Original Research Article

Germination and early development of corn seeds under the influence of plant growth regulator

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ABSTRACT

The corn crop has been cultivated throughout the country, with increasing productivity with the help of technology products. There are greater demand and greater use of improved seeds, associated with treatments of fungicides, insecticides, and bioregulators. It is believed that the use of biostimulant can improve many plant characteristics, one of which is productivity. The present work had as objective to evaluate the effect of the use of biostimulant applied in the treatment of seeds on the germinability and initial development of corn plants. The biostimulants used in the experiment were the Haf-Plus® from the Inesta group, which is an organomineral stimulant and Stimulate® from Stoller do Brazil which is a hormonal bio stimulant. The experimental design was completely randomized, in a 2 x 4 factorial scheme, with two biostimulants (Stimulate® and Haf Plus®) in 4 doses (Stimulate: control, 0.5 mL of Stimulate + 1 mL of water, 1.0 mL of Stimulate + 0.5 mL of water, 1.5 mL of Stimulate, and for Haf Plus: control, 0.125 mL + 0.375 mL of distilled water, 0.25 mL of Haf Plus + 0.25 mL of water and 0.5 mL of Haf Plus), with 4 replicates of 10 seeds each. The Stimulate biostimulant was efficient to promote a significant increase of the entire root system and the volume of aerial part of the corn plants. With this, its use can increase the productivity because it makes the young plants more vigorous.

Keywords: Stimulate, Haf-plus, a plant hormone, seed treatment

1. INTRODUCTION

The corn plays a key role in the Brazilian and world agricultural production systems and is considered one of the most important cereals grown and consumed in the world, due to its high production potential, its chemical composition and nutritional value (Dourado Neto et al., 2004). Seed treatment is a practice used to increase seed performance, especially of high-value species such as corn hybrids, as it protects the crop during the early stages of the cycle (Pereira et al., 2008). These gains can be obtained by applying various products to the seeds, such as fungicide, insecticide, micronutrients and growth stimulators or vegetable bioregulators.

Among the most promising technologies to perform at this stage of the crop is the use of growth regulators, which make the plants more tolerant to stress factors and, consequently, can develop more vigorously in conditions that are not ideal, allowing better chances of to reach their genetic potential of productivity (Castro et al, 2008).

The biostimulants are defined by many authors, such as natural or synthetic substances arising from the mixing of two or more plant bioregulators or of these with other substances (amino acids, vitamins, and nutrients), which can be applied directly to the plant or seed treatment (Kiahold et al., 2006). It is sought, therefore, to obtain greater productions and better in the quality of the seeds. Many of these products increase the water and nutrient uptake by plants, as well as their resistance to water stresses and the residual effects of herbicides on the soil, making their use in agriculture increasing (Vasconcelos, 2006).

For better development of the root system, seeking an increase in productivity, there are plant growth regulators and bio-stimulants that stimulate the growth and elongation of the root system, and proved that the density and depth of the roots are fundamental aspects of plant productivity, for good root system is directly related to increased production (Vieira and Santos, 2005). In addition, biostimulants promote greater tolerance to abiotic stresses by producing responses in plant development. These hormones send chemical messages that stimulate plant growth, acting primarily on roots, shoot, and adapt better to their environment (Long, 2006).

The effects on the use of the biostimulant in agriculture are still quite divergent, which shows the need for new research to better evaluate the effects of these products on the cultivation of different crops since the responses of the plants vary according to the environmental conditions during the development. The purpose of this work was to evaluate the germinability of seeds and the initial development of corn plantain after the treatment of the seeds with the bioregulators.

2. MATERIAL AND METHODS

The experiment was conducted at the Laboratory of Seed Technology and Weed Science (LaSeM) of the State University of Mato Grosso - UNEMAT, Alta Floresta Campus – MT. Brazil. The experiment was organized in a completely randomized design, and the effect of two biostimulants at different germination and initial development stages of a corn cultivar was studied.

The work was organized in a 2 x 4 factorial scheme, and the treatments were composed by the combination of two biostimulants (Stimulate® and Haf Plus®) in 4 doses, with 4 replicates. Stimulate consists of 0.005% indolebutyric acid, kinetin) 0.009% and gibberellic acid 0.005% and Haf Plus is a fertilizer composed of boron (0.2% or 2.4 g L^{-1}), organic carbon (14% or 168 g L^{-1}), cobalt (0.02% or 0.6 g L^{-1}), copper (0.05% or 0.6 g L^{-1}), iron (0.1% or 1.2 g L^{-1}), manganese (25% or 300 g L^{-1}), molybdenum (0.2% or 2.4 g L^{-1}), nitrogen (5% soluble) and organic matter (25% or 300 g L^{-1}).

The seeds of each treatment with the biostimulants were homogeneously mixed with the products in the respective doses of each treatment as shown in Table 1. The biostimulant mixture with the seeds was given in the following proportion: Stimulate - 100 grams of seed for each dosage (D0): without mixing, 0.5 mL of Stimulate plus 1 mL of distilled water (D1), 1 mL of Stimulate + 0.5 mL of distilled water (D2), 1.5 mL of pure Stimulate (D3) (Table 1). And for Haf Plus - 100 grams of seeds for each dosage, being as follows; (D0) without mixing, dose 0.125 mL + 0.375 mL distilled water (D1), 0.25 mL Haf Plus + 0.25 mL distilled water (D2), and 0.5 mL Haf Plus pure (D3).

After the seeds were treated, they were placed on two sheets of germitest paper and covered with another, previously moistened (distilled water) with the ratio of 2.5 times the dry weight. After being rolled, these were identified and taken to Mangelsdorff germination chamber with temperature controlled at 25 °C for 7 days (Brazil, 2009). The counting was not performed at 4 days, in order to avoid any damage or damage of the seedlings formed, considering only the evaluation performed after one week of the assembly of the experiment. After this period, germination%, number of abnormal seedlings, root and aerial system length were evaluated. In addition, the root and aerial area of corn seedlings were determined using the LICOR leaf area meter model LI3100 Area meter.

Table 1. Scheme of the doses and products applied in the treatments.

Doses	Product	
	Stimulate (mL) + water	**Haf Plus (mL) + water**
D0	0.000	0.000
D1	0.500 + 1.000	0.125+0.375
D2	1.000+0.500	0.250+0.250
D3	1.500 pure	0.500 pure

The data were submitted to analysis of variance, and the means were compared by Tukey test at 5% probability, with the help of Sisvar software (Ferreira, 2011).

3. RESULTS AND DISCUSSION

For the variable germination, abnormal seedlings and shoot length, no difference was observed between biostimulants and doses of the products, either in isolation or for interaction between them (Table 2). Thus, it is possible to verify that both Stimulate and Haf-Plus did not interfere in the germination, number of normal seedlings and length of the aerial part of the corn seeds. Lavezo (2012) also did not verify the effect of the same biostimulants on the germinative capacity of soybean cultivars. However, the biostimulants provide a significant increase in the number of leaves in the cotton crop, and this fact was attributed to the plant regulators present in the applied product, where the growth of the aerial part was observed, through increased cell division, expansion and differentiation cellular (Sampaio, 1998).

Scarpellini et al. (2003) evaluated biostimulants in the treatment of soybean seeds and did not show an increase in the percentage of germination of the seeds. No results were also observed regarding plant height, plant weight, and productivity.

Almeida et al. (2009) reported that biostimulants have the ability to allow greater expression of seed germination potential, with accelerated root growth, increasing nutrient and water uptake by plants.

Table 2. Mean square values % of germination (G%), abnormal seedlings (AP) and aerial part length (APL) of corn seeds submitted to treatments with biostimulants at different doses

Font of Variation	G%	AS	APL
Product (P)	28,1250^{ns}	0,1250^{ns}	51.2578^{ns}
Dose (D)	11,4583^{ns}	0,0833^{ns}	92.0703^{ns}
P * D	11,4583^{ns}	0,7083^{ns}	313.7370^{ns}
Error	34,3750	0,4583	147.7110
C.V. (%)	6,07	18,32	17,24

*** and * significant at 1 and 5% probability respectively by the F. ^{ns} test: not significant.*

Regarding the root length of corn seedlings (Table 3), a significant interaction between the factors studied was observed (Table 3).

For Stimulate it is noted that doses 3 and 2 were higher than dose 1 and the control, indicating a beneficial effect of the product at higher doses. No differences were observed between the doses for root length for the Haf-Plus biostimulant.

Similarly, Vieira et al. (2001) found that the stimulate biostimulant applied through seed treatment showed higher root system growth and total root length for sisal, bean and rice crops and also observed that the application of these products did not obtain significant results regarding phytotoxicity for these cultures.

The Stimulate product has as a special feature to promote greater rooting by the presence of three synthetic hormones, which provide greater cell division, increasing and improving the formation of the root and aerial system, giving greater photosynthetic capacity and greater absorption of water and nutrients. (Stoller, 1998).

When comparing the two products, it is possible to verify that at dose 2 there was a significant difference between the products, where the upper Stimulate, demonstrating its ability to promote root lengthening.

Table 3. Root length of corn seedlings submitted to treatment with biostimulants at different concentrations.

Dose	Product	
	Stimulate	Haf-Plus
0	119,75 A b	130,50 A a
1	117,00 A b	129,00 A a
2	142,00 A a	111,00 B a
3	147,50 A a	126,50 A a
CV (%)	12,26	

Means followed by the same capital letter in the row and lowercase in the column, do not differ among themselves by the Tukey test at 5% probability.

Regarding the total root area of corn, a significant interaction between the factors was observed (Table 4). For Stimulate, the lower dose applied (D1) caused a decrease in the radicle area of the plants, indicating a negative effect of the product. However, the larger doses D2 and D3 stimulated the root development, however not differing from the control without application of the product. With respect to Haf-Plus, the highest mean was observed at the lowest dose (D1), which differed only from the D2 dose, indicating that the product did not cause a significant increase in the root area of the plants compared to the control without application. In the comparison between the two products, the superiority of the Stimulate from the D2 dose is perceived, indicating, therefore, the superiority of the same in the stimulation to the initial root development of the corn plants.

Table 4. The total area occupied by the root portion of corn seedlings submitted to treatment with biostimulants at different concentrations.

Dose	Product	
	Stimulate	Haf-Plus
0	27,35 A ab	22,55 A ab
1	22,60 A b	29,33 A a
2	36,85 A a	18,53 B b
3	33,83 A a	24,03 B ab
c.v. (%)	18,64	

Means followed by the same capital letter in the row and lowercase in the column, do not differ among themselves by the Tukey test at 5% probability.

Ferreira et al. (2007) found a difference in root length of corn cultivars in an evaluation made with four biostimulants, applied through seed treatment, where it obtained a significant difference in root dry mass production. Klahold et al. (2005) did not find a significant difference in evaluation with dosages of the same biostimulant for root volume in relation to the control treatments.

Vieira et al. (2001) also found in the research that the biostimulants applied through seed treatment provided greater growth of the root system, as well as in the total root area. Sanders et al. (2001) evaluated the effect of the application of five biostimulants on carrot development (*Daucus carota* L.) and found a significant increase in the number of roots.

For the leaf aerial, there was a significant interaction among the factors, where for the Stimulate, the higher doses (D2 and D3) provided an increase in the leaf area of the plants. Regarding Haf-Plus, no significant difference was observed between doses. The Stimulate

proportion increased leaf area development relative to Haf-Plus only at the highest dose (D3), again providing further development.
According to Ferreira et al. (2007), the use of biostimulants via seed treatment and foliar via in corn cultivation leads to an increase in dry root mass and total root system volume, as well as the height of ear insertion, and grain yield, Dario and Baltierri et al. (1998) in one study, observed the efficacy of plant regulators in the corn crop, where the total volume of the root system was positive.

Table 5. Total area occupied by aerial part of corn seedlings submitted to treatment with biostimulants at different concentrations.

Dose	Product	
	Stimulate	**Haf-plus**
0	22,25 A b	19,73 A a
1	20,05 A b	24,80 A a
2	26,15 A ab	21,05 A a
3	30,25 A a	19,18 B a
c.v(%)	17,68	

Means followed by the same capital letter in the row and lowercase in the column, do not differ among themselves by the Tukey test at 5% probability.

According to Vieira and Castro (2004), the product Stimulate had the power to stimulate greater root development, increasing the nutrients and water absorption by the roots and thus allowing a greater hormonal balance.
Santos and Vieira (2005) verified in their research that the Stimulate product used for the treatment of cotton seeds, provided more vigorous seedlings, with a greater volume of leaf area and height of the plants, being indicated to obtain higher production yield.

4. CONCLUSION

The Stimulate biostimulant is efficient to promote root growth, aerial and total area of corn seedlings when seeds are treated with 1.0 mL of Stimulate® + 0.250 mL Haf Plus® mixed with water and also when the seeds are treated with Stimulate® (1,500 mL) and Haf Plus® (0.500 mL) without dissolution in water.

REFERENCES

Almeida AS, Carvalho I, Deuner C, Villela FA, Tillmann MAA. Bioactivator in the physiological performance of rice seeds (*Oryza sativa* L.). R Bras Sem. 2011; 33 (3): 501-11.

Castro PRC, Kluge RA. Ecophysiology of annual crops. São Paulo: Nobel, 1999. 126p.

Castro PRC, Kluge RA, Peres LEP. Hormones and plant regulators. In: Castro PRC, Kluge RA, Peres LEP. Manual of physiology: Theory and practice. Piracicaba: Agronomica Ceres, 2005. p.389-440.

Conab; Total corn (1st and 2nd harvest) - Brazil. 2013; 12. Accessed 16 October 2014. Available: http://www.conab.gov.br/OlalaCMS/uploads/arquivos/13_12_10_16_06_56_boletim_english_December_2013.pdfxls.

Dario GJA, Baltieri EM. Evaluation of the efficiency of the plant regulator Stimulate (cytokinin + indolebutyric acid + gibberellic acid) in corn (*Zea mays* L.). Technical Relat. School of Agriculture "Luiz de Queiroz", Piracicaba, 1998. 12 p.

Dourado Neto D, Dario GJA, Vieira-Júnior PA, Manfron PA, Martin TN, Bonnecarrére RAG, Crespo PEN. Application and influence of the regulator on the growth of corn plants. R Fac Zoot Vet Agron. 2004; 11 (1): 93-102.

Embrapa. Cultivation of corn. Embrapa-cnpms, 2008: 5. Accessed 20 May 2010. Available: http://www.cnpms.embrapa.br/publicacoes/milho/economia.htm.

Fancelli AL. Physiology, nutrition and corn fertilization for high yield. Department of Plant Production Esalq / USP: Piracicaba-SP; 2000.

Favarim JL, Marini JP. Importance of micronutrients for grain production. 2000: 6. Accessed 01 June 2007. Available: http://www.sna.agr.br/artigos/.

Ferrini F, Nicese F. Reponse of English oak (*Quercus robut* L.) trees to biostimulants application in the urban environment. J Arboric. 2002; 28 (2): 70-5.

Ferreira DF. Sisvar: A computer statistical analysis system. Ciênc Agrotec. 2011; 35 (6): 1039-42.

Ferreira LA, Oliveira JA, Von-Pinho EVR, Queiroz DL. Biostimulant and fertilizer associated with corn seed treatment. R Bras Sem. 2007; 29 (2): 80-9.

Floss EL, LG Floss. State-of-the-art organomineral fertilizers: physiological functions and use in agriculture. R Plant Straight. 2007; 100 (1): 26-9.

Grohs M, Marchesan E, Roso R. Performance of rice cultivars using growth regulators in different cropping systems. Pesq Agrop Bras. 2012; 47 (6): 776-83.

Hamza B, Suggars A. Biostimulants: myths and realities. Turfgrass Trends. 2001; 10 (1): 6-10.

Karnok KJ. Promises, promises: can biostimulants deliver? G Cour Manag. 2000; 68 (1): 67-71.

Klahold CA. Response of the soybean (*Glycine max* (L.) Merrill) to the action of biostimulant. 2005.37 f. Dissertation-State University of Western Paraná, Marechal Cândido Rondon, Brazil. 2005.

Janegitz MC, Serrano FB, Oliveira PMA, Paula JCB, Hermann ER. Effect of biostimulants via seed on initial development of corn and sorghum roots. In: Brazilian Meeting of Soil Fertility and Plant Nutrition, 28. 2008, Londrina. Challenges for the use of the soil with efficiency and environmental quality: Annals ... Londrina: Embrapa Soja; IAPAR; UEL, 2008. 1 CD-ROM

Long E. The importance of biostimulants in turfgrass management. 2006:1. Acessed 10 September 2006. Available: http//www.golfenviro.com/alticle%archive/biostimulants-roots.html.

Malavolta E, Vitti GS, Oliveira SA. Evaluation of the Nutritional State of the Plants: principles and applications, 2 ed. Piracicaba-SP: Esalq. 1997.

Pereira LMA, Minohara L, Vieira RD, Panizzi RC, Gotardo M. Fungicidal treatment of corn seeds and methodologies for conducting the cold test. R Ceres. 2008; 55 (3): 210-17.

Rocha MC, Silva ALB, Almeida A, Collard FH. Effect of the use of biostimulant Agrobio on the physical and chemical characteristics in the post-harvest of the yellow passion fruit (*Passiflora adulis* f. Flavicarpa Deg.) In the municipality of Taubaté. R Biociênc. 2001; 7 (1): 1-7.

Rodrigues TJD, Leite IC. Gibberellins. In: Rodrigues TJD, Leite IC. Plant physiology: plant hormones. Jaboticabal: Funep, 2004; p.19-38.

Rosolem CA, Fernandes EM, Andreotti M, Crusciol CAC. Root growth of 265 corn seedlings affected by soil resistance to penetration. Pesq Agropec Bras. 1999; 34 (5): 821-28.

Sampaio ES. Plant physiology: theory and experiments. Ponta Grossa, Uepg Publishing, 1998. 190p.

Sanders DS, Ricotta JA, Hodges L. Improvement of carrot stands with biostimulants and fluid drilling. Hortsci. 1990; 25 (2): 181-83.

Santos CM, Vieira EL. Effect of biostimulant on seed germination, seedling vigor and initial cotton growth. Magistra. 2005; 17 (3): 124-30.

Scarpellini JR, Cassanelli JR, Farias AM. Effect of thiamethoxan on seed treatment on the development of soybean crop. Arq Inst Biol. 2003; 70 (3): 1-5.

Silva VR, Reinert DJ, Reichert JM Soil density, chemical attributes and corn root system affected by grazing and soil management. R Bras Ciênc Solo. 2000; 24 (1): 191-99.

Stoller of Brazil. Stimulate in vegetables. Technical Report of Stoller do Brasil, Cosmopolis, v. 1, 1998.

Taiz L, Zeiger E. Plant Physiology. 3.ed. Porto Alegre: Artmed, 2004, 559p.

Vasconcelos ACF. Use of biostimulants in corn and soybean crops. 2006. 112 f. Thesis (Doctorate in Soils and Nutrition of Plants) - Luiz de Queiroz College of Agriculture, University of São Paulo, Brazil.

Vieira EL, Castro PRC. Stimulant action on early development of cotton plants (*Gossypium hirsutum* L.). Piracicaba: USP / Depto. Biological sciences, 2002. 3p.

Vieira EL. Applications of plant regulators in tropical agriculture. Guaíba: Agropecuária, 2001.

Vieira EL. Biostimulant action on seed germination, seedling vigor, root growth and soybean yield (*Glycine max* (L.) Merrill), common bean (*Phaseolus vulgaris* L.) and rice (*Oryza sativa* L.). 2001. 122 f. Thesis (Doctorate in Fitotecnia) - Superior School of Agriculture "Luiz de Queiroz", University of São Paulo, Piracicaba, 2001.

Vieira EL, Santos CMG. Plant stimulant in the growth and initial development of the cotton root system in rhizotrons. In: Brazilian Congress of Cotton, 2005. 2005. 1 CD-ROM.

Zheng YM, Ding YF, Wang QS, Li GH, Wang HZ, Wang SH. Effect of nitrogen applied before transplanting on tillering and nitrogen utilization in rice. Acta Agron Sinica. 2008;34 (3): 513-19.