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Ascophyllum nodosum seaweed extract effects in maize crop

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Abstract. Interest in natural products that increase the productive efficiency of plants together with low environmental impact is growing in agriculture. The objective of this work was to evaluate the effects of leaf spraying of a natural biostimulant extracted from the seaweed *Ascophyllum nodosum* on maize crop. Two experiments were set up under field conditions in the 2013/2014 crop season. The treatments: 1) control, without application of the product; 2) 300 mL ha^{-1} of the commercial product in the V8 stage; 3) 600 mL ha^{-1} of the commercial product in the V8 stage; 4) 300 mL ha^{-1} of the commercial product in the R1 stage; 5) 300 mL ha^{-1} of the commercial product in the V8 stage and repeated in the R1 stage; and 6) 600 mL ha^{-1} of the commercial product in the V8 stage and repeated in the R1 stage. A randomized block experimental design with four replications was used. The evaluations were: plant height 20 days after the first application for the treatments that received the product in the V8 stage, final plant height, ear height, prolificacy, and grain yield. There was no significant effect from the seaweed extract for any of the characteristics assessed.
Keywords: Zea mays L. Biostimulant. Leaf spraying. Vegetative development.

Introduction

In sustainable farming practices, many agents have recently been tested for their effects as biostimulants or biofertilizers, promoting plant growth (SABIR et al., 2014). The effects of biostimulants, as well as doses and forms of application, are factors that can affect crop productivity (DOURADO NETO et al., 2014). Technological crops such as maize greatly absorb innovations in the production system (FERREIRA et al., 2007), especially in the main crop of the year. Knowing more about the effect of these products on the crop allows defining the best strategies of using. Ascophyllum nodosum seaweed extract has been used as a biostimulant to promote growth and productivity in a large number of agricultural production systems (RAYORATH et al., 2008). The species of seaweed Ascophyllum nodosum is the most researched and used in agriculture as fertilizer and soil conditioning agent for the purpose of promoting plant growth and productivity (FAN et al., 2014; SABIR et al., 2014).

Any improvement in agricultural practices that increase the efficiency of nutrient uptake by plants or the production-related physiological processes should reduce the environmental impact of agriculture, increasing productivity and sustainability in less investment systems (JANNIN et al., 2013).

The mechanisms of action of seaweed extracts in plants appear to be varied and complex, as reported by Jannin et al. (2013). Among the responses found by those authors is the differentiated expression of genes related to the metabolism of Nitrogen, Sulfur, Carbon and photosynthesis, which indicates an action at the molecular level in several metabolic routes. The specie of alga tested in the present work has been used for some time in Europe and North America, being the most used specie for the production of commercial extracts (BLUNDEN et al., 1997). Due to that, it is right the interest to prove its efficiency in tropical environments.

When considering field evaluations, complications are always greater by the interaction of the various factors that affect the performance of a crop, but are indispensable for a safe recommendation of using. In addition, the results of research on the use of biostimulants in maize crop are contradictory, making further research to explain the effects of these products on plants very important (SANTOS et al., 2013). The objective of this work was to evaluate the effects of leaf spraying of a natural biostimulant based on the extract of the seaweed *Ascophyllum nodosum* on maize crop.

Material and methods

Two experiments were carried out in the region of Lavras-MG with maize from November of 2013 to May of 2014. The experiments were carried out in commercial maize fields under no-tillage system. Average daily temperature and precipitation data were recorded by the climatological station of the Federal University of Lavras (UFLA). The first experiment was set up in a maize producing area belonging to UFLA, from November of 2013 to April of 2014. The second experiment was installed in a private property area comprising the period from December of 2013 to May of 2014. The maize crop for the first experiment was implanted on 11/26/2013 with the hybrid BG7037H spaced 0.60 m between rows. The sowing fertilization consisted of 350 kg ha^{-1} of NPK formulation 08:28:16 and the cover fertilization consisted of 200 kg ha^{-1} of urea on 12/21/2013. The final population of plants, evaluated before harvest, was 79633 plants ha^{-1}.The second experiment was planted on 12/3/2013 with the hybrid P30F53HX spaced 0.80 m between rows. The sowing fertilization consisted of 430 Kg ha^{-1} of NPK formulation 08:28:16 and the cover fertilization consisted of 400 Kg ha^{-1} of the formulated NPK 30:00:20 on 03/01/2014. The final population of plants, evaluated before the harvest, was 57500 plants ha^{-1}. The cultural treatments given to the two areas were those commonly used in the region for crops of good performance, in accordance with the current technical recommendations.

The experimental design used in the two experiments was randomized blocks with four replications. The experimental plot consisted of four rows of 5.0 m long. The two central rows of each plot were considered as useful area for data collection. Spraying was done using a costal sprayer, evenly distributing the previously calculated volume on the four plot lines. The previous calibration of the equipment was carried out only with water, applied in the plots that received the control treatment. Doing that, it was possible to discover the volume that would be spent to spray each treatment, varying only the doses of the evaluated product. Six treatments, consisting of different combinations of doses and phenological stages of leaf spraying of a commercial product, with biostimulant properties, based on extract of the seaweed *Ascophyllum nodosum* (Table 1). The described phenological stages are in accordance with the classification of Ritchie et al. (2003). The V8 stage comprises a phase in the crop cycle in which mechanized leaf spraying reach their limit and at the same time precedes a final stage of vegetative development of intense growth and accumulation of photo assimilates. The stage R1 comprises the beginning of a process of accumulation of dry matter in the grains and still shows high rates of absorption of nutrients. Therefore, two strategic stages in the maize cycle for cultural interventions.

Table 1. Description of the treatments evaluated in the experiments.

	Doses of the commercial product and phenological stages:	
Treatments:	V8	R1
Control	-	-
1	300 mL ha^{-1}	-
2	600 mL ha^{-1}	-
3	-	300 mL ha^{-1}
4	300 mL ha^{-1}	300 mL ha^{-1}
5	600 mL ha^{-1}	600 mL ha^{-1}

Productive and vegetative development characteristics were evaluated. First measurement of plant height (m) was measured 20 days after the first application of the product, based on the treatments that received the product in the V8 stage. Four plants from the plot area were sampled to measurements, from the ground level to the top of the last fully expanded leaf. Final height of plants (m) was measured in four plants in the useful area of the plot before harvest, from soil level up to the insertion of the flag leaf. Ear insertion height (m) was measured in four plants in the useful area of the plot before harvest, considering the height of the first (highest) ear. Prolificacy was measured considering all the ears present in the useful area of the plot, counting and dividing by the total of plants in that area. Grain yield (kg ha^{-1}) data were corrected for the standard humidity of 13% on a wet basis. The harvest occurred on 04/25/2014 for the first experiment and on 05/09/2014 for the second.

Tests of additivy of the model, normality of errors and homogeneity of variances were performed. There were no restrictions to the assumptions of the analysis of variance and it was performed at 5% of probability, through the statistical program SISVAR (FERREIRA, 2011).

Results and discussions

In the Table 2 the precipitations and average temperatures of the region are shown, per decade, covering from the beginning of the experiment installation to the female flowering stage of the maize (R1), which occurred on 01/30/2014 for the first experiment and 02/06/2014 for the second. The irregularity of the precipitations during the development of the maize can be seen and the tendency of increasing temperatures in the considered interval. This allows affirming that it was an atypical year in relation to the water regime, considering the long drought periods occurred. This should have been reflected in the results, as will be presented below.

By the F test of the analysis of variance there was no significant effect of the seaweed extract in any of the characteristics evaluated in both experiments. Under similar conditions, that is, of a crop with water restriction, Nabati et al. (2008) found positive effects on the water status of a grass species by the application of products with properties of plant biostimulants, among them the Ascophyllum nodosum seaweed extract. Although it was not the objective of the present study to evaluate the water status of the plants, it is unlikely that the algal extract promoted any benefit in this sense, since the general lack of response to the variables measured in the two experiments.

The Table 3 presents the averages of the treatments for the vegetative development characteristics evaluated in the two experiments. In general, it was observed that there was a high experimental precision for the three vegetative development characteristics evaluated in both experiments, due to the low values of coefficient of variation (CV) found, according to criteria proposed by PIMENTEL-GOMES (2009).

Table 2. Climatological data of the region of the experiments in the period considered**.**

Period	Decennial	Precipitation (mm)	Average temperature (ºC)
09/11 – 19/11	1º	56.2	22.1
19/11 – 29/11	2º	70.7	21.3
29/11 – 09/12	3º	89.4	23.03
09/12 – 19/12	4º	32	21.93
19/12 – 29/12	5º	53.6	22.86
29/12 – 08/01	6º	2.8	23.91
08/01 – 18/01	7º	86.9	24.07
18/01 – 28/01	8º	161.4	23.58
28/01 – 07/02	9º	0	24.75
07/02 – 17/02	10º	30.5	23.08

Table 3. Mean values for the first measurement of plant height (PH), final plant height (FPH) and ear insertion height (EIH) as a function of the different treatments, for each experiment

Treatments:	**PH**	**FHP**	**EIH**
	---------------------------m----------------------------		
First experiment			
300 mL R1	0.95 a	2.47 a	1.50 a
300 mL V8	0.95 a	2.42 a	1.46 a
300 mL V8/ 300 mL R1	0.95 a	2.45 a	1.49 a
600 mL V8	0.94 a	2.45 a	1.55 a
600 mL V8/ 600 mL R1	0.92 a	2.47 a	1.53 a
Control	0.92 a	2.42 a	1.49 a
CV (%)	5.63	2.12	3.33
General Average	0.93	2.44	1.50
Second experiment			
300 mL R1	1.66 a	2.57 a	1.71 a
300 mL V8	1.73 a	2.62 a	1.69 a
300 mL V8/ 300 mL R1	1.74 a	2.64 a	1.72 a
600 mL V8	1.75 a	2.66 a	1.69 a
600 mL V8/ 600 mL R1	1.79 a	2.70 a	1.68 a
Control	1.77 a	2.69 a	1.71 a
CV (%)	4.32	2.84	3.96
General Average	1.73	2.64	1.70

In the columns, averages followed by the same letter do not differ from each other by the 5% significance test F

It is attributed to the algae extract studied in these work properties analogous to those of phytohormones such as gibberellins, due to the stimulus to the growth of plant tissues. This fact, however, was not observed in the work in question. Rayorath et al. (2008) also did not confirm the assumption that these are the substances responsible for the effects of the product.

The performance of the crop for the productive characteristics is presented in Table 4. It is worth mentioning that despite the water deficit already highlighted, yield averages can be considered satisfactory in comparison to other works already carried out in the same region in previous years (BRITO et al., 2013, PEREIRA et al., 2010).

Table 4. Mean values for prolificacy and grain yield (kg ha^{-1}) as a function of the different treatments in each experiment

Treatments:	Prolificacy	Grain yield
	First experiment	
300 mL R1	0.90 a	7.994 a
300 mL V8	0.85 a	7.970 a
300 mL V8/ 300 mL R1	0.94 a	8.715 a
600 mL V8	0.87 a	7.693 a
600 mL V8/ 600 mL R1	0.91 a	8.028 a
Control	0.89 a	8.556 a
CV (%)	10.55	15.65
General Average	0.89	8.159
	Second experiment	
300 mL R1	1.10 a	9.382 a
300 mL V8	1.05 a	9.191 a
300 mL V8/ 300 mL R1	1.02 a	9.686 a
600 mL V8	1.04 a	8.926 a
600 mL V8/ 600 mL R1	1.00 a	9.174 a
Control	1.09 a	10.861 a
CV (%)	7.38	15.36
General Average	1.05	9.537

In the columns, averages followed by the same letter do not differ from each other by the 5% significance test F

Even in non-grain crops such as potatoes and onions, Lola-Luz et al. (2014) found results consistent with this work, with respect to yield, using an extract made from the same species of algae. In one of the few studies, to date, investigating specifically the effect of Ascophyllum nodosum extract on maize, Blunden et al. (1997) found a positive effect on leaf chlorophyll content in relation to the control treatment. However, the authors did not evaluate whether this effect resulted in higher yield later, in addition to that the application was made via soil and potted plants rather than field, conditions different from those tested here, what restrict the inferences.

Thus, there is a lack of information regarding the effect of seaweed extract on maize crop performance, especially when used under field conditions. With results similar to those found here Dourado Neto et al. (2014) evaluating the effect of a biostimulant composed by synthetic phytohormones in maize also did not find a response in yield, despite several favorable effects on the growth and components of crop production. The authors point out that the very adequate environmental conditions should have favored the control treatment in such a way that the differences with the other treatments became non-significant. Therefore, the opposite should have occurred in the present work, where the irregular precipitation conditions probably did not allow the treated plants to express the potential advantage of the application of the extract.

Similarly, Ferreira et al. (2007) observed no difference in yield for use of a synthetic biostimulant via maize seed treatment. As a result of the application of Ascophyllum nodosum extract in a water stress condition, similar to the one occurring in the present study due to the climatic irregularity, was published by Spann & Little (2011) for citrus plants. The work reports that treated plants presented greater efficiency in the use of water and consequently greater growth and accumulation of dry matter.

In the case of saline stress, Baky et al. (2014) reported beneficial effects on the photosynthetic rate and yield with the application of seaweed extract in wheat. According to the authors, stress triggers a scenario in which reactive oxygen species adversely affect the physiological systems of plants. Thus, the antioxidant compounds present in algae extracts are the responsible to maintaining active physiological processes, such as photosynthesis.

As pointed out by Ferreira et al. (2007) the responses to the application of biostimulants are very variable. With this work, the extract of the seaweed Ascophyllum nodosum did not have any effect on the vegetative and productive development characteristics of maize, evaluated in two different experiments regarding the technological level employed. Certainly, the conclusions are not definitive in view of the water restriction to which the crop was submitted, even coinciding with periods critical to the lack of water as the female flowering (R1).

Little is known about the mode of action of seaweed extracts, and consequently the exact positioning for the use of these products is not yet defined. The work in question still had the climatic stresses to have been taken to the field, in conditions of commercial agriculture. Thus, further research is needed to better understand and recommend the use of seaweed extracts in maize.

Conclusions

The extract of the seaweed Ascophyllum nodosum does not affect the vegetative development and the maize production under the conditions tested in this work.

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