

Peanut seed yield under influence of fertilizer and biostimulant

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Abstract

Nowadays, the search for increase in the crop productivity with high organoleptic, physical and physiological quality of seeds remains one of the main objectives. Considering the importance of peanuts (*Arachis hypogaea* L.) for Brazilian agriculture and for the production of seeds, it is indispensable to use technological innovations aiming at the advancement of productivity and profitability for the seed producer. This study aimed to evaluate the yield and the components of peanut seed production of cultivar BR1, subjected to the foliar and seed application of Ca + B, Mo + P and Stimulate[®]. The design was randomized blocks with the use of three products (Ca + B, Mo + P, Stimulate[®]), two types of applications (via foliar and seed), the PK culture, and the absolute control, following a factorial scheme of [(3 × 2) + 2]. The doses of 2.0 mL/kg (Ca + B), 1.6 mL/kg (Mo + P), and 15 mL/kg (Stimulate[®]) via seeds were indicated the best for the development of the peanut crop due to its profitability and efficiency. The application of Ca + B, Mo + P, and Stimulate[®] via seeds is beneficial for the initial counting, emergence, emergence speed index, biological productivity, pod production, seed production and leaf area.

Keywords: *Arachis hypogaea* L.; Nutrients; Production.

Abbreviations: MSR_root dry mass; MSPA_aerial part dry mass; COMRAIZ_root length; COMPA_aerial part length; NVP_number of pods per plant; NSV_number of seeds per pod; NSP_number of seeds per plant; RAF_leaf area reason; DAF_leaf area duration; AF_Leaf area; EM_seedling emergence; PCE_first seedling emergence count; AP_plant height; DC_stem diameter; NF_number of leaves; NR_number of branches.

Introduction

The peanut (*Arachis hypogaea* L.) is native to South America. It is originated from Bolivia and is the fourth most planted oleaginous culture in the world, after soy, cotton, and canola, and being considered by the producers as a species of great food value and promising potential in the Brazilian agribusiness. Due to its rich protein content, it is widely used as a food supplement, mainly for the low income population that has little access to the animal protein sources (Santos et al., 2005).

The cultivar BR1 is recommended for the conditions of semi-arid regions, with an upright position, which facilitates harvesting, low oil content (45%), and 29% crude protein, presenting on average 3–4 seeds per rounded pod and red coloration. Its average cycle is 90 days and produces about 1.8 t ha⁻¹ peanut in the bark on the rainfed regime in the northeast and its seed yield ranges 71%–73% (Santos and Suassuna, 2006).

In the Pernambuco state, the production of peanuts in the bark reaches 227 t, with a planted area of approximately 117 ha. This generates a profitability of 424 thousand reais to the producers (IBGE, 2012). A study by Santos et al. (2006) reported that the erect varieties are mainly cultivated in Northeast. These cultivars present short cycle and easiness of handling and harvest. These characteristics are extremely

important and relevant, since the peanut is cultivated mainly by small farmers.

Nowadays, another prominent aspect in agriculture is the application of products via foliar and seed, which for several years were only carried out under conditions of correcting nutrient deficiencies in the plants and are now being used with the purpose of increasing the productivity of different cultures (Silva et al., 2009). Among these products, molybdenum (Mo), boron (B), phosphorus (P), calcium (Ca), organomineral products, and growth regulators, such as Stimulate[®], have been used on crops such as soybeans, beans, corn, peanuts, and olerícolas.

The redistribution of macro- and micronutrients in plants is an essential feature for their survival under limiting or excessive supply conditions (Malavolta et al., 1997).

In the agricultural production system, the seed is an input of fundamental importance to achieve increased crop yields.

In Northeast Brazil, the occurrence of droughts and climatic uncertainties hamper the production of seeds, so the peanuts produced under different management is an alternative for these regions. Brazilian agriculture in the last decades has added technological innovations, which mainly focused on crop productivity and high organoleptic, physical, physiological, and sanitary quality of seeds. Based on these

considerations, this study aimed to verify the effects of foliar and Ca + B, Mo + P, and Stimulate® seeds on the yield and components of peanut seed production in cultivar BR1.

Results and Discussion

Development of seedlings

The application of the treatments directly on peanut seeds combined with the Ca + B, Mo + P, and Stimulate® were responsible for the higher values on first seedling count and the rate of emergence (IVE). However, direct application of treatments on seed did not differ statistically from each other, but differed when applied as foliar application (Table 2). The Ca is beneficial because it is closely related to the soil reaction, acting as double action agent as an essential nutrient and controlling pH (Santos et al., 2005). Boron enhanced the growth and development of seedlings; however, its foliar application according to Silva and Ferreyra (1998), is more efficient when compared to the seed application, different from the results of present work.

Results published by Oliveira and Thung (1998) disagreed with our research. They affirmed that Mo applied by foliar is more effective in the enzymatic system of N fixation, when compared to that applied by seed, preventing the lack of this nutrient.

Brazilian soils are usually deficient in P (less than 0.1% in solution) due to the source of soil material (Raij et al., 1996). Therefore, P application via seeds produced favorable effects in this study.

The Stimulate® applied via seeds increased the seedling emergence and speed index due to the presence of hormones. Also, the balance between them directly influenced the germination process (Vieira and Castro, 2004), being more expressive compared to the foliar application (Table 2).

Table 3 presents the data of the first seedling count, emergency, and index of the emergence speed of peanut seedlings obtained under the influence of fertilization and biostimulant. It was observed that the application of Mo + P and Stimulate® via seeds differed statistically in relation to the absolute control and PK culture. Presumably, the P applied via seeds, provided energy to form rootlets, resulting in mechanical support and increasing the absorption of water and ions (Malavolta, 2006).

The Mo is a component of enzymes that catalyze diverse reactions, participating in electron transfer processes. Therefore, application of this micronutrient via seeds was beneficial for the variables (Table 3). According to Ferreira (2001), application of Mo, both by seeds and foliar route, is efficient. However, their application through seeds requires much smaller doses, being more profitable, similar to the present study. These results differ from those reported by Silva et al. (2009), by which they did not report any significant differences with the use of Mo in the peanut crop.

Notably, application of Ca + B via seeds also statistically differed, compared to the cultivation with PK. The Ca + B presumably helped in the maintenance and structural and functional integrity of the membranes and the cell wall of the seeds (Malavolta, 2006), favorably inducing these characteristics.

The Stimulate® application on seeds effectively increased the first seedling count, the emergence and emergence rate index seedling, compared to the control and application of PK (Table 3). Among the various mechanisms and factors involved in the emergence process, the presence of hormones and the balance between them had a direct effect. The presence of auxins, gibberellins and cytokinins in Stimulate® may have favored the seedling development. In the presence of biostimulant applied on soybean seeds, significant increases were observed in the percentage of seedling emergence (Melo, 2012).

The root, mass of aerial part and the length of both peanut plant remained uninfluenced statistically via foliar and seed application of Stimulate®. The results obtained in this study, were in accordance with Fernandes (2008) who reported that seeds and foliar application micronutrients does not influence the dry mass, plant length and productivity of peanut. Caires and Rosolem (2000) did not notice any significant effect by application of nutrients in the development of peanut.

The dry mass of root and length of aerial parts of peanut did not reveal any significant difference, when subjected to nutrient application and Stimulate®, when compared with control treatments and the PK culture. Costa (2013), who worked on the application of nutrients by foliar and seeds in peanut cultivar BR1 did not observe any statistical difference between the treatments for the variables dry mass and root and length of aerial part.

The aerial and root dry mass evaluations are essential in evaluating the development of the peanut plants, ensuring their establishment in the field (Almeida, 2011).

Considering the production and productivity components (Table 4), the products did not influence the form of application by seed and leaf and did not differ statistically from each other. Corroborating with the results of Silva et al. (2009), it was observed that the nutrient application (via seeds or leaf) did not affect the peanut seed yield. This result is in contrast with Hippler et al. (2011), who reported that nutrient application affects the productivity of peanuts (*Arachis hypogaea* L.).

Silva et al. (2012), studied the efficiency of micronutrient products on the peanut yield and concluded that there was a significant response of productivity to Mo application, when applied through seeds. According to Mantovani et al. (2013), the application of boron via leaf in the peanut crop can cause a negative effect on the crop yield.

The peanut cultivar BR1 achieved average production and seeds ranging from 3958–5687 kg/ha⁻¹ and 2321–3473 kg/ha⁻¹, respectively. These values were above the average values found in trials conducted in the Northeast region, reported 3800 kg/ha⁻¹ for pod production and 2300 kg/ha⁻¹ for seed production (Gomes et al., 2007; Santos and Farias, 1999).

Productivity

The biological productivity and the pod and seed production of peanut plants obtained under the influence of fertilization and biostimulants are presented in Table 5. The application of Mo + P via seeds (seed production), and Stimulate® via seeds (biological productivity and pod production) expressed

Table 1. Physical and chemical analysis of the soil used for peanuts in Garanhuns, Pernambuco, Brazil.

Physical soil analysis*						
	Argil+Silt	Argil	Silt	Sand		
Content	35%	24%	11%	64%		
Chemical analysis of soil **						
pH (H ₂ O)	P	K ⁺	Ca ⁺⁺	Mg ⁺	Na ⁺	Al ⁺⁺⁺
	-mg dm ⁻³		-----cmol _c dm ⁻³ -----			
6.80	62	0.90	7.75	2.45	0.28	0.00

Sources: *Laboratory of Soil Chemistry and Fertility UAG / UFRPE and **Instituto Agronômico de Pernambuco (IPA)

Table 2. First count (%), Emergency (%) and Index of emergence speed of peanut seedlings obtained under the influence of fertilization and biostimulant.

Treatments	First Count (%)		Emergency (%)		Emergency Speed Index	
	Via seed	Via foliar	Via seed	Via foliar	Via seed	Via foliar
Ca + B	72 aA	53 aB	75 bA	77 abA	15.035 aA	12.279 aB
Mo + P	74 aA	49 aB	72 bB	81 aA	15.458 aA	10.720 bB
Stimulate®	75 aA	61 aB	84 aA	75 bB	16.083 aA	13.461 aB

Means followed by the same capital letter in the row and lowercase in the column do not differ statistically from each other by the Tukey test, 5% probability.

Table 3. First count (%), Emergency (%) and Index of emergence speed of peanut seedlings obtained under the influence of fertilization and biostimulant compared to the absolute control and cultivation with PK.

Treatments	Absolute Witness		
	First Count (%)	Emergency (%)	Emergency Speed Index
Ca + B via seed	-9.5 ^{NS}	-3.5 ^{NS}	-1.339 ^{NS}
Ca + B via leaf	9.5 ^{NS}	-1 ^{NS}	1.416 ^{NS}
Mo + P via seed	13.25 [*]	6.5 [*]	2.899 [*]
Mo + P via leaf	9.5 ^{NS}	2.5 ^{NS}	1.839 ^{NS}
Stimulate® via seed	12 [*]	6 [*]	2.464 [*]
Stimulate® via leaf	-1.5 ^{NS}	-3 ^{NS}	-0.157 ^{NS}
Treatments	Cultivation with PK		
	First Count (%)	Emergency (%)	Emergency Speed Index
Ca + B via seed	21.5 [*]	14.5 [*]	4.693 [*]
Ca + B via leaf	-2.5 ^{NS}	-12 ^{NS}	-1.937 ^{NS}
Mo + P via seed	25.25 [*]	17.5 [*]	6.253 [*]
Mo + P via leaf	-0.5 ^{NS}	-8.5 ^{NS}	-1.514 ^{NS}
Stimulate® via seed	13.5 [*]	14 [*]	3.511 [*]
Stimulate® via leaf	0 ^{NS}	-5 ^{NS}	-0.890 ^{NS}

*Significant to the witness, by Dunnett's test, at a 5% probability level; ^{NS} Not significant, by the Dunnett test, at a 5% probability level.**Table 4.** Biological productivity, production of pods and seeds from peanut plants under the influence of fertilization and biostimulant.

Treatments	Biological Productivity (Kg/ha)		Production of Pods (Kg/ha)		Seed Production (Kg/ha)	
	Via seed	Via leaf	Via seed	Via leaf	Via seed	Via leaf
Ca + B	18947 bA	21577 aA	3958 aA	4635 aA	2321 aA	2646 aA
Mo + P	24999 abA	22213 aA	5687 aA	4854 aA	2371 aA	3473 aA
Stimulate®	26791 aA	25104 aA	5552 aA	5354 aA	2544 aA	2895 aA

Means followed by the same capital letter in the row and lowercase in the column do not differ statistically from each other by the Tukey test, at 5% probability.

Table 5. Biological productivity, pods and seed production from peanut plants under the influence of fertilization and biostimulant compared to the absolute control and cultivation with PK.

Treatments	Absolute witness		
	Biological Productivity (Kg/ha)	Production of Pods (Kg/ha)	Seed Production (Kg/ha)
Ca + B via seed	-4417 ^{NS}	-177.1 ^{NS}	757.2 ^{NS}
Ca + B via leaf	-1788 ^{NS}	500 ^{NS}	1082 ^{NS}
Mo + P via seed	1638 ^{NS}	1552.1 ^{NS}	806.8 [*]
Mo + P via leaf	-1151 ^{NS}	718.8 ^{NS}	1908.8 ^{NS}
Stimulate® via seed	3427 [*]	1416.7 [*]	979.6 ^{NS}
Stimulate® via leaf	1740 ^{NS}	1218.8 ^{NS}	1330.5 ^{NS}
Treatments	Cultivation with PK		
	Biological Productivity (Kg/ha)	Production of Pods (Kg/ha)	Seed Production (Kg/ha)
Ca + B via seed	-4031 ^{NS}	-854.2 ^{NS}	530.4 ^{NS}
Ca + B via leaf	-1402 ^{NS}	-177.1 ^{NS}	855.3 ^{NS}
Mo + P via seed	2021 ^{NS}	875 ^{NS}	580 [*]
Mo + P via leaf	-765 ^{NS}	41.7 ^{NS}	1682 ^{NS}
Stimulate® via seed	3813 [*]	739.6 [*]	752.8 ^{NS}
Stimulate® via leaf	2125 ^{NS}	541.7 ^{NS}	1103.8 ^{NS}

*Significant to the witness, by Dunnett's test, at a 5% probability level; ^{NS} Not significant, by the Dunnett test, at a 5% probability level.

Table 6. Number of bedridden plants and number of days for flowering of peanut plants obtained under the influence of fertilization and biostimulant compared to the absolute control and cultivation with PK.

Treatments	Absolute Witness	
	Numbers Plants Bedridden	Number of Days for Flowering
Ca + B via seed	-2.25 ^{NS}	-1.25 ^{NS}
Ca + B via leaf	-0.25 ^{NS}	-1.75 ^{NS}
Mo + P via seed	8.25 [*]	-0.25 ^{NS}
Mo + P via leaf	-5.25 ^{NS}	-1.0 ^{NS}
Stimulate® via seed	-4.25 ^{NS}	2.0 [*]
Stimulate® via leaf	9.5 [*]	2.0 [*]
Treatments	Cultivation with PK	
	Numbers Plants Bedridden	Number of Days For Flowering
Ca + B via seed	-5.0 ^{NS}	-0.25 ^{NS}
Ca + B via leaf	-3.0 ^{NS}	-0.75 ^{NS}
Mo + P via seed	11.0 [*]	0.75 ^{NS}
Mo + P via leaf	-8.0 ^{NS}	0.00 ^{NS}
Stimulate® via seed	-7.0 ^{NS}	-1.00 ^{NS}
Stimulate® via leaf	12.25 [*]	-1.00 ^{NS}

*Significant to the witness, by Dunnett's test, at a 5% probability level; ^{NS} Not significant, by the Dunnett test, at a 5% probability level.

a significant difference, when compared to the absolute control and the PK cultivation. This can be explained by the fact that Mo is a micronutrient in less quantity in the Brazilian soil; hence, the addition of this element via seed, may have aided effectively; whereas, P via seeds provides high fixation of flowering and increased production (Malavolta, 2006). Carneiro et al. (2004) and Silva et al. (2012) studied the effect of Mo on peanut production, via seed and foliar and did not find any increase in the production.

The Stimulate® has properties and characteristics that favor an adequate hormonal balance, increasing plant growth and development, stimulating cell division, differentiation, and cell stretching (Vieira and Castro, 2004). These properties may have been decisive for the increase in the biological productivity and pod production (Table 5). The number of pods per plant, number of seeds per pod, and the number of seeds per plant of peanuts obtained under the influence of fertilization and biostimulant did not reveal any significant difference, compared with absolute control and the PK culture.

One of the components of the plants that contribute to the variation in population is the number of pods per plant that varies inversely with the increased or reduced population. Silva et al. (2009) reported that application of nutrients on productivity of peanut IAC 886 and its components (number of pods/plant, number of seeds/pods, and number of seeds/plant) is unexplained. However, Mantovani et al. (2013) concluded that application of foliar nutrients in peanuts caused a negative effect on the number of pods per plant. Foliar application of Ca + B increased the number of pods per plant and seeds per pod in the soybean (Bevilaqua et al., 2002).

The application of Stimulate® (via seeds) on leaf area ratio (RAF) differed statistically when compared to the absolute control. The productivity of crops depends on the leaf area and dry mass, because the higher RAF generates greater photosynthetic area resulting in a high productive potential, confirming results of this work. According to Campos et al. (2008), the relevance of the RAF determination is correlated with the extent of primary assimilatory organ, which is responsible for the transformation of photosynthesis into the dry phytomass. Campos (2005), studied the effect of plant regulators using foliar application and verified that the application of Stimulate® provided higher RAF and superior

peanut plants, compared to control plants, not subjected to the Stimulate®.

The ratio, duration, and leaf area did not reveal any significant differences, when comparing the treatments with control and PK cultivation. The yield potential of a crop may be related to the increase, ratio or duration of the leaf area that further increase the photosynthetic production. These are essential characteristics in the growth analysis, since they reflect the results of the application of a certain treatment (Melo, 2012).

For nutrients and Stimulate®, it was expected that they would cause greater expansion of the foliar tissues evaluated by the analyses, since these contain substances that participate in the regulating processes in the plants, such as stretching and cellular expansion. However, no statistical difference was observed, which may be as a result of PK supporting the development of the culture under the study.

Leaf growth

We observed that application of Mo + P via seeds and Stimulate® via leaf statistically affected the number of fallen plants, compared to the absolute control and the PK culture (Table 6). Although Mo is a component of enzymes that participate in the electron transfer process in seeds, and P anticipates the root formation that is essential for functioning as a mechanical support (Malavolta, 2006), the Mo + P treatment via seeds showed lower values than the absolute control and cultivation with PK.

The use of foliar phyto-regulators in agriculture promotes the hormonal balance of plants, benefiting the expression of their genetic potential and stimulating the development of the root system of the crop (Castro and Vieira, 2001). Thus, the Stimulate® should contribute to the decrease in the number of bedridden (fallen on the ground) plants, but the result was contrary to the expected. In a study by Buzzello et al. (2013) with soybean cultivation, reduction was observed in the bedding, which caused by the application of growth regulators; thus, agreeing with the present research.

Considering the number of days for flowering, Stimulate® applications via seeds and leaf caused statistical difference, when compared to the absolute control. No significant difference was observed comparing the nutrient and phytostimulant applications with the PK cultivation (Table 6).

Regardless of its growth habit, peanut flower production went through four stages: initially a slow increase in flower production, followed by a faster production, then a peak flowering, and eventually withering. These fluctuations are inherent to the plant development process and are not directly conditioned by the external environmental factors (application of development promoting substances) (Nicholaides et al., 1969). However, authors (Guimarães, 1993; Santos et al., 1994) emphasized that the number of days for flowering depends on the conditions of the external environment.

The application of Ca + B via seeds and foliar application were responsible for the highest values (number of plants bedridden), not statistically different from each other. These high values can be attributed to the strong winds that were observed in the study area. This phenomenon is attributed to the location of application of nutrients, where they are immensely exposed to inclement weather. According to Gomes et al. (2010), wind and rain are among the main agents that promote lodging.

The foliar application of Stimulate® statistically differed from the seed application, favoring the plants nonbedding. The Stimulate® contains plant regulators in its composition that assist in the vital and structural processes of the vegetable, increasing production, improving the quality of the product and simplifying harvesting operation (Santos et al., 2013). According to Cato (2006), one of the main reasons for the use of foliar plant regulators in peanut cultivation is to decrease unnecessary vegetative growth, greater than that required for maximum plant performance. The excessive vegetative growth uses nutrients and generates extra useless photosynthesized materials, instead of being distributed for the development of reproductive structures. Considering the number of days for flowering, products did not influence the application form via seed and leaf and did not differ statistically.

The foliar application was responsible for the highest leaf count, which did not statistically differ among treatments. It complemented the plant nutrition during periods of high nutrient consumption, favoring its nutritional balance and development of the peanut crop, in which the number of leaves was increased (Castro et al., 2005).

The number of leaves is a good parameter in the vigor of plants, since plants with greater number of leaves can be favored in the production of photoassimilates (Venturi and Paulilo, 1998). According to Martins-Corder and Saldanha (2006), the production of substances is necessary for the growth of plants which is directly related to the amount of leaves.

The combination of Mo + P and Stimulate® with the application form via leaf and seeds was responsible for the highest values, not statistically different for the height variable. The height of the plants was increased under the influence of the nutrients and Stimulate®, where the use via foliar gave expressive results when compared with the seeds application. In order to obtain good results, the substance needs to be translocated to greater demand within the plant. An element is considered absorbed when it is inside the cell, and the absorption by foliar cells resembles that of the root cells (Malavolta et al., 1997), where its entrance through the leaves is more effective. Rezende et al. (2005), reported that the height of the plant remained significantly unaltered by foliar fertilization of P in the soybean crop.

In relation to the number of branches and stem diameter of the peanut plants, no significant effect was observed for the treatments, when the nutrient application and Stimulate® were evaluated. However, several studies mention that the application of nutrients through seeds hinders processes inherent in the development of seedlings, and foliar application is one of the alternatives to solve this problem (Moreira and Siqueira, 2002; Mantovani et al., 2013).

Materials and Methods

Conduction of experiment

The experiment was conducted under field conditions in the agricultural year of 2014, in the municipality of Garanhuns, Pernambuco, in an area belonging to the Federal Rural University of Pernambuco/Garanhuns Academic Unit, at coordinates 08°53'25"S and 36°29'34"W, at an average altitude of 896 m (Earth, 2013). The laboratory analyzes were managed at the Garanhuns Laboratory Center, the Garanhuns Academic Unit, the Federal Rural University of Pernambuco (CENLAG/UAG/UFRPE).

The predominant climate in the region is the As' type, which is equivalent to a hot and humid climate according to Köppen classification (Mota and Agendes, 1986), with an annual average temperature of 25 °C and average annual rainfall of 1.038 mm, with the months of May to July being more rainy and the relative humidity of the air ranging from 75% to 83% (Andrade et al., 2008).

The experimental area presents smooth undulating relief. Before sowing peanut, the soil samples were collected at a depth of 20 cm for analysis and fertility testing in the Soil Physics Laboratory (CENLAG) and the Agronomic Institute of Pernambuco, respectively (Table 1). The fertilization was performed according to the protocol recommended for the state of Pernambuco, Second Approach (IPA, 2008).

Seed treatment and foliar fertilization

Cultivar BR1 peanut seeds were treated with Ca + B nutrients (density: 1.35 g/L); Mo + P (density: 1.61 g/L) products of Altagro® plant nutrition, and Stimulate® (auxin, cytokinin, and gibberellin), manufactured by Stoller do Brasil LTDA (density: 1.019 g/mL), at doses of 2.0 mL/kg, 1.6 mL/kg, and 15 mL/kg, respectively. The foliar fertilization of the plants was performed during pre-emergence and before flowering, based on the orientation of the manufacturers of the products with 5 L/ha (Ca + B), 3 L/ha (Mo + P), and 1.5 L/ha (Stimulate®), distributed as follows: T₁ absolute control; T₂ cultivation with PK; T₃ cultivation with application of (Ca + B) via seeds; T₄ cultivation with application of (Mo + P) via seeds; T₅ cultivation with application of (Ca + B) via foliar; T₆ cultivation with application of (Mo + P) via foliar; T₇ cultivation with application of Stimulate® via seeds; and T₈ cultivation with application of Stimulate® via foliar.

The seeds were sowed by placing 18 seeds per linear meter (Santos et al., 2005), with 3 rows (using the central row of each treatment for analysis), and spacing of 0.45 cm between the rows in a total area of 182 m² (26 × 7.0 m).

During plantation, the experimental area received an equivalent of 80 kg ha⁻¹ of superphosphate simple (P₂O₅) and 40 kg ha⁻¹ of potassium chloride (K₂O), applied in the planting line and placed between the lines of the peanut,

with the exception of the absolute witness. In order to supply nitrogen to the peanut crop, a commercial inoculant strain (SEMIA 6144) of *Bradirizobium* (Biomax® Premium Turfa - peanut) was used, at a dose of 100 g/40 kg of seeds. Weed control was performed as needed through inspections, pest and disease control was not required, and sprinkler irrigation was used during drought periods. While conducting the experiment, the average data of maximum, average, and minimum temperatures were 29.7 °C, 23 °C, and 22 °C, respectively and the cumulative rainfall was 7.2 mm, respectively.

Variables evaluated

Seedling emergence (EM): The number of emerged seedlings was counted from the 5th to the 10th day after sowing, and the data were presented as percentages.

First seedling emergence count (PCE): This was done in conjunction with the emergency test on the 5th day after sowing.

Seedling emergence speed index (IVE): The normal seedlings were daily monitored at the same time from the first emergency count, the index being calculated according to the formula proposed by Maguire (1962). G1, G2, Gn = number of normal seedlings computed in the first, second, and last count, respectively; N1, N2, Nn = number of days of sowing to the first, second and last count, respectively.

Plant height (AP): The height was determined using a ruler graduated in cm at the end of the crop cycle (90 days) from the soil surface to the end of the main stem of 10 plants in each treatment.

Stem diameter (DC): This was measured from 10 plants in each treatment at the end of the crop cycle, 5 cm from the soil surface with the aid of a digital caliper.

Number of leaves (NF) and number of branches (NR): These were counted at the end of the vegetative period, using samples of 10 plants per treatment.

Leaf area reason (RAF) and Duration of leaf area (DAF): These were calculated according to the proposal of West et al. (1920) and Briggs et al. (1920), respectively, wherein $RAF = (L1 + L2)/(W1 + W2)$; the value is expressed in $cm^2 g^{-1}$. $DAF = \frac{1}{2} (L1 + L2) (T2 - T1)$ and its unit is $cm^2 day^{-1}$. Herein, W = dry mass; L = Foliar area; T = time; 1 = initial period and 2 = final period of analysis. This variable is expressed by the unit $g/cm^2/day^{-1}$.

Length of root and aerial part of plants: At the end of the experiment, the roots and aerial parts in each treatment were measured using a graduated ruler and the results were expressed in centimeters per plant.

Aerial part dry mass (MSPA) and root dry mass (MSR): At the end of the experiment the plants were placed in an air circulation oven at 80 °C for 24 h (Nakagawa, 1999).

Number of bed plants: The bedded plants were quantified by the visual observation of recurved plants of each treatment at an angle equal to or greater than 45° at the end of the experiment.

Number of days to flowering: This was considered at the emergence date of the seedlings until the time, when 50% of the plants in each treatment exhibited at least one open flower.

Number of pods per plant, seeds per pod, and seeds per plant: These were determined by counting the pods and seeds of 10 plants selected from each treatment.

Biological productivity: This was obtained by weighing all the plants of each treatment separately, including the pods, measured in $kg ha^{-1}$.

Production of pods and seeds: All pods and seeds of each treatment were weighed, the results were measured in $kg ha^{-1}$.

Statistical analysis

The experiment was conducted in a design with four blocks, random for each treatment, using three products (Ca + B, Mo + P, Stimulate®), two types of application (foliar application and seed), the PK culture, and the absolute control, following a factorial of $[(3 \times 2) + 2]$. The data were subjected to analysis of variance and the means were compared by the Dunnett and Tukey's test, at 5% probability. Statistical analyzes were performed using SAEG statistical software, Version 9.1 (SAEG, 2007).

Conclusion

Doses of 2.0 mL/kg (Ca + B), 1.6 ml/kg (Mo + P), and 15 ml/kg (Stimulate®) via seeds application were indicated for the development of peanut culture due to their profitability and efficiency. The application of Ca + B, Mo + P, and Stimulate® via seeds is beneficial for first seedling counting, emergence, emergence speed index, biological productivity, pod production, seed production, and leaf area ratio. The use of the products via seeds and leaf when compared do not change the number of pods/plant, number of seeds/pod, number of seeds/plant, duration and leaf area, number of days for flowering, number of leaves, number of branches, and stem diameter of peanut plants.

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