

# Study of the Rooting Potential of Humic and Fulvic Acids, Amino Acids and Seaweed Extracts in Maize Culture

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**Abstract:** Corn is a commodity of great expression. For high yields, it is necessary that plants have availability of resources to develop and rely on vigorous root systems and adequate initial development. The inclusion in crops of products with humic and fulvic acids, seaweed and amino acids, is among resources. The objective was to present the results of a study conducted, the effect of the use of amino acids, humic and fulvic acids and seaweed associated with plant nutrients in the initial development of corn (*Zea mays* L.) cultivated in pots. The trial, with corn cultivate Bandeirante, was conducted outdoors in the Department of Plant Nutrition of the UniPinhal Agronomic Engineering Course, in Espírito Santo do Pinhal—SP (latitude 22°06'57" N, longitude 46°40'58" W and altitude of 892.7 m), from March to April 2018, in randomized blocks with eight treatments and four replicates. The products studied were applied in two periods: V1 and V3, by drench. Each plot consisted of a 20 L plastic container containing soil (classified as Acrisols-World Reference Base/FAO), corrected for fertility. At 55 d after germination were evaluated: root mass and length and culm diameter. All the results were treated statistically (analysis of variance and Duncan test at 5%). The treatments applied in the trial benefited the root development and culm diameter; humic and fulvic acids + N, P, Mo and Co + humic and fulvic acids + N, P and K, when considering all the criteria, was shown to be the most efficient.

**Key words:** Organic acids, metabolism, synergism.

## 1. Introduction

Corn is a major commodity, currently the world production of corn is 1,034.33 million tons and Brazil is the third largest producer in the world [1]. The average Brazilian maize yield, around 5 t/ha of corn, is extremely low compared to the United States, where the average is 11 t/ha [2].

For high productivity, it is necessary that plants have availability of resources to develop themselves and rely on vigorous root systems and adequate initial development. The inclusion in crops of products with humic and fulvic acids, seaweed and amino acids, is among such resources.

Humic and fulvic acids benefit the physical, chemical and microbiological quality of soils [3]. In addition to the effects on soil physical properties, humic substances help the rhizosphere chemistry and microbial dynamics by stimulating the release of organic acids and sugars by the roots [4].

In some studies, humic substances stimulate plant metabolism, improving nutrient uptake and transport, respiration and chlorophyll content, among other aspects [5].

According to M. A. Baldotto and L. E. B. Baldotto [6], humic substances act directly on plants: improving ion transport and increasing respiratory activity, chlorophyll content, nucleic acid synthesis and the activity of various enzymes. These authors mention, as the most studied effects of these acids,

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those related to the root system, notably in the formation of lateral roots and their elongation and the formation of root hairs. They consider that these factors provide increases of root mass and surface area of the roots, contributing to increasing the absorption of water and nutrients.

Studies demonstrated the potential use of humic and fulvic acids in promoting the increased efficiency of mineral fertilization [7], in corn and in wheat and demonstrated the positive effects of the use of humic and humic acids associated with nutrients in rooting and production [8].

Among marine algae, *Ascophyllum nodosum* (L.) Le Jolis stands out as a source of nutrients, amino acids, cytokinins, auxins, and abscisic acid, substances that stimulate plant cell metabolism, leading to increased growth and productivity [9, 10].

For Saa *et al.* [11] the inclusion of marine algae in crops is justified by their richness in mineral nutrients, auxins, amino acids and phytoalexins emphasize that the use as a nutritional supplement, biostimulants or even biofertilizers increases the productivity of the crops and makes the plants more resistant to pests and diseases.

Spann and Little [12] report that the use of algae in plants promote the endogenous production of growth hormones such as auxin, gibberellins and cytokinins. They consider the inclusion in the crops of such organisms to anticipate the germination of seeds, increases rooting, improving the formation of lateral roots and the absorbents roots and the absorption of water and nutrients, higher nutritional levels of the plant, and induces resistance to the abiotic agents.

It was also demonstrated a positive effect of the use of extracts of *A. nodosum* on the multiplication of the soil microbiota, mainly on the mycorrhizal fungi that secrete beneficial substances to the physical and chemical properties of the soil, which can improve the rhizosphere [13].

It is postulated that the use of amino acids, via soil or foliar, improves ionic uptake and transport,

resistance to water deficit and represents energy savings for plants [14].

Teixeira [15] considers that amino acids can contribute as nitrogen supplement and perform several other functions, for example, aspartic acid responds by the translocation of nitrogen by phloem, proline participates in the formation of lignin that is important to increase plant resistance to hydric and thermal stresses, the tryptophan precursor of indolylacetic acid and the serine precursor of tryptophan, among others. It also emphasizes that amino acids can act as biostimulants, improving rooting and development of the plants, favoring the quality and quantity of the production, leaving the plant resistant to external agents. There is evidence that the use of amino acids causes the plant to save energy and improve translocation of nutrients, thus having beneficial effects, since it is known that well-nourished plant is more tolerant to adverse conditions, and uses energy for faster recovery of the plant.

Exogenous amino acids stimulate protein synthesis and improve the transport and storage of nitrogen. Studies have shown that amino acids applied via foliar or radicular stimulate abundant rooting, which provides full plant establishment [14, 15]. In tomato and in eucalyptus seedlings it was observed that the use of biofertilizers containing amino acids promoted the formation of voluminous roots with greater green and dry mass [16].

Teixeira *et al.* [17] studied the influence of the use of the amino acids glutamate, cysteine, phenylalanine and glycine via seeds in emergence, accumulation of dry mass in soybean cultivated under controlled conditions. It was concluded that the use of amino acids was efficient, considering all the parameters used in the study. The most suitable amino acid doses were glutamate—12.37 mg/kg (seed), phenylalanine—3.09 mg/kg (seed), cysteine—12.37 mg/kg (seed) and glycine—9.28 mg/kg (seed).

The objective of this study was to present the results of a study conducted to verify the effect of the

inclusion of amino acids, humic and fulvic acids and marine algae associated to plant nutrients in the initial development of maize (*Zea mays* L.) cv. Bandeirantes.

## 2. Materials and Methods

The experiment was carried out in the Plant Nutrition Sector of the UniPinhal Agronomic Engineering Course, in Espírito Santo do Pinhal (SP) (latitude 22°06'57" N, longitude 46°40'58" W and altitude of 892.7m), with maize (*Z. mays* L.) cv Bandeirante from March/April 2018, the soil was corrected according to soil analysis (Table 1), in a randomized block with eight treatments (Table 2) and four replicates. The studied products were applied via drench, in two seasons: V1 and V3, vegetative stages with one and three pairs, respectively. Each plot consisted of a plastic container of 20 L of capacity containing soil (classified as Argissolo). It was fertilized in the planting with the 400 kg/ha of the fertilizer containing 4% of nitrogen, 14% of P<sub>2</sub>O<sub>5</sub> and 8% of K<sub>2</sub>O and in cover, at 30 d of the plant, 60 kg/ha

of N (as ammonium sulfate). At 55 d after germination were evaluated: fresh mass and root length and stem diameter. All the results were treated statistically, according to the statistical design: analysis of variance and Tukey test at 5%.

## 3. Results and Discussion

The results obtained (expressed in Table 3) show that the treatments applied in the trial benefited the root development and stalk diameter.

Considering the diameter of the stalk, the combinations of the two commercial formulations containing nutrients and humic and fulvic acids (Treatment 5), and the combination seaweed and humic and fulvic acids + N, P and K (Treatment 7) were the most efficient.

By analyzing root lengths, it was observed that all treatments promoted benefits in relation to control, showing the efficacy of humic and fulvic acids and seaweed. However, when observing the green mass data of the root system, it can be highlighted that the

**Table 1 Results of substrate analysis used in the test.**

Organic matter (g/dm <sup>3</sup> )	pH (CaCl <sub>2</sub> )	P	S	K	Ca	Mg	Al	SB	H + Al	CTC	V
		mg/dm <sup>3</sup>					mmolc/dm <sup>3</sup>				(%)
4	5.2	2	2	2.1	20	6	1	28.1	18	46.1	61
mg/dm <sup>3</sup>											
B	Cu	Fe			Mg			Zn			
1.3	1.3	10			0.6			0.4			

SB: sum of soil bases (K + Mg + Ca); CTC: soil cation exchange capacity; V: soil base saturation.

**Table 2 Treatments used in the test.**

Treatments	Fertilizers
1	Control
2	Amino acids + humic and fulvic acids + N, P, Mo and Co *
3	Amino acids + humic and fulvic acids + N, P and K **
4	Seaweed ***
5	Amino acids + humic and fulvic acids + N, P, Mo and Co * and amino acids + humic and fulvic acids + N, P and K **
6	Amino acids + humic and fulvic acids + N, P, Mo and Co * and marine algae ***
7	Amino acids + humic and fulvic acids + N, P and K ** and marine algae ***
8	Amino acids + humic and fulvic acids + N, P, Mo and Co *; humic and fulvic acids + N, P and K ** and marine algae ***

\*Acorda from Juma-Agro composed of 6% organic carbon, 3% P, 2% Mo and 0.3% Co, 0.2 L/ha. Additive with amino acids;

\*\*Aduban from Juma-Agro containing 8.5% organic carbon, 9% N, 2% P and 1% K, 0.2 L/ha. Additive with amino acids;

\*\*\*Algaplex from Acadian, containing 30% of seaweed *A. nodosum*, 2 L/ha.

**Table 3** Treatments applied and results obtained (averages of four plots and statistical results).

Treatments	Stalk diameter (cm)	Roots length (cm)	Fresh root weight (g/plant)
1 (control)	2.46 <sup>c</sup>	63.50 <sup>b</sup>	179.77 <sup>b</sup>
2	2.66 <sup>ab</sup>	83.19 <sup>a</sup>	183.22 <sup>ab</sup>
3	2.74 <sup>ab</sup>	84.39 <sup>a</sup>	181.11 <sup>b</sup>
4	2.29 <sup>c</sup>	80.22 <sup>a</sup>	174.84 <sup>b</sup>
5	2.77 <sup>a</sup>	89.13 <sup>a</sup>	215.65 <sup>a</sup>
6	2.38 <sup>c</sup>	85.69 <sup>a</sup>	197.33 <sup>ab</sup>
7	3.03 <sup>a</sup>	74.48 <sup>a</sup>	185.44 <sup>ab</sup>
8	2.47 <sup>ab</sup>	78.35 <sup>ab</sup>	204.10 <sup>a</sup>
F	19.02 <sup>**</sup>	4.68 <sup>**</sup>	5.82 <sup>**</sup>
CV %	4.94	8.04	6.36

<sup>\*\*</sup>Significant at 1% averages followed by the same letters, within the columns, are statistically equal to 5% by the Duncan test.

combination of the two formulations containing humic and fulvic acids and nutrients (Treatment 5) and the combination humic and fulvic acids + N, P, Mo and Co and humic acids and fulvic + N, P and K + marine algae (Treatment 8) were the most efficient. The positive response of the use of the formulations containing humic and fulvic acids and amino acids confirms that the action of these acids are efficient in the improvement of soil quality [3] and it can stimulate that substances that promotes plant metabolism [5] positive amino acids for their biostimulating role, provides greater rooting and plant development, energy-saving: exogenous amino acids stimulate protein synthesis and improve nitrogen transport and storage [15].

The results are similar to those obtained by Dotta *et al.* [14] in tomato and Souza and Peres [16] in eucalyptus seedlings who observed that the use of biofertilizers containing amino acids promoted the formation of voluminous roots with greater green and dry mass. They also agree with the results of Teixeira *et al.* [17] working with amino acids in the treatment of seeds showed the efficiency of the seeds in seed germination and soybean production.

The use of isolated marine algae only benefited the root length, which can be explained by Taiz and Zeiger [10] and A. A. R. Albuquerque and T. C. S. Albuquerque [9], Spann and Little [12] and Saa *et al.* [11] that mention cytokinins, gibberellins, auxins,

amino acids in the composition of such organisms, substances that stimulate cell multiplication.

The use of the isolated marine algae did not promote increment of mass of the roots and, therefore, in the diameter of stems. Meanwhile, it should be noted that the plots treated with humic and fulvic acids also received plant nutrients. Thus it can be inferred that marine algae contributed as biostimulants and did not provide sufficient nutritional levels to supply plants.

#### 4. Conclusions

The results obtained in the test allowed concluding that:

- The treatments applied in the trial benefited the root development and stem diameter;
- In relation to the stem diameter, the combination of humic and fulvic acids + N, P and K + seaweed was the most efficient followed by humic and fulvic acids + N, P, Mo and Co associated with humic and fulvic acids + N, P and K;
- As for root length, all the products and combinations adopted in the study were efficient, not differentiating between them;
- The inclusion of humic and fulvic acids + N, P and K and humic and fulvic acids + N, P, Mo and Co associated with humic and fulvic acids + N, P and K + seaweed, in relation to the green mass was superior to the others;

• Humic and fulvic acids + N, P, Mo and Co + humic and fulvic acids + N, P and K, when considering all the criteria, was shown to be the most efficient.

## References

- [1] CONAB. 2018. "Follow-Up of the Brazilian Grain Harvest: Agricultural Monitoring 2017/18 Harvest." *CONAB 5*: 1-145. (in Portuguese)
- [2] Do Povo, G. 2018. "Even with Rain and Snow, the US Has the Highest Corn Yield in History, 2018." Accessed June 20, 2018. <https://www.gazetadopovo.com.br/agronegocio/agricultura/mesmo-com-chuva-e-neve-eua-tem-maior-produtividade-e-de-milho-da-historia-e1bd22gv55weqzbwq1n6tu0q0/>. (in Portuguese)
- [3] Ernani, P. R. 2008. *Soil Chemistry and Nutrient Availability*. Lages SC: Department of Soils and Natural Resources, UDESC, 230. (in Portuguese)
- [4] Canellas, L. P., Dantas, D. J., Aguiar, N. O., Peres, L. E. P., Zsogon, A., Olivares, F. L., Dobbss, L. B., Façanha, A. R., Nebbioso, A., and Piccolo, A. 2011. "Probing the Hormonal Activity of Fractionated Molecular Humic Components in Tomato Auxin Mutants." *Annals of Applied Biology* 159 (2): 202-11.
- [5] Canellas, L. P., Mendonça, E. S., Dobbs, L. B., Baldotto, M. A., Velloso, A. C. X., Santos, G. A., and Amaral Sobrinho, N. M. B. 2008. "Reactions of Organic Matter." In *Fundamentals of Soil Organic Matter: Tropical and Subtropical Ecosystems*, edited by Santos, G. A., Silva, L. S., Canellas, L. P., and Camargo, F. A. O. Porto Alegre: Metropole, 45-63. (in Portuguese)
- [6] Baldotto, M. A., and Baldotto, L. E. B. 2014. "Corn Productivity under Field Conditions in Response to the Application of Humic Acids in the Absence and Presence of Liming and Mineral Fertilization, 2014." Accessed May 10, 2019. <https://www.sbcs.org.br/fertbio2014/anais/>. (in Portuguese)
- [7] Ahmad, I., Saquib, R. I. U., Qasim, M., Saleem, M., Khan, A. S., and Yaseen, M. 2013. "Humic Acid and Cultivar Effects on Growth, Yield, Vase Life, and Corm Characteristics of *Gladiolus*." *Chilean Journal of Agricultural Research* 73 (4): 339-44.
- [8] Rodrigues, L. F. O. S., Guimarães, V. F., Silva, M. B., Pinto Junior, A. S., Klein, J., and Costa, A. C. P. R. 2014. "Agronomic Characteristics of Wheat as a Function of *Azospirillum brasilense*, Humic Acids and Nitrogen under Greenhouse Conditions." *Brazilian Journal of Agricultural and Environmental Engineering* 18 (1): 31-7. (in Portuguese)
- [9] Albuquerque, A. A. R., and Albuquerque, T. C. S. 2008. "Cultivation of Cabbage on Fertirrigated Substrate with Organominerals Applications." Accessed March 2, 2018. <https://ainfo.cnptia.embrapa.br/digital/bitstream/CPATSA/38881/1/OPB1909.pdf>. (in Portuguese)
- [10] Taiz, L., and Zeiger, E. 2004. *Plant Physiology*, 3rd ed. Porto Alegre: Artmed, 559. (in Portuguese)
- [11] Saa, S., Olivos-Del Rio, A., Castro, S., and Brown, P. H. 2015. "Foliar Application of Microbial and Plant Based Biostimulants Increases Growth and Potassium Uptake in Almond (*Prunus dulcis* [Mill.] D. A. Webb)." *Frontiers in Plant Science* 6: 87-95.
- [12] Spann, T. M., and Little, H. A. 2011. "Applications of a Commercial Extract of the Brown Seaweed *Ascophyllum nodosum* Increases Drought Tolerance in Container-Grown 'Hamlin' Sweet Orange Nursery Trees." *HortScience* 46 (4): 577-82.
- [13] Alam, M. Z., Braun, G., Norrie, J., and Hodges, M. 2013. "Effect of *Ascophyllum* Extract Application on Plant Growth, Fruit Yield and Soil Microbial Communities of Strawberry." *Canadian Journal of Plant Science* 93 (1): 23-36.
- [14] Dotta, J. H., Teixeira, N. T., and Oliveira, F. C. 2008. "Micronutrients and Amino Acids in the Development of the Tomato Plant Cultivated in Rizotron." FERTIBIO, Londrina, Anais, CD ROOM. Accessed July 16, 2019. <http://www.diadecampo.com.br/zpublisher/materias/Materia.asp?id=20466&secao=Pacotes+Tecnol%F3gicos>. (in Portuguese)
- [15] Teixeira, N. T. 2015. *Strategies That Potentiate Coffee Production*. Coffee Directory, Uberlândia: Campos & Negócios, 48-63. (in Portuguese)
- [16] Souza, L. R., and Peres, F. S. B. 2016. "Use of Biofertilizers Based on Amino Acids in the Production of *Eucalyptus dunnii* Seedlings." *Pesq. Flor. Bras. Colombo* 36 (87): 211-8. (in Portuguese)
- [17] Teixeira, W. F., Fagan, E. B., Soares, L. H., Silva, L. G., Cabral, E. M. A., and Dourado Neto, D. 2018. "Adequacy of Doses of Amino Acids in the Treatment of Soybean Seeds." *Revisit Cerrado Agrociências* 9: 7-31. (in Portuguese)