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ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

*Asian Journal of Science and Technology*
*Vol. 12, Issue, 08, pp. 11818-11823, August, 2021*

# RESEARCH ARTICLE

# PRODUCTIVITY AND PROFITABILITY OF SAFRINHA CORN IN FUNCTION OF DOSES OF HUMIC SUBSTANCES BIOFERTILIZER

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## ARTICLE INFO

***Article History:***
Received 24th May, 2021
Received in revised form
24th June, 2021
Accepted 21st July, 2021
Published online 30th August, 2021

***Key words:***
Nutrient Complexer;
Biotechnology Products;
Physiological Changes;
*Zea mays* L.

## ABSTRACT

The increase in research to measure the real efficiency of the use of biofertilizers based on humic acids in agriculture, especially in corn culture, is increasingly necessary. The objective of this study was to evaluate the effect of the use of Basfoliar® BlackGold biofertilizer on the productivity of "safrinha" corn, in order to determine the dose with the best agronomic response. The experiment was conducted in the field, on the Estrela do Sul Farm, in the municipality of Campos de Júlio-MT. A randomized block design with five repetitions was adopted, on a dystrophic Red Latosol with a very clayey texture. The treatments corresponded to the following doses of the humic substances biofertilizer BlackGold: 0; 0.5; 1.0; 1.5; 2.0; 2.5; 3.0 and 3.5 L.ha$^{-1}$. Ten ears were harvested from each plot to count the number of ear rows, ear diameter (cm), ear length (cm), cob diameter (cm), mass of ten ears (g) and mass of one thousand grains (g), corrected to a moisture content of 13%. The BlackGold biofertilizer did not promote increases in agronomic and yield components evaluated, except in productivity, where the dose of 0.5 L.ha$^{-1}$ caused an increase of 8.5 bags.ha$^{-1}$ compared tothe control. It was concluded for the present experiment that the use of biofertilizers of humic substances is presented as an alternative for the increase of productivity of safrinha corn, requiring the expansion of such studies to field conditions in Campos de Júlio-MT.

**Citation:** ***Juliano Matheus Klahold, Celestina Alflen Klahold, Andressa Gregolin Moreira, Karina Galvão de Souza and Marcelo Crestani Mota, 2021.*** "Productivity and profitability of safrinha corn in function of doses of humic substances biofertilizer", *Asian Journal of Science and Technology*, 12, (08), 11818-11823.



# INTRODUCTION

Corn (*Zea mays* L.) has become one of the most cultivated agricultural products on Earth, due to its great potential for productivity and versatility of use, with destination for animal and human consumption, industrial use and as seeds (DOURADO NETO *et al.*, 2004; ANDRADE *et al.*, 2018). The growing world population increase and the high costs with fertilization emphasize the need for reduction in production losses, and greater exploitation of the potential of existing corn cultivars in the market, in order to provide higher productivity per area (MIRANDA *et al.*, 2014). Therefore, this food demand requires the adoption of new technologies to improve the agronomic and productive development of the corn crop, which includes the increasing use of improved seeds associated with the application of fungicides, herbicides, and growth regulators via seed (SILVA *et al.*, 2008; FRASCA *et al.*, 2020).

The State of Mato Grosso (MT) has great productive potential, due to its privileged geographical area and favorable climate for grain production, conditions that make it one of the largest producers of safrinha corn in Brazil, with production of 34.608 million tons and productivity of 6392 kg.ha$^{-1}$, obtained in a planted area of 5.414 million hectares in the 2019 harvest (CONAB, 2020). Among the grain producing municipalities in MT, Campos de Júlio deserves prominence because it is located at an altitude of approximately 650 m, occupying an area of 6,804.577 km², contemplating arable land, mostly flat, which facilitates mechanization and makes the municipality highly viable for agricultural production of grains in the state. Soybeans and corn are the main agricultural products in Campos de Júlio, with the leguminous crop being cultivated in the first harvest, between October and February, while the grass is a second harvest crop, cultivated from February to May.

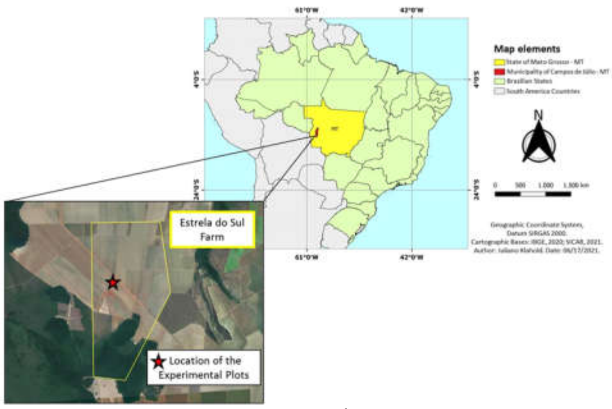
The second harvest or safrinha was synonymous with risk and low technology, often using seeds purchased for planting the harvest, not taking into account the adaptability of the grain to cultivation in the "safrinha" period (DUARTE, 2004). Therefore, when the "safrinha" planting is desired, it is essential to plan even before the implementation of the summer crop, because the later the corn is sown, the lower its productive potential and the higher the risk of losses due to lack of rainfall and low soil humidity (GALVÃO; MIRANDA, 2004).

One of the major concerns for producers is to adequately replace the nutrients extracted by agricultural practices, especially so that the implanted genotypes express their maximum productive potential. For this purpose, farmers who have more technical assistance and information are using products with formulations of nutrients and biofertilizers in foliar applications or seed treatment. In the case of corn, the best productive responses occur when foliar nutrient application comprises the vegetative development stages of four (V4) and seven (V7) developed leaves (COELHO, 2018). However, with the reports of favorable results of the applications of these products, the launch of new inputs stimulates producers to the constant and indiscriminate use of various substances in the management of crops (GOTT,2011). Thus, the use of biofertilizers stands out because of the benefits provided to the crop, especially because they are complexes that promote hormonal balance of plants, favoring the expression of their genetic potential through changes in vital and structural processes, stimulate hormonal balance and development of the root system (ONO *et al.*, 1999; VIEIRA; CASTRO, 2001; VIEIRA; SANTOS, 2005; SILVA *et al.*, 2008). In addition, they act in cell division and leaf elongation, in the synthesis of chlorophyll, in the action of photosynthesis, in the differentiation of floral buds, in the setting and size of the fruits, in the absorption of nutrients and in productivity increments (SILVA *et al.*, 2016; FRASCA *et al.*, 2020). Which in turn directly influences the increase in water absorption capacity and resistance to water and climate stresses (VASCONCELOS, 2006), indicating the reduction of the need for granulated fertilizers (RUSSO; BERLYN, 1990). Humic and fulvic acids, which naturally result from the decomposition of organic matter, are capable of stimulating physiological changes in plants. When associated with organic acids, humic and fulvic substances contribute to nutrient uptake, activation of soil microbiota, root and aboveground growth of corn plants (CHEN; AVIAD, 1990; NARDI *et al.*, 2002; OLAN *et al.*, 1994). This is essential for obtaining productive gains (CARON *et al.*, 2015).

According to Long (2006), as biofertilizers are components that produce plant growth response by improving tolerance to abiotic stresses, they have the ability to regulate plant responses to the environment where they are located. According to Castro and Kluge (1999), biofertilizers based on the gibberellin hormone, when applied during the vegetative stage, induce the growth of the aerial structures of corn plants without harming the production of dry mass and productivity. However, according to He *et al.* (2009) gibberellins do not act alone, that is, they depend on the interaction with other hormones, for example auxin, for the effect on physiological processes to occur. In recent years a significant number of studies have shown that crops achieve substantial yield gains when biofertilizers are used, as shown in Alleoni *et al.* (2000) with beans, Klahold *et al.* (2006) and Campos *et al.* (2008) with soybeans, Albrecht *et al.* However, Casillas *et al.* (1996) and Zhang and Schmidt (2000) stated that these substances are only efficient when applied in small concentrations. Ferreira *et al.* (2007), when using the biofertilizer Stimulate® and the liquid fertilizer Cellerate®, and Santos *et al.* (2013) when applying the biofertilizers BU-RG, BU-EC and BU-VG, found that they may not favor or even decrease the absorption of nutrients by plants, and that this should be associated with the plant species and the composition of humic substances present in the products used. In the study by Vasconcelos (2006), both corn and soybean did not show satisfactory yields when subjected to the application of biofertilizers (Brotax Solo®, Naturvital®, PT4-O® and Brotax-5®), with no increase in dry matter, plant size, protein and nutrient content. Janegitz *et al.* (2008), when analyzing the effects of four brands of biofertilizers (Bioamino Extra®, Aminolom®, PT4® and Radix®) on the emergence of corn and sorghum plants, found no significant difference between the treatments. Belançon (2008) found that biofertilizers had rooting capacity, but did not increase plant height, average weight of seeds per ear and grain yield of wheat. For these reasons, research plays an important role in generating information about the action of biofertilizers oncorn crops, and thus making it available to the scientific community and rural producers. According to Dourado Neto *et al.* (2004), the application of Stimulate® biofertilizer, in corn culture, increased the yield when performed in seed treatment, being more efficient compared to spraying in the sowing line and via foliar 43 days after sowing. Therefore, the objective of the present work was to evaluate the use of Basfoliar® BlackGold biofertilizer on the productivity of safrinha corn in the municipality of Campos de Júlio-MT.

## MATERIAL AND METHODS

The experiment was conducted in the field from February to June 2020, at Estrela do Sul Farm (13°55'17" S and 59°16'34" W), located on highway MT 388 - km 18, in the municipality of Campos de Júlio-MT, located on the Parecis Plateau (Figure 1).

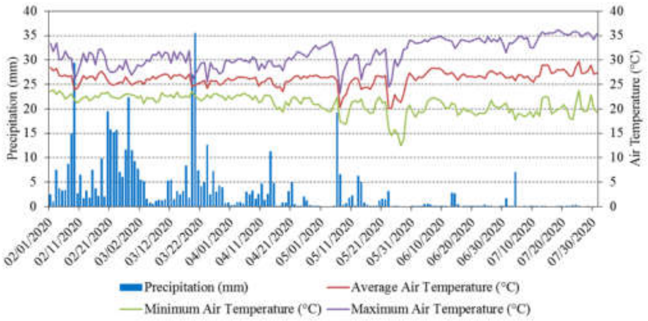



Source: Author.

**Figure 1. Location map of the experimental area**

The region has a Tropical warm and sub-humid climate, climate classification Aw according to Köppen-Geiger, with average annual precipitation of 2500 mm, average annual temperature of 24 °C and average altitude of 650 m, with its relief flat and gently undulating (ALVARES *et al.*, 2013).

The temperature and precipitation data found during the study are shown in Figure 2.




**Source:** https://power.larc.nasa.gov/data-access-viewer/

**Figure 2. Meteorological data recorded during the field experiment at Estrela do Sul Farm**

The soil was classified as dystrophic Red Latosol with a very clayey texture (FERREIRA; SANTIAGO, 2012), with 65% clay, 7.5% silt and 27.5% sand. The chemical attributes of the soil in the arable layer (0.2 m), determined before the installation of the experiment, presented the following results: H+Al = 3.9 $cmol_c.dm^{-3}$, Ca = 3.55 $cmol_c.dm^{-3}$, Mg = 2.3 $cmol_c.dm^{-3}$, K = 0.1 $cmol_c.dm^{-3}$, P = 10.95 $mg.dm^{-3}$, organic matter = 41.35 $mg.dm^{-3}$, pH = 5.3 and base saturation = 60.4%. The experimental design used was randomized blocks, divided into eight treatments (doses of 0; 0.5; 1.0; 1.5; 2.0; 2.5; 3.0 and 3.5 $L.ha^{-1}$ of BlackGold) and five repetitions, totaling 40 experimental plots. The applications of BlackGold occurred on March 11, whenthe corn presented a vegetative stage between four (V4) and five (V5) fully expanded leaves. The evaluated variety of corn was hybrid FS450 from For Seed. The commercial product (biofertilizer) Basfoliar® BlackGold from Compo Expert was used as a source of humic acids. This product presents in its composition 1.5% N, 1% $P_2O_5$, 1.4% $K_2O$, 0.3% Mg, 0.3% S, 2.4% Ca, 2.3% of humic acids, 18% of total organic carbon, 26% of fulvic acids, pH ranging from 3.5 to 5, and density of 1.29 $g.cm^{-3}$, with a technical recommendation for application of 2 $L.ha^{-1}$. In order to perform an efficient application and with greater precision in the distribution of the product, a Jacto electric knapsack sprayer was used, coupled to a bar with two nozzles spaced at 0.5 m, with a flow rate of 88.1 $L.ha^{-1}$. It is noteworthy that at the time of the applications the soil was partially wet and the environmental conditions of temperature, relative humidity and wind speed were within the normal range for application. The plots consisted of five rows, each five meters long, spaced at 0.45 m from each other, with a population density of 2.56 plants per linear meter. In order to reduce possible sampling errors, only the three central rows were considered, excluding 0.5 m from the beginning and end of the sowing lines, totaling a usable area of 3.6 m² for measuring productivity. Sowing was performed in the soybean stubble (cultivar Maracaí from Seedcorp HO) and with base fertilization, which consisted of 100 kg ha-1 of the 11-52-00 formulation. Subsequently, cover crops were fertilized in two stages: one application of 60 $kg.ha^{-1}$ of K at the V1 stage and the other of 90 $kg.ha^{-1}$ of N in the form of protected urea at the V2 stage. During cultivation, the practices recommended for the crop were performed, such as weed control, control of invading insects and application of fungicide to prevent diseases. Regarding the management, 2 L of atrazine + 3 L of Roundup + 200 mL of insecticide (zeta-cypermetrine+bifenthrin) were used per hectare in the V3 phenological stage. Fungicide (pyraclostrobin+ epoxiconazole) was also applied at a dose of 350 $mL.ha^{-1}$ with a self-propelled sprayer at VT. After the end of the corn crop cycle, which occurred on July 11, 2020 (142 days after emergence), the evaluation of variables related to agronomic components, corn yield and net profitability was performed. Ten ears were harvested from each plot to count the number of ear rows, ear diameter (cm), ear length (cm), cob diameter (cm), mass of ten ears (g), mass of one thousand grains (g), at 13% (wet basis). The yield was determined from the 10 ears collected from each experimental plot, with threshing of the grains performed manually. The grain sample was weighed and the percentage of grain humidity measured in a digital humidity determiner. The grain mass values obtained in each plot were corrected to a humidity of 13% and the value extrapolated to hectare ($bags.ha^{-1}$) (Equation 1). Being: the mass of ten ears collected in the plot divided by 10 to obtain the average mass ofan ear in grams; 57000 is the plant population per hectare adopted for hybrid FS450 from ForSeed; 60000 is the mass, in grams, of a bag of corn.

$$Productivity = \frac{\left[\left(\frac{mass\ of\ ten\ ears}{10}\right) * 57000\right]}{60000} \quad \text{Eq. 1}$$

The results obtained were submitted to variance analysis and the means were compared by Tukey's test at 5% probability, using the SISVAR® 5.6 *software* (FERREIRA, 2011).

## RESULTS AND DISCUSSION

The agronomic characteristics of the cob, such as cob diameter and length, and cob diameter, were not affected by the doses of BlackGold biofertilizer applied at the V4-V5 stage (Table 1).

**Table 1. Effect of doses of BlackGold biofertilizer on diameter and length of ear and cob diameter of corn grown in the 2019/2020 crop Campos de Júlio-MT (2020)**

| Doses of biofertilizer ($L.ha^{-1}$) | Spike diameter | Spike length | Cob diameter |
|---|---|---|---|
| | ------------------ | cm | ------------------ |
| 0 | 4.57 | 17.54 | 2.62 |
| 0.5 | 4.59 | 18.33 | 2.62 |
| 1.0 | 4.57 | 17.43 | 2.61 |
| 1.5 | 4.56 | 17.31 | 2.63 |
| 2.0 | 4.59 | 17.82 | 2.60 |
| 2.5 | 4.56 | 18.05 | 2.61 |
| 3.0 | 4.58 | 17.96 | 2.62 |
| 3.5 | 4.55 | 17.54 | 2.58 |
| Average | 4.57 | 17.77 | 2.61 |
| CV(%) | 1.15 | 2.77 | 1.59 |
| F Test | ns | ns | ns |

ns: not significant.

The results obtained may be associated with the overall effect of the production environment established in the area, corroborating Gott (2011), since the site chosen for the experiment has been used for agricultural purposes for decades, and over the years the levels of investment in soil management and correction have increased significantly. Both the results presented in Table 1 and those in Table 2 are referenced by those foundby Krenchinski *et al.* (2014), who identified no significant difference between the treatments cob length and number of rows, because they are particularities of high genotypic relationship(MEIRA *et al.*, 2009).

**Table 2. Effect of the doses of BlackGold biofertilizer on the number of rows, mass of ten ears and mass of one thousand grains of corn grown in the 2019/2020 crop. Campos de Júlio-MT (2020)**

| Dosesof biofertilizer(L.ha$^{-1}$) | Numberof rows | Massoften cobs (g) | Mass of thousandgrains (g) | Productivity (bags.ha$^{-1}$) |
|---|---|---|---|---|
| 0 | 15.80 | 1784.90 | 316.62 | 169.57 |
| 0.5 | 15.92 | 1874.48 | 329.28 | 178.08 |
| 1.0 | 16.08 | 1786.28 | 312.84 | 169.70 |
| 1.5 | 16.08 | 1755.04 | 318.22 | 166.73 |
| 2.0 | 15.80 | 1839.22 | 332.94 | 174.73 |
| 2.5 | 15.68 | 1820.92 | 324.58 | 172.99 |
| 3.0 | 15.88 | 1836.50 | 323.50 | 174.47 |
| 3.5 | 15.92 | 1747.64 | 313.75 | 166.03 |
| Average | 15.90 | 1805.62 | 321.47 | 171.53 |
| CV(%) | 1.99 | 4.69 | 3.67 | 4.69 |
| FTest | ns | ns | ns | ns |

ns: not significant.

According to Magalhães *et al.* (2006) and Lopes *et al.* (2007), the number of ear rows is defined until the V8 stage, and may show little variation, depending mainly on nutritional conditions and water availability and, especially, genetic factors. However, even if the applications of different doses were made until the V5 stage, there were no potentiating effects of different doses on the increase of this yield component. The productivity and other yield components of corn did not differ significantly from each other, but in the treatments 0.5; 1.0; 2.0; 2.5 and 3.0 L.ha$^{-1}$ all showed higher productionthan the zero dose. Krenchinski *et al.* (2014) found statistical variation for the mass of one thousand grains, in which the treatment with 4% biofertilizer stood out significantly comparedto the control, contrary to the results of Dourado-Neto *et al.* (2014).

Santos *et al.* (2013) verified growth of linear biomass accumulation in all treatments with biofertilizers in corn, proving the positive effect of the substances, which was not possible to verify in the work developed in Campos de Júlio. According to the authors cited, biofertilizers are essential in the synthesis of reserve substances, increase the absorption and utilization of nutrients. This observation is extremely important and ratified by Scalon *et al.* (2009), because its effects are only felt by the plants and noticed visually when applied concomitantly with foliar fertilizers, and are also compatible with pesticides, proving the effect of the product as a complexing agent of nutrients. This may explain the low values of $R^2$ found in all components evaluated (Tables 1 and 2), suggesting that the experimental plots presented uniformity between treatments, since BlackGold is a physiological product that contains humic substances and presents low concentrations of nutrients in its composition. Studies such as that of Lana and Magela (2019) indicate that humic substances stimulate the metabolic pathway, and thus benefit growth, because there is an increase in enzyme activity that allows rapid adjustment of metabolism, directing the pathways to the needs of the cells, in addition to increasing the assimilation of carbon and nitrogen, which are of fundamental importance for plant growth. Such an occurrence maximizes root volume, allowing a greater and more efficient development of the aerial part of the plants. These are facts that were believed to add significant productivity to the corn crop, but this was not observed in the present study. This is in agreement with the results found by Ferreira (2007) and Belançon (2008). In a study by Frasca *et al.* (2020), in beans, the treatment Micro + Fulvic Acids led to a greater increase in biomass, besides presenting a difference compared to the control, which can be observed in relation to this work, on the production aspect.

Frasca *et al.* (2020) also mention that fulvic acids provide an increase in the concentration of nutrients in leaf tissue, constituting part of the organic matter in the soil, improving physical and chemical properties, directly affecting the uptake of nutrients and consequently productivity. According to Crusciol (2021), the purpose of humic substances is to act as complexing agents for nutrients, helping to facilitate absorption and make the plants more resilient to stress, both climatic and induced (herbicides, such as glyphosate in RR plants). As far as the present study is concerned, it was observed during the crop period in the field, in the flowering period (June 04), that the precipitation volumes were almost null, which may have caused the product applied to have had a better response and thus increased corn productivity in the treatments 0.5; 1.0; 2.0; 2.5 and 3.0 L.ha$^{-1}$ in relation to the control. The data found by Frasca *et al.* (2020) agree with the present work in relation to productivity, because they did not find significant changes with the use of biofertilizers, with productivity ranging from 36.61 bags.ha$^{-1}$ to 50.65 bags.ha$^{-1}$ of beans, while in this work productivity ranging from 169.57 bags.ha$^{-1}$ to 178.08 bags.ha$^{-1}$ was obtained. Similarly to Domingos *et al.* (2015), who performed similar work in Faxinal-PR and found that the dose that presented the most outstanding effects on corn hybrid Pionner 30F53 Y was the 1.5 L.ha$^{-1}$ applied at the V4 stage, providing an increase of 19.9 bags compared to the control treatment. One of the reasons, according to Santos *et al.* (2014), is that when biofertilizers are applied in the period before flowering, these induce vegetative development, sometimes higher than that required for high yields.

Although there was no difference between the treatments used and the control, there were increases in productivity. Analyzing Figure 3, there is an increase of 8.5 bags.ha$^{-1}$, which means an increase of 5% in productivity compared to the control. Knowing that the cost of biofertilizer is approximately R$ 13.20 per liter, and that the recommendation for use by agrochemical dealers is 2 liters per hectare, it reaches a cost of R$ 26.40 of application of BlackGold biofertilizer per hectare. On the other hand, when using the dosage of 0.5 L.ha$^{-1}$, which provided higher productivity, the cost was R$ 7.60. This represents to the producer a reduction in investmentin this input of around R$ 18.80 per hectare and an increase of 3.3 bags per hectare over the dosage recommended by dealers for the edaphoclimatic conditions of Campos de Júlio-MT. Although not statistically significant, the decrease in productivity of treatment T7, which combined several of the practices tested in other treatments, is noteworthy (Figure 3).

These data show that the higher the dosage applied, the greater the productive effect of the crop will be. In other words, the producer cannot indiscriminately use several products the productive effect of the crop will be. In other words, the producer cannot indiscriminately use several products available on the market thinking that this will guarantee better performance of the crop (GOTT, 2011).

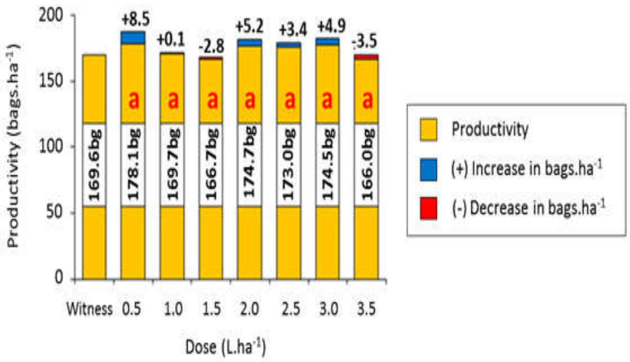



**Figure 3. Net profitability of corn crop for different doses of humic/ fulvic substances(BlackGold biofertilizer) applied at V4/V5. Means followed by the same letter in the column do not differ significantly, by Tukey's test (*P* > 0, 05)**

Considering that biofertilizers are nutrient complexing agents, it is suggested that, in future works, field experiments be conducted that consider the combination of these products with foliar fertilizers, in order to obtain robust answers as to the effects and consequences of different doses on the physiological and productive parameters of corn.

## CONCLUSION

The humic substances biofertilizer Basfoliar® BlackGold did not promote increases in the agronomic and yield components evaluated. However, its application at a dosage of 0.5 $L.ha^{-1}$ in V4-V5 provided the greatest productivity and net profitability when compared to the other dosages.

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