	2.497,3	a	100,00
PMG	2.992,0	a	119,80
DMPP 0.30	3.190,7	a	127,80
DMPP 0.25	2.976,0	a	119,20
DMPP 0.15	2.773,3	a	111,10
DMPP 0.05	2.857,3	a	114,40
DMPP 0.70	2.696,0	a	108,00
Average	2.854,7		
Test F	1.72ns		
CV	13,48		

Note: ns – not significant FNS – Natural soil fertility, without the addition of fertilizer; PMG – planting with granule mixture (1.5*) + cover with urea (0.12*) and KCl (0.3*) + absence of foliar; DMPP 0.3 – PMG (1.0*) + coverage with DMPP (0.3*) and KCl (0.42*) + foliar; DMPP 0.25 – PMG (1.0*) + coverage with DMPP (0.25*) and KCl (0.3*) + foliar; DMPP 0.15 – PMG (0.9*) + cover with DMPP (0.15*) and KCl (0.2*) + foliar; DMPP 0.05 – PMG (0.6*) + coverage with DMPP (0.05*) and KCl (0.1*) + foliar; DMPP 0.7 – planting with NPK with DMPP (0.7*) + absence of foliar. (*) – Amount of NPK fertilizer in t $^{ha-1}$.
Source: Prepared by the authors themselves, 2025

Considering the average productivity of the State of Goiás (3,120 Kg $^{ha-1}$) in the 2015/2016 harvest (CONAB, 2016), it is verified that the only treatment that allowed productivity higher than this average was the application of 112 Kg $^{ha-1}$ of N, 315 Kg $^{ha-1}$ of P2O5 and 427 Kg $^{ha-1}$ of K2O in the previous cultivation of industrial tomato. Regarding the recommendation proposed by SOUSA & LOBATO (2004), the amount applied in the previous crop was higher than that recommended for obtaining high yield expectations.

The relative average yields of soybean yields as a function of fertilization indicated that T2, T3 and T4 approached the maximum efficiency production. In the evaluated parameter of yield, there was no response between the treatments that received or did not receive the fertilizers partially coated and stabilized with DMPP.

4 CONCLUSION

The soybean crop presents a positive relative efficiency index in terms of increasing productivity for treatments with higher amounts of fertilizer applied, in residual effect. The application of foliar fertilizer is not efficient for increasing productivity, nor for replacing base fertilization.

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