***Azospirillum brasilense* in corn: less nitrogen fertilizer and higher yield**

**Novelty statement**

The benefits of the application of *Azospirrillum brasiliense* in the corn crop associated with nitrogen fertilization can promote better plant development, and consequently an increase in productivity. This provides a decrease in the supply of nitrogen fertilizer as well as production costs.

**Abstract**

The demand for food in the world grows every day, with this, it seeks to increase the productivity of crops. Analyzing this scene, the objective of this work was to verify the use of the diazotrophic bacterium *Azospirillum brasilense* inoculated corn seeds (*Zea mays L*) isolated and in association with nitrogen fertilizer. The experiment was carried out at four sites in a four-block randomized design with six treatments. The treatments consisted of control, mineral nitrogen (100 and 50 kg ha-1), Nitro 1000® and Azonit® (*Azospirillum brasilense*) and Azonit® with mineral nitrogen (50 kg ha-1). In overall, fertilization with mineral nitrogen provided greater initial development of the corn crop, however, inoculation with *Azospirillum brasilense* supplied the nutritional need for nitrogen of the crop and maintained the yield index of the crop compared with the use of mineral nitrogen. The combined treatment of *Azospirillum brasilense* with mineral nitrogen (50 kg ha-1) increased the yield of the crop, indicating the need to develop studies to clarify the ideal rate of mineral nitrogen combined with inoculation with *Azospirillum brasilense.*

**KEY WORDS:** Inoculant. Inoculation. Azonit. Urea. *Zea mays L*.

**INTRODUCTION**

In Brazil, the corn crop (*Zea mays L*.) occupies approximately 21,116.7 thousand cultivated hectares (Conab, 2022). Also according to the official agency, due to major climatic problems that occurred mainly in relation to the drastic drought in November and December, the southern states can reach yields below 3,000 kg ha-1 in Paraná and Rio Grande do Sul for the first harvest.

The corn crop has a high productive potential, being able to reach high productivity levels, despite this, several factors can influence the biotic and abiotic processes. In this way, several technologies are generated in order to reduce the negative impact of these factors that interfere with productivity. Among these technologies, the use of growth-promoting microorganisms has gained prominence, such as *Azospirillum* (Fukami *et al*., 2018).

*Azospirillum* is a genus of nitrogen-fixing bacteria that live in association with plant roots (Fukami *et al*., 2018). In addition to biological nitrogen fixation, these bacteria are also known as growth promoters, as they stimulate the production of plant hormone such as auxins, gibberellins and cytokinins. The production of these compounds increases the density and length of root hairs, the rate of appearance of lateral roots and the surface area of the root system (Hungria, 2011).

According to Munareto *et al*. (2019), the use of *Azospirillum brasiliense* in the wheat crop, in the form of inoculation, provided an increase in grain yield and productive components.

Studies on corn in different regions of the country (Galindo *et al*. 2019; Lana *et al*. 2012) showed that the effects of fertilization associated with inoculation with *Azospirillum brasiliense* generated changes in the diversity of its bacterial community due to different doses of N.

In a study carried out by the association of *Azospirillum* with corn, the results showed increases in grain yield from 24% to 30% in relation to the control (Hungria, 2011). Similar results were obtained by studies that quantified an increase of 17% in corn grain yield, related to the greater average length of the ears due to inoculation with *Azospirillum* spp. (Cavallet *et al*. 2000). In addition, other works have shown that the use of these microorganisms can stimulate the development of plants in the vegetative period, greater resistance to water stress and chlorophyll content in leaves (Quadros *et al*. 2014).

Despite the various benefits of using *Azospirillum* in corn, there is still a need to supplement nitrogen fertilization (Lana *et al*. 2012).

Thus, the objective of this work was to evaluate the efficiency of inoculation with bacteria of the genus *Azospirillum brasilense* in corn (*Zea Mays L*.) in the Midwest and South region of Brazil, with and without supplementation with mineral nitrogen.

**Material and Methods**

**Study area**

The experimental trial was carried out in the 2019/2020 crop year in the towns of Planaltina – DF (15°40'01''S; 47°20'05''W, 873 m altitude), Água Fria de Goiás – GO (14°45'48"S; 47°39'03"W, 1146 m altitude), Midwest region of Brazil, and Formigueiro – RS (30º03'47"S; 53º39'18"W, 65 m altitude) and Itaara – RS (29º35'03.5"S; 53º48'23"W, 447 m altitude, southern region of Brazil (Fig. 1).

**Soil sampling and cultural practices**

Chemical and physical analysis of the soil of each experimental field (0-20 cm) and biological analysis (0-10 cm) were performed to verify the fertility and populations of diazotrophic bacteria present in each site (Table 1). The cultural and phytosanitary treatments were carried out in accordance with the recommendations for the culture, according to each region, following the premise of good agricultural practices. In a no-tillage system, the implantation fertilization was 250 kg ha-1 of the formulated 10-20-20, and cover fertilization of 150 kg ha-1 of KCl was carried out, with the exception of the area located in Planaltina - DF, due to the levels of K present in the soil (Table 1).

The treatments (Table 2) with nitrogen (N) fertilization consisted of the application of urea (45% N) at the dosage commonly used by producers (100 kg ha-1) and in half of the dose used (50 kg ha-1), with 50% applied at sowing and 50% at tassel (VT). Which represented 45 and 22.5 kg ha-1 of N at sowing and 45 and 22.5 kg ha-1 of N in the tassel (VT) (Ciampitti *et al*. 2016).

The treatments with inoculants containing *Azospirillum brasilense* (Nitro 1000 and Azonit) were applied via seed using 100 ml ha-1, following the dose recommended by the manufacturers for the culture. Seeds were not chemically treated with fungicide and insecticide. The sixth treatment used was the combination of the inoculant Azonit at a dosage of 100 ml ha-1 with half a dose of nitrogen fertilization used (50 kg ha-1 of urea), with 50% applied at sowing and 50% at the tassel (VT) (Ciampitti *et al*. 2016).

In the areas located in the cities of Planaltina and Água Fria de Goiás, sowing was carried out on December 19 and 20, 2019 using the commercial corn hybrid P3707VYH. Eight seeds were sown m-2, targeting 80,000 plants ha-1. In the experimental areas of the state of Rio Grande do Sul, the tests began with sowing on December 19 and 28 for the cities of Formigueiro and Itaara respectively, with the hybrid Feroz Viptera 3, being sown 7 seeds m-2 and objective than 70,000 plants ha-1. The experimental plot consisted of 10 lines, spaced 0.5 m apart and 5 m long.

**Climate data**

Climatic data throughout the study in each location (Table 3) were collected from the first date of the month planted to the last date of the month harvested, from data from the nearest meteorological station - Agrodetecta®.

**Experimental design and evaluated parameters**

The experimental design used was randomized blocks, six treatments and four replications in each experimental location.

Different parameters described below were evaluated to verify the effect of the inoculant containing *Azospirillum brasilense* on the corn crop, without and with the use of mineral nitrogen, being evaluated the stand of plants, at 10 days after emergence (DAE) was quantified the number of plants that emerged per linear meter in the three central lines of each plot. To determine the biomass of the aerial part, in stages V2 and R1, five plants were collected per experimental plot for quantification. To determine the height of plants, in V2 and R1, the distance between the soil and the point of active plant growth was measured, evaluating five plants per plot (Ciampitti *et al*. 2016).

To determine the nutrient content in the leaf, at stage R1, 10 leaves were collected per plot for the determination of nutrients. The length of the ear without straw, the number of rows of grains per ear and the number of grains per row in ten ears of each plot were determined.

The mass of a thousand grains 1000 grains and the productivity were quantified through the threshing of 6.0 m2 per experimental plot, the volume of grains being weighed and their moisture determined to calculate the final yield at 13% moisture. After harvesting, grain samples were separated to quantify the nutrient content.

The data obtained were submitted to analysis of normality, homogeneity and variance, and the treatment means were compared by the Skott Knott test, at a 5% significance level.

**Results**

**Planaltina - DF**

The variable shoot biomass (BPA) in the V2 and R1 stages of corn in Planaltina, (Table 4), did not show a significant difference between treatments. In the evaluations of plant height (AP), there was no significant difference between treatments in V2, but in the R1 stage, the application of mineral N in the two applied doses promoted greater plant height compared to the other treatments.

The variables ear length (EC) and number of rows of grains per ear (NFGE) did not show statistically significant difference between treatments in the city of Planaltina. There was a statistically significant difference between treatments for the number of grains per row (NGF), with the treatments of mineral nitrogen dose (100 kg ha-1), Azonit and Azonit combined with a half dose of mineral N (50 kg ha-1) higher than the other treatments. Thus, the use of *Azospirillum brasilense* was equivalent to mineral nitrogen in the complete dose, alone or in association with a half dose of nitrogen fertilizer.

However, for the mass of 1000 grains (MMG), the only treatment that statistically differed from the others was the control. For the results of grain yield (PROD) in Planaltina, despite the increments of 7.8% and 6.0% for the doses of 100 kg ha-1 and 50 kg ha-1 of mineral N respectively and 8.6% for Azonit combined with 50 kg ha-1 of mineral N, no statistically significant difference between treatments was observed.

The levels of macronutrients and micronutrients (Table 5) showed no statistically significant difference in the leaf analysis. However, in the analysis of grains, treatments with a full dose of mineral nitrogen (100 kg ha-1), Azonit and Azonit combined with half a dose of mineral nitrogen (50 kg ha-1) showed the highest levels of macronutrients N (nitrogen), P (phosphorus) and Mg (magnesium). This result evidences that the use of *Azospirillum brasilense* supplies the nitrogen culture needs with the formed symbiosis and optimizes the use of other nutrients, such as P and Mg.

In the analysis of micronutrients in the grains, S (sulfur) had higher levels of the nutrient than occurred for treatments with inoculation with Azonit (*Azospirillum brasilense*), without and with mineral nitrogen.

**Agua Fria de Goias - GO**

In the experiment conducted in the city of Água Fria de Goiás, the control treatment and the treatment with Azonit presented the lowest statistically values for the BPA parameter in R1 (Table 6).

As for AP (V2 and R1), CE and NGF there was no statistically significant difference between treatments. Treatments with mineral nitrogen resulted in the highest values of MMG, however for NFGE and PROD only the absolute control differed statistically from the others, showing itself to be inferior and evidencing the importance of nitrogen supply for the crop.

Although the difference is not statistically significant, the results of grain yield in Água Fria de Goiás, demonstrate increments of 10% and 8.7% for the doses of mineral N, of 8.2% for the inoculation with Nitro 1000, 9.3% for Azonit alone and 9.7% for Azonit combined with half a dose of mineral N (Table 6). These results are related to better development of corn plants.

For the levels of macronutrients and micronutrients (Table 7) in the leaves and grains, there was a statistically significant difference only for the levels of K (potassium) in the foliar analysis, with the control being the treatment with application of mineral N. at the full dose ( 100 kg ha-1) and the Azonit treatment associated with half a dose of mineral N (50 kg ha-1) presented the highest concentrations of K. Comparing the nutrient contents, it appears that the levels are adequate ( 17.5 to 22.5 g kg-1), however, shows the inference of the treatments (Malavolta *et al*. 1997).

**Formigueiro – RS**

For the trial carried out in Formigueiro (Table 8), the BPA assessments in R1, AP (V2 and R1), EC, NFGE and NGF did not show statistically significant differences for the treatments. However, there was a statistically significant difference for BPA in V2, where treatment with mineral nitrogen (100 kg ha-1) promoted the highest biomass production due to its high solubility, and rapid availability to root absorption.

The treatment with Azonit, combined with half dose of mineral nitrogen (50 kg ha-1) promoted the increase of the MMG, different from the other treatments, consequently the treatment obtained the highest productivity. Since, this treatment presented increments of 15.0% in productivity in relation to the control treatment, being this the only treatment that differed from the others.

The treatments containing only inoculants (Nitro 1000 and Azonit) promoted an increase in productivity of 11 and 14%, respectively, in relation to the control and did not differ from the treatments that provided mineral nitrogen.

In the chemical analysis of macronutrients and micronutrients, nitrogen in foliar analysis and iron in grain analysis differed between treatments, and inoculation promoted higher concentration of this micronutrient (Table 9).

**Itaara – RS**

Among the parameters analyzed in the city of Itaara, there was a statistically significant difference for BPA in V2 and in PROD, and the control treatment was inferior to the others in the production of biomass and the treatment with Azonit combined with half a dose of mineral nitrogen (50 kg ha-1) which promoted the highest productivity (28% increase), being statistically similar to the complete mineral nitrogen treatment (100 kg ha-1) (Table 10).

In the chemical analysis of the study conducted in Itaara, only N for macronutrients and micronutrients differed from the others (Table 11). In the foliar analysis, the treatments Azonit and Azonit combined with half a dose of mineral nitrogen (50 kg ha-1) were the ones that promoted the highest concentration of this nutrient, and for the grains the control showed the lowest concentration.

**Discussion**

The application of nitrogen associated with the inoculant provided significantly superior results in the agronomic performance of maize, mainly with regard to grain yield, MMG, shoot and root dry mass in Planaltina. Galindo *et al*. (2020a) found an influence of N doses on macronutrient contents in wheat grains. Increase in the mass of a thousand grains and of grains per ear was also found in the results of Mascarello and Junior (2015) and Sangoi *et al*. (2015).

Martins *et al*., (2018) found significant differences, with an increase of 17.18% for the number of ears and 10.78% for popcorn grain productivity, reducing the topdressing to 50 kg ha-1 in the presence of *Azospirillum brasiliense*, demonstrating the potential in the economy of nitrogen fertilizers in production.

Nitrogen fertilization at sowing contributed to increase the growth of corn, with the inoculation of *Azospirillum brasilense* in the seeds and/or leaves the results were similar to the nitrogen fertilizer for the growth of plants Moreno *et al*. (2019). Corroborating this statement, the treatment with Mineral N. had the highest concentration of nitrogen in the leaf analysis (Table 9).

Comparing nutrient levels in leaves with Malavolta et al. (1997), the levels are still low, showing that the incorporation of the applications resulted in benefits in the development of the culture, increasing the nitrogen concentration. Heckman, Sims and Beegle (2003) found Fe levels in grains ranging from 9.0 to 89.5 mg kg-1, thus, the influence of inoculation on micronutrient contents can be observed in the results.

The application of *Azospirillum brasilense* associated with nitrogen fertilization does not interfere with plant development and grain yield, however, halving the supply of nitrogen fertilizer associated with inoculation proved to be the most viable treatment for the crop, providing an increase in productivity. This result is similar to the results found by Godoy *et al*. (2011), Repke *et al*. (2013) and Rochenbach *et al*. (2017).

The results obtained evidenced the ability of *Azospirrillum* to carry out biological nitrogen fixation in symbiosis with the plant (Fukami *et al*. 2018). These benefits related to *Azospirrillum* can promote better plant development, and consequently higher yields (Galindo *et al*. 2020b; Quadros *et al*. 2014).

Thus, bacteria of the genus *Azospirillum* can generate several stimuli in plant development, such as the production of plant phytohormones such as auxins, gibberellins and cytokinins (Cavallet *et al*. 2000), which consequently promote greater root development and photosynthetic activity (Gordillo-Delgado *et al*. 2016; Kazi *et al*. 2016).

**Conclusion**

Fertilization with mineral N provides greater initial development of the corn crop due to the immediate supply of nitrogen, but inoculation with the diazotrophic bacterium *Azospirillum brasilense* supplied the nutritional requirement of the nitrogen crop and did not affect the absorption of other nutrients. Inoculation of *Azospirillum brasilense* in corn did not affect the development and yield of the crop. The halving of nitrogen fertilizer supply, associated with inoculation, proved to be the most viable treatment for the culture, providing greater productivity. However, studies on the optimal rate of mineral N. combined with inoculation with *Azospirillum brasilense* are topics that need to be clarified.

**Acknowledgements**

The first author acknowledges the financial grant Innova Agrotecnologia, Foz do Iguaçu, PR, Brazil.

**Author contributions**

ARA, RPA and CAFA designed the experiments, RS, DMG, ARA, RPA and CAFA interpreted the results, RS and DMG did the writing and RS, ARA, RPA and CAFA statistically analyzed the data and made illustrations

**References**

Brum MS, Cunha VS, Stecca JDL, Grando LFT, Martin TN (2016). Components of corn crop yield under inoculation with *Azospirillum brasilense* using integrated crop-livestock system. *Acta Scientiarum Agronomy*. V. 38, p. 485-492.

Cavallet L, Pessoas A C Dos S, Helmich J J, Helmich P R, Ost CF (2000). Produtividade do milho em resposta à aplicação de nitrogênio e inoculação das sementes com *Azospirillum* spp. *Revista Brasileira de Engenharia Agrícola e Ambiental*. V.4, n.1, p. 129-132.

Ciampitti IA, Elmore RW, Lauer J (2016). *Fases do desenvolvimento da cultura do milho*. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Conab - *Acompanhamento da safra brasileira de grãos.* v.9 – safra 2021/22, nº6 – Sexto levantamento, março, 2022. Accessed: 21/03/2022.

Corassa GM, Bertollo GM, Gallon M, Bona SD, Santi AL (2013). Inoculação com *Azospirillum brasilense* associada à adubação nitrogenada em trigo na região norte do Rio Grande do Sul. *Enciclopédia biosfera*. V. 9, p. 1298-1308.

Dickmann L, Andreotti M, Nakao AH, Catalani GC (2017). Residual da adubação fosfatada e do *Azospirillum brasilense* no feijoeiro em sucessão ao consórcio milho/capim-Marandu. *Revista Ciência Agronômica*, v. 48, n. 3, p. 404-412.

Fukami J, Cerezini P, Hungria M (2018). *Azospirillum*: benefits that go far beyond biological nitrogen fixation. *AMB Express***,** v.8**,** 73. https://doi.org/10.1186/s13568-018-0608-1

Galindo FS, Teixeira Filho MCM, Buzetti S, Pagliari PH, Santini JMK, Alves CJ, Megda MM, Nogueira TAR, Andreotti M, Arf, O (2015). Maize yield response to nitrogen rates and sources associated with *Azospirillum brasilense. Agronomy Journal.* 111:1985-97. https://doi.org/10.2134/agronj2018.07.0481

Galindo FS, Teixeira Filho MCM, Da Silva EC, Buzetti S, Fernandes GC, Rodrigues WL (2020a). Technical and economic viability of cowpea co-inoculated with *Azospirillum brasilense* and *Bradyrhizobium* spp. and nitrogen doses. *Revista Brasileira de Engenharia Agrícola e Ambiental.* 24:305-12. https://doi.org/10.1590/1807-1929/agriambi.v24n5p305-312

Galindo FS, Teixeira Filho MCM, Buzetti S, Santini JMK, Boleta EHM, Rodrigues LW (2020b). Macronutrient accumulation in wheat crop (*Triticum aestivum* L.) with *Azospirillum brasilense* associated with nitrogen doses and sources**.** *Journal of Plant Nutrition*. 43:1057-69. https://doi.org/10.1080/01904167.2020.1727511

Garcia MM, Pereira LC, Braccini AL, Angelotti P, Suzukawa AK, Marteli DCV, Felber PH, Bianchessi PA, Dametto IB (2017). Efeitos de *Azospirillum brasilense* sobre o desenvolvimento e produtividade do milho cultivado sob redução da adubação nitrogenada. *Revista de Ciências Agrárias,* 40(2): 353-362.

Godoy JCS, Watanabe SH, Fiori CCL, Guarido RC (2011). Produtividade de milho em resposta a doses de nitrogênio com e sem inoculação das sementes com *Azospirillum brasilense*. *Campo Digit@l,* v6, n1, p. 26-30, Campo Mourão.

Gordillo-Delgado F, Marín E, Calderón A (2016). Effect of *Azospirillum brasilense* and *Burkholderia unamae* Bacteria on Maize Photosynthetic Activity Evaluated Using the Photoacoustic Technique**.** *International Journal of Thermophysics*. 37, 1-11.

Heckman JR, Sims JT, Beegle D (2003). Nutrient removal by corn grain harvest. *Agronomy Journal*, v.95, n.3, p.587-591. https://doi.org/10.2134/agronj2003.5870

Hungria M, Campo RJ, Souza EM, Pedrosa FO (2010). Inoculation with selected strains of *Azospirillum brasilense* and *A. lipoferum* improves yields of maize and wheat in Brazil. *Plant Soil*. V331, p. 413-425.

Hungria M (2011). *Inoculação com Azospirillum brasilense: inovação em rendimento a baixo custo.* Embrapa Soja, Document 325. Londrina-PR.

Kazi N, Deaker R, Wilson N, Muhammad K, Trethowan R (2016). The response of wheat genotypes to inoculation with *Azospirillum brasilense* in the field. *Field Crops Research.* V.196, p.368-378.

Lana MC, Dartora J, Marini D, Hann JE (2012). Inoculation with *Azospirillum*, associated with nitrogen fertilization in maize. *Revista Ceres*, Viçosa, v.59, n.3, p.399-405. https://doi.org/10.1590/S0034-737X2012000300016.

Malavolta E, Vitti GC, Oliveira SA (1997). *Avaliação do estado nutricional das plantas: princípios e aplicações.* Piracicaba: Associação Brasileira para a Pesquisa da Potassa e do Fosfato, p.319.

Martinez SB, Pomés J, Masi MA, Chale W, De Benedetto JP, Garbi M (2016). Production and response to *Azospirillum brasilense* inoculation in two globe artichoke hybrids. *Acta Horticulturae*. V.1147, p.213-216.

Martins TG, Freitas Júnior SP Luz LN, Marco CA, Vásquez EMF (2018). Inoculation efficiency of *Azospirillum brasilense* on economising nitrogen fertiliser in landrace popcorn.*Revista Ciência Agronômica*, v.49, n.2, p.283-290.

Mascarello G, Junior LAZ (2015). Produtividade de milho em resposta a doses de nitrogênio e inoculação das sementes com *Azospirillum brasilense***.** *Revista Cultivando o Saber*, Paraná, Ed. Especial, p.46-55.

Moreno AL, Kusdra JF, Picazevicz AAC (2019). Crescimento do milho em resposta a *Azospirillum brasilense* e nitrogênio. *Revista Ibero Americana de Ciências Ambientais*. v.10, n.5, p.287-294. DOI: http://doi.org/10.6008/CBPC2179-6858.2019.005.0025

Munareto JD, Martin TN, Fipke GM, Cunha VS, Rosa GB (2019). Nitrogen management alternatives using *Azospirillum brasilense* in wheat. *Pesquisa Agropecuária Brasileira*, v.54. DOI: https://doi.org/10.1590/S1678-3921.

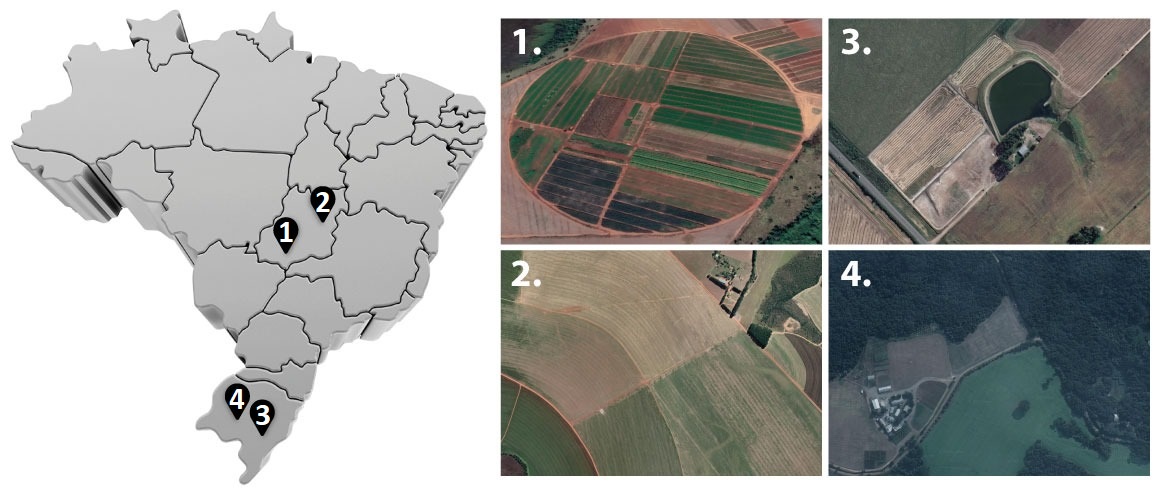
Portugal JR, Arf O, Peres AR, Gitti DC, Garcia NFS (2017). Coberturas vegetais, doses de nitrogênio e inoculação com *Azospirillum brasilense* em milho no Cerrado. *Revista Ciência Agronômica*, v.48, n.4, p.639-649.

Quadros PD, Roesch LFW, Silva PRF, Vieira VM, Roehrs DD, Camargo FAO (2014). Desempenho agronômico a campo de híbridos de milho inoculados com *Azospirillum*. *Revista Ceres*, Viçosa, v.61, n.2, p.209-218.

Repke RA, Cruz SJS, Silva CJ, Figueiredo PG, Bicudo SJ (2013). Eficiência da *Azospirillum brasilense* combinada com doses de nitrogênio no desenvolvimento de plantas de milho. *Revista Brasileira de Milho e Sorgo*, v.12, n.3, p.214-226.

Rockenbach MDA, Alvarez JWR, Fois DAF, Tiecher T, Karajallo JC, Trinidad SA (2017). Eficiência da aplicação de *Azospirillum brasilense* associado ao nitrogênio na cultura do milho. *Acta Iguazu,* Cascavel, v.6, n.1, p.33-44.

Sangoi L, Silva LMM, Mota MR, Panison F, Schmitt A, Souza NM, Giordani W, Schenatto DE (2015). Desempenho agronômico do milho em razão do tratamento de sementes com *Azospirillum* sp. e da aplicação de doses de nitrogênio mineral. *Revista Brasileira de Ciência do Solo*, Viçosa, v.1, n.39, p.1141-1150.



**Fig. 1:** Experimental locations in Brazil, (1) Planaltina - DF, (2) Água Fria de Goiás - GO, (3) Formigueiro - RS, (4) Itaara - RS, 2019/20.

**Table 1:** Chemical and physical analysis in the 0 - 20 cm layer and biological analysis in the 0 - 10 cm layer of the soil in the four experimental areas, in the 2019/20 crop.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Locality | pH  CaCl2 | P1 | | | K+ | S | Ca2+ | Mg2+ | Al3+ | H++Al3+ | CTC2  pH 7.0 |
|  |  | ----------- mg dm-3--------- | | | | | -------------- cmolc dm-3--------------- | | | | |
| Planaltina | 5.4 | 18.7 | | | 292 | 5.5 | 3.9 | 1.4 | 0.0 | 3.7 | 9.9 |
| Água Fria de Goiás | 5.7 | 25.6 | | | 149 | 7.0 | 3.6 | 0.9 | 0.0 | 4.7 | 9.7 |
| Formigueiro | 5.0 | 8.1 | | | 139.6 | 13.7 | 13.8 | 6.4 | 0.0 | 3.9 | 20.6 |
| Itaara | 4.7 | 11.3 | | | 135 | 10.0 | 6.1 | 2.4 | 0.0 | 8.8 | 14.1 |
|  | V3 | MO4 | Fe | | Mn | Cu | Zn | Argila | Silte | Areia | PBD |
|  | ---- % --- | | | ---- mg dm-3----- | | | ------- g kg-1-------- | | | (Nº of soil g cells-1)5 | |
| Planaltina | 62.1 | 2.9 | 22 | | 30.7 | 1.1 | 4.9 | 488 | 305 | 207 | 2.00 x 10³ |
| Água Fria de Goiás | 51.3 | 2.8 | 47 | | 10.2 | 0.9 | 1.9 | 352 | 208 | 440 | 1.50 x 10³ |
| Formigueiro | 84.1 | 2.3 | - | | 18.1 | 2.3 | 2.9 | 400 | 429 | 171 | 7.70 x 105 |
| Itaara | 62.0 | 3.1 | - | | 13.0 | 1.5 | 5.3 | 310 | 420 | 270 | 2.04 x 104 |

1P: Phosphorus (Mehlich); 2CTC: Cationic exchange capacity; 3V%: Percentage of base saturation; 4MO: Organic matter; 5Serial dilution method (Incubation in culture medium); 6PBD: Populations of diazotrophic bacteria present in soil.

**Table 2:** Description of the treatments used to evaluate the use of Azospirillum brasilense in the corn crop, 2019/20.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **n°** | **Treatments** | **Active Ingredient Concentration** | **Dose**  **(kg ha-1 or ml ha-1)** | **application stage1** |
| 1 | Witness | - | - | - |
| 2 | Mineral Nitrogen 2 | Nitrogen (45%) | 100 + 100 | S; F |
| 3 | 1/2 Mineral Nitrogen | Nitrogen (45%) | 50 + 50 | S; F |
| 4 | Nitro 1000 | *Azospirillum brasilense* (2 x 10­8 UFC.mL-1)3 | 100 | TS |
| 5 | Azonit | *Azospirillum brasilense* (1 x 108 UFC.mL-1) | 100 | TS |
| 6 | Azonit + 1/2 N. Mineral | *Azospirillum brasilense*  (1 x 108 UFC.mL-1);  + Nitrogen (45%) | 100 + 50 + 50 | TS; S; F |

1TS: Treatment of Seeds; S: Seeding; F: Flowering; 2Mineral Nitrogen: Urea (45% de Nitrogen); 3UFC: Colony forming units.

**Table 3:** Monthly average temperature (°C) and accumulated monthly precipitation (mm) during the cultivation period, in the four experimental sites, 2019/20.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Months | Planaltina | Água Fria de Goiás | | | Formigueiro | Itaara | | |
| Average Temperature (°C)1 | | | | | | |
| Dec/19 | 25.3 | | 24.4 | 23.4 | | | 24.7 |
| Jan/20 | 25.1 | | 23.3 | 22.6 | | | 25.3 |
| Feb/20 | 24.8 | | 23.5 | 23.6 | | | 24.3 |
| Mar/20 | 24.4 | | 23.3 | 18.9 | | | 25.1 |
| Apr/20 | 23.8 | | 23.1 | 16.3 | | | 19.8 |
| May/20 | 21.0 | | 21.4 | 16.2 | | | 16.4 |
| **Dec - May** | **24.0** | | **23.2** | **20.2** | | | **22.6** |
|  | Accumulated precipitation (mm) | | | | | | |
| Dec/19 | 256 | | 125 | 191 | | | 73 |
| Jan/20 | 179 | | 581 | 31 | | | 256 |
| Feb/20 | 282 | | 196 | 46 | | | 52 |
| Mar/20 | 336 | | 169 | 32 | | | 38 |
| Apr/20 | 150 | | 77 | 194 | | | 32 |
| May/20 | 29 | | 40 | 171 | | | 206 |
| **Dec - May** | **1232** | | **1189** | **665** | | | **657** |

Source: 1Weather station - Agrodetecta®.

**Table 4:** Evaluation of growth components and grain yield of corn (P3707VYH) submitted to the six treatments in the city of Planaltina - DF, 2019/20.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | BPA (g)1 | | | AP (cm) | | CE (cm) | NFGE | NGF | MMG (g) | PROD |
| V2 | R1 | V2 | | R1 | R6 | R6 | R6 | R6 | (kg ha-1) |
| Witness | 6.4 | 1135.8 | 43.1 | | 303.8 b | 17.6 | 16.5 | 29.4 b | 327.8 b | 9.542 |
| Mineral Nitrogen | 7.9 | 1204.9 | 43.6 | | 311.1 a | 18.4 | 17.0 | 33.2 a | 349.8 a | 10.282 |
| 1/2 Mineral Nitrogen | 6.2 | 1194.7 | 41.9 | | 306.5 a | 18.0 | 16.8 | 32.1 b | 350.6 a | 10.115 |
| Nitro 1000 | 6.8 | 1189.9 | 41.9 | | 301.8 b | 18.0 | 16.8 | 32.0 b | 351.5 a | 9.800 |
| Azonit | 6.4 | 1175.1 | 42.2 | | 299.7 b | 18.5 | 16.6 | 34.6 a | 360.3 a | 9.919 |
| Azonit + 1/2 Mineral N. | 7.3 | 1246.9 | 42.6 | | 301.7 b | 19.1 | 17.0 | 35.3 a | 359.6 a | 10.366 |
| Mean | 6.8 | 1191.2 | 42.55 | | 304.1 | 18.3 | 16.8 | 32.8 | 349.9 | 10.004 |
| Anova | ns2 | ns | ns | | \* | ns | ns | \* | \* | ns |
| CV3 (%) | 8.2 | 4.8 | 4.2 | | 1.5 | 4.2 | 3.8 | 6.0 | 2.2 | 4.6 |

1BPA: Aerial part biomass (g); AP: Plant height (cm); CE: Ear length (cm); NFGE: Number of grain rows per ear; NGF: Number of grains per row; MMG: Mass of 1000 grains (g); PROD: Grain yield (kg ha-1). 2Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 3CV: Variation Coefficient.

**Table 5:** Macronutrient and micronutrient content in corn grains (P3707VYH) with different treatments. Planaltina - DF, 2019/20.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Macronutrient (g.kg-1) | | | | | Micronutrient (mg.kg-1) | | | |
| N | P | K | Mg | S | Cu | Fe | Zn | B |
|  | Leaf analysis | | | | | | | | |
| Witness | 34.8 | 3.0 | 23.1 | 1.5 | 1.3 | 9.2 | 126.7 | 22.2 | 9.5 |
| Mineral Nitrogen | 37.1 | 3.6 | 22.9 | 1.5 | 1.3 | 9.8 | 125.7 | 26.0 | 9.3 |
| 1/2 Mineral Nitrogen | 36.2 | 3.3 | 23.1 | 1.5 | 1.3 | 10.4 | 128.3 | 28.5 | 10.3 |
| Nitro 1000 | 34.2 | 3.1 | 22.0 | 1.4 | 1.3 | 8.5 | 123.6 | 25.4 | 8.5 |
| Azonit | 36.0 | 3.2 | 21.5 | 1.5 | 1.3 | 10.1 | 134.7 | 27.0 | 9.5 |
| Azonit + 1/2 Mineral N. | 36.0 | 3.1 | 20.6 | 1.4 | 1.3 | 10.3 | 120.9 | 28.3 | 8.8 |
| Mean | 35.7 | 3.2 | 20.6 | 1.5 | 1.3 | 9.7 | 126.7 | 28.3 | 8.8 |
| Anova | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| CV% | 3.6 | 10.3 | 6.5 | 11.1 | 3.4 | 8.5 | 5.3 | 13.2 | 15.2 |
|  | Grains | | | | | | | | |
| Witness | 12.3 b | 2.4 b | 3.9 | 0.7 b | 0.6 b | 1.1 | 16.7 | 18.2 | 1.1 |
| Mineral Nitrogen | 13.6 a | 2.8 a | 3.8 | 0.8 a | 0.7 b | 1.3 | 18.8 | 18.7 | 1.7 |
| 1/2 Mineral Nitrogen | 12.0 b | 2.0 b | 3.1 | 0.7 b | 0.6 b | 1.1 | 12.6 | 15.2 | 1.0 |
| Nitro 1000 | 11.0 b | 2.4 b | 3.6 | 0.7 b | 0.6 b | 1.0 | 13.1 | 15.9 | 1.7 |
| Azonit | 14.0 a | 3.0 a | 4.0 | 0.9 a | 0.8 a | 1.3 | 21.2 | 21.3 | 1.0 |
| Azonit + 1/2 Mineral N. | 15.1 a | 2.9 a | 4.1 | 1.0 a | 0.9 a | 1.2 | 24.3 | 22.0 | 1.7 |
| Mean | 13.0 | 2.9 | 3.8 | 0.8 | 0.7 | 1.2 | 17.8 | 18.6 | 1.4 |
| Anova | \* | \* | ns | \* | \* | ns | ns | ns | ns |
| CV% | 8.2 | 12.2 | 13.0 | 15.7 | 14.8 | 16.9 | 36.7 | 16.9 | 55.7 |

1Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 2CV: Variation Coefficient.

**Table 6:** Evaluation of growth components and grain yield of corn (P3707VYH) submitted to six treatments in Água Fria de Goiás - GO, 2019/20.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | BPA (g)1 | | AP (cm) | | CE (cm) | NFGE | NGF | MMG (g) | PROD |
| V2 | R1 | V2 | R1 | R6 | R6 | R6 | R6 | (kg ha-1) |
| Witness | 4.5 | 978.6 b | 16.2 | 279.4 | 18.1 | 14.5 b | 33.5 | 376.5 b | 9.123 b |
| Mineral Nitrogen | 7.1 | 1113.5 a | 18.6 | 281.3 | 17.7 | 16.4 a | 34.7 | 391.5 a | 10.035 a |
| 1/2 Mineral Nitrogen | 6.4 | 1199.1 a | 16.9 | 280.6 | 17.9 | 15.8 a | 35.7 | 389.9 a | 9.913 a |
| Nitro 1000 | 6.4 | 1101.6 a | 17.2 | 281.6 | 17.9 | 15.5 a | 35.4 | 381.1 b | 9.867 a |
| Azonit | 5.2 | 980.0 b | 17.2 | 281.1 | 18.0 | 16.2 a | 36.2 | 379.1 b | 9.968 a |
| Azonit + 1/2 Mineral N. | 5.6 | 1086.2 a | 17.8 | 281.0 | 17.9 | 16.0 a | 35.0 | 376.0 b | 10.007 a |
| Mean | 5.9 | 1076.5 | 17.3 | 280.8 | 17.9 | 15.7 | 35.1 | 382.4 | 9.819 |
| Anova | ns2 | \* | ns | ns | ns | \* | ns | \* | \* |
| CV3 (%) | 3.4 | 6.2 | 8.6 | 1.7 | 2.5 | 3.9 | 5.7 | 2.1 | 4.6 |

1BPA: Aerial part biomass (g); AP: Plant height (cm); CE: Ear length (cm); NFGE: Number of grain rows per ear; NGF: Number of grains per row; MMG: Mass of 1000 grains (g); PROD: Grain yield (kg ha-1). 2Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 3CV: Variation Coefficient.

**Table 7:** Macronutrient and micronutrient content in corn grains (P3707VYH) with different treatments. Água Fria de Goiás - GO, 2019/20.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Macronutrient (g.kg-1) | | | | | Micronutrient (mg.kg-1) | | | |
| N | P | K | Mg | S | Cu | Fe | Zn | B |
|  | Leaf analysis | | | | | | | | |
| Witness | 36.4 | 2.6 | 20.0 a | 2.3 | 1.3 | 8.3 | 138.7 | 22.3 | 7.8 |
| Mineral Nitrogen | 36.7 | 2.5 | 20.6 a | 2.4 | 1.4 | 8.3 | 131.6 | 25.2 | 8.3 |
| 1/2 Mineral Nitrogen | 36.7 | 2.4 | 18.2 b | 2.1 | 1.4 | 8.7 | 142.0 | 25.8 | 8.0 |
| Nitro 1000 | 37.3 | 2.4 | 19.3 b | 2.3 | 1.3 | 8.3 | 139.0 | 26.4 | 8.0 |
| Azonit | 36.9 | 2.4 | 18.6 b | 2.1 | 1.4 | 7.5 | 123.6 | 21.6 | 7.3 |
| Azonit + 1/2 Mineral N. | 36.2 | 2.7 | 19.7 a | 2.6 | 1.3 | 8.1 | 120.5 | 20.4 | 7.3 |
| Mean | 36.7 | 2.5 | 19.4 | 2.3 | 1.4 | 8.2 | 132.6 | 23.6 | 7.8 |
| Anova | ns | ns | \* | ns | ns | ns | ns | ns | ns |
| CV% | 1.3 | 7.0 | 4.2 | 7.4 | 6.2 | 12.6 | 9.8 | 14.8 | 9.7 |
|  | Grains | | | | | | | | |
| Witness | 12.9 | 2.4 | 3.2 | 0.8 | 0.7 | 1.3 | 19.5 | 14.8 | 1.0 |
| Mineral Nitrogen | 13.6 | 2.5 | 3.3 | 0.7 | 0.8 | 1.0 | 15.8 | 15.3 | 1.4 |
| 1/2 Mineral Nitrogen | 13.3 | 2.2 | 3.2 | 0.6 | 0.7 | 1.0 | 15.8 | 13.4 | 1.1 |
| Nitro 1000 | 12.9 | 2.5 | 3.3 | 0.7 | 0.8 | 1.7 | 19.3 | 15.6 | 1.1 |
| Azonit | 13.2 | 2.3 | 3.2 | 0.7 | 0.7 | 1.6 | 16.3 | 14.1 | 1.3 |
| Azonit + 1/2 Mineral N. | 13.6 | 2.4 | 3.3 | 0.7 | 0.7 | 1.1 | 15.9 | 14.2 | 1.5 |
| Mean | 13.3 | 2.4 | 3.3 | 0.7 | 0.7 | 1.3 | 17.1 | 14.6 | 1.2 |
| Anova | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| CV% | 6.9 | 14.6 | 9.2 | 16.8 | 14.5 | 45.3 | 27.6 | 15.9 | 48.0 |

1Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 2CV: Variation Coefficient.

**Table 8:** Evaluation of growth and grain yield components of corn (Feroz Viptera 3) submitted to six treatments in the city of Formigueiro - RS, 2019/20.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | BPA (g)1 | | | AP (cm) | | CE (cm) | NFGE | NGF | MMG (g) | PROD |
| V2 | | R1 | V2 | R1 | R6 | R6 | R6 | R6 | (kg ha-1) |
| Witness | | 1.5 b | 209.6 | 25.4 | 114.8 | 10.6 | 14.3 | 22.4 | 163.1 b | 3.429 b |
| Mineral Nitrogen | | 2.5 a | 238.5 | 27.8 | 124.9 | 12.7 | 15.0 | 25.6 | 170.8 b | 3.938 a |
| 1/2 Mineral Nitrogen | | 1.9 b | 241.7 | 27.7 | 125.8 | 12.9 | 14.6 | 25.3 | 160.9 b | 3.810 a |
| Nitro 1000 | | 2.0 b | 231.4 | 24.0 | 122.7 | 11.8 | 14.4 | 23.8 | 171.5 b | 3.816 a |
| Azonit | | 1.8 b | 250.5 | 22.8 | 119.3 | 12.0 | 14.9 | 23.6 | 166.2 b | 3.915 a |
| Azonit + 1/2 Mineral N. | | 1.5 b | 242.3 | 22.8 | 122.7 | 11.3 | 14.7 | 23.8 | 200.6 a | 3.944 a |
| Mean | | 1.9 | 235.7 | 25.1 | 121.7 | 11.9 | 14.7 | 24.1 | 172.2 | 3.809 |
| Anova | | \* | ns2 | ns | ns | ns | ns | ns | \* | \* |
| CV3 (%) | | 20.3 | 12.9 | 11.7 | 8.3 | 13.3 | 5.1 | 15.1 | 4.5 | 5.8 |

1BPA: Aerial part biomass (g); AP: Plant height (cm); CE: Ear length (cm); NFGE: Number of grain rows per ear; NGF: Number of grains per row; MMG: Mass of 1000 grains (g); PROD: Grain yield (kg ha-1). 2Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 3CV: Variation Coefficient.

**Table 9:** Macronutrient and micronutrient content in corn grains (Feroz Viptera 3) with different treatments. Formigueiro - RS, 2019/20.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Macronutrient (g.kg-1) | | | | | Micronutrient (mg.kg-1) | | | |
| N | P | K | Mg | S | Cu | Fe | Zn | B |
|  | Leaf analysis | | | | | | | | |
| Witness | 16.6 b | 1.9 | 21.6 | 2.3 | 1.0 | 4.3 | 273.0 | 23.3 | 67.9 |
| Mineral Nitrogen | 25.0 a | 1.9 | 23.4 | 2.4 | 1.2 | 4.8 | 359.7 | 26.6 | 70.2 |
| 1/2 Mineral Nitrogen | 16.2 b | 2.0 | 20.8 | 2.1 | 1.2 | 6.6 | 317.4 | 26.0 | 60.6 |
| Nitro 1000 | 17.7 b | 1.9 | 21.0 | 2.2 | 1.1 | 4.5 | 309.8 | 23.5 | 64.3 |
| Azonit | 19.2 b | 2.0 | 21.7 | 2.3 | 1.0 | 6.4 | 285.1 | 28.5 | 70.0 |
| Azonit + 1/2 Mineral N. | 24.4 a | 2.2 | 23.4 | 2.3 | 1.1 | 6.1 | 287.0 | 26.7 | 69.2 |
| Mean | 19.2 | 2.0 | 22.0 | 2.3 | 1.1 | 5.5 | 305.3 | 25.8 | 67.0 |
| Anova | \* | ns | ns | ns | ns | ns | ns | ns | ns |
| CV% | 17.0 | 10.0 | 8.7 | 13.3 | 15.5 | 28.1 | 12.5 | 13.1 | 11.7 |
|  | Grains | | | | | | | | |
| Witness | 13.2 | 2.2 | 3.0 | 1.1 | 1.0 | 1.8 | 27.3 b | 23.3 | 1.0 |
| Mineral Nitrogen | 14.5 | 2.1 | 3.3 | 1.0 | 1.0 | 2.3 | 21.5 b | 23.0 | 2.0 |
| 1/2 Mineral Nitrogen | 12.8 | 2.0 | 2.8 | 0.9 | 1.1 | 2.3 | 62.0 b | 23.8 | 2.5 |
| Nitro 1000 | 11.5 | 2.3 | 2.8 | 0.9 | 1.0 | 1.8 | 86.3 a | 18.3 | 3.0 |
| Azonit | 12.4 | 2.0 | 2.6 | 0.9 | 1.1 | 1.8 | 99.0 a | 19.5 | 1.3 |
| Azonit + 1/2 Mineral N. | 12.0 | 2.0 | 2.7 | 0.9 | 1.1 | 2.0 | 94.3 a | 20.0 | 1.6 |
| Mean | 12.7 | 2.1 | 2.9 | 1.0 | 1.1 | 2.0 | 65.1 | 21.3 | 1.9 |
| Anova | ns | ns | ns | ns | ns | ns | \* | ns | ns |
| CV% | 8.7 | 17.9 | 12.0 | 25.0 | 12.8 | 39.1 | 31.5 | 20.6 | 83.7 |

1Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 2CV: Variation Coefficient.

**Table 10:** Evaluation of growth components and grain yield of corn (Feroz Viptera 3) submitted to the six treatments in the city of Itaara - RS, 2019/20.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | BPA (g)1 | | AP (cm) | | CE (cm) | NFGE | NGF | MMG (g) | PROD |
| V2 | R1 | V2 | R1 | R6 | R6 | R6 | R6 | (kg ha-1) |
| Witness | 0.6 b | 471.4 | 16.5 | 193.2 | 14.8 | 15.4 | 30.2 | 260.6 | 4.088 b |
| Mineral Nitrogen | 1.1 a | 559.9 | 18.2 | 209.0 | 15.5 | 15.3 | 33.4 | 273.2 | 5.068 a |
| 1/2 Mineral Nitrogen | 1.2 a | 476.5 | 15.9 | 182.4 | 13.8 | 15.0 | 26.3 | 263.2 | 3.672 b |
| Nitro 1000 | 1.3 a | 509.8 | 15.0 | 196.8 | 15.2 | 15.3 | 29.9 | 269.6 | 4.423 b |
| Azonit | 1.6 a | 531.9 | 15.3 | 202.2 | 15.3 | 16.0 | 31.2 | 271.5 | 4.470 b |
| Azonit + 1/2 Mineral N. | 1.3 a | 612.9 | 16.3 | 232.2 | 14.9 | 15.5 | 31.0 | 275.1 | 5.234 a |
| Mean | 1.2 | 527.1 | 16.2 | 202.6 | 14.9 | 15.4 | 30.3 | 268.9 | 4.492 |
| Anova | \* | ns2 | ns | ns | ns | ns | ns | ns | \* |
| CV3 (%) | 17.9 | 11.5 | 10.9 | 11.9 | 7.8 | 4.2 | 9.4 | 3.8 | 12.3 |

1BPA: Aerial part biomass (g); AP: Plant height (cm); CE: Ear length (cm); NFGE: Number of grain rows per ear; NGF: Number of grains per row; MMG: Mass of 1000 grains (g); PROD: Grain yield (kg ha-1). 2Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 3CV: Variation Coefficient.

**Table 11:** Macronutrient and micronutrient content in corn grains (Feroz Viptera 3) with different treatments. Itaara - RS, 2019/20.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Macronutrient (g.kg-1) | | | | | Micronutrient (mg.kg-1) | | | |
| N | P | K | Mg | S | Cu | Fe | Zn | B |
|  | Leaf analysis | | | | | | | | |
| Witness | 15.6 b | 2.3 | 21.1 | 2.7 | 1.0 b | 5.7 | 528.4 | 25.3 | 54.6 |
| Mineral Nitrogen | 15.7 b | 2.7 | 24.0 | 2.4 | 1.3 a | 6.1 | 472.1 | 34.2 | 62.5 |
| 1/2 Mineral Nitrogen | 15.0 b | 2.3 | 23.7 | 2.9 | 1.1 b | 6.1 | 503.7 | 26.8 | 59.4 |
| Nitro 1000 | 16.5 b | 3.1 | 26.0 | 3.0 | 1.4 a | 6.6 | 484.7 | 37.3 | 64.2 |
| Azonit | 19.8 a | 2.8 | 26.4 | 2.9 | 1.2 a | 7.1 | 496.1 | 34.3 | 60.0 |
| Azonit + 1/2 Mineral N. | 23.2 a | 2.7 | 25.0 | 2.9 | 1.3 a | 7.2 | 474.6 | 33.4 | 57.8 |
| Mean | 17.6 | 2.7 | 24.2 | 2.8 | 1.2 | 6.5 | 493.3 | 31.9 | 59.8 |
| Anova | \* | ns | ns | ns | ns | ns | ns | ns | ns |
| CV% | 21.7 | 16.6 | 14.1 | 16.7 | 14.3 | 24.3 | 18.5 | 21.1 | 9.3 |
|  | Grains | | | | | | | | |
| Witness | 12.1 b | 2.6 | 2.6 | 0.9 | 1.0 | 1.5 | 24.0 | 19.8 | 1.1 |
| Mineral Nitrogen | 14.2 a | 2.6 | 2.6 | 0.9 | 1.1 | 1.8 | 21.0 | 17.3 | 1.4 |
| 1/2 Mineral Nitrogen | 14.4 a | 2.7 | 2.5 | 0.9 | 1.1 | 1.5 | 22.5 | 18.8 | 1.3 |
| Nitro 1000 | 15.4 a | 2.7 | 2.6 | 0.9 | 0.9 | 1.3 | 20.7 | 19.3 | 1.2 |
| Azonit | 14.7 a | 2.7 | 3.1 | 1.1 | 1.0 | 1.5 | 24.5 | 21.5 | 2.1 |
| Azonit + 1/2 Mineral N. | 14.1 a | 2.8 | 2.9 | 1.1 | 1.0 | 1.5 | 25.0 | 20.8 | 1.4 |
| Mean | 14.2 | 2.7 | 2.7 | 1.0 | 1.0 | 1.5 | 23.0 | 19.6 | 1.4 |
| Anova | \* | ns | ns | ns | ns | ns | ns | ns | ns |
| CV% | 9.0 | 20.7 | 16.6 | 33.0 | 13.4 | 36.5 | 16.5 | 25.9 | 52.8 |

1Means followed by the same letter (column) do not differ significantly from each other by the Skott Knott test (p>0.05); 2CV: Variation Coefficient.