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Effect of the seaweed extract applied on seeds and/or foliar sprays on soybean development and productivity

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Abstract

Soybean is a plant of great economic importance, to keep or emphasise high grain production is indispensable supply of adequate nutrients, which can take place in various techniques, foliar fertilization is one of them. The foliar nutrient application is one the most important practice to correct deficiency symptoms. This study aimed to verify the results obtained with the seaweed extract used as fertilizer (Ascomaxx®) in seed treatments and sprays as foliar fertilizer at R2 and R4 stages of soybean. This work was conducted at the experimental station Terra Paraná Pesquisa e Treinamento in Assis Chateaubriand PR, Brazil in 2013/2014, and the results were analysed on Universidade Estadual de Maringá - UEM. The characteristics studied were the stand of crop at 7 and 14 days after emergence and pre-harvest, plant height, number of soybean pods and productivity. It was observed that seaweed extract applied via seed affected neither the initial nor final stand. The results suggest that foliar applications of the seaweed extract and the application timing were responsible to accentuate the productivity in soybean mainly when it was applied during de reproductive stage (R2 and R4), grain production was until 30% better under these conditions, compared with the control treatment.

Key words: Tolerance, biotic, abiotic, stresses, alga.

Introduction

The soybean (*Glycine max* (L.) Merrill) is currently one of the most widespread leguminous crops of the world, a fact explained by the potential that it holds in terms of derivatives such as oil, bran and other industrial uses which supply many of the nutritional requirements of world's population. It is a major source of income in the agricultural exports of countries like the United States, Brazil and Argentina, in this way soybean is a crop of great economic importance in the global scenario.

The growth in production and the increase in production capacity of Brazilian soybeans are allied to scientific advances and the availability of technologies in the productive sector as the use of foliar mineral fertilizers, among other technologies [11].

The requirement to increase soybean productivity has led many producers to seek alternatives and one of them is the use of foliar fertilization. To use this technology exist today numerous commercial products containing macro and micronutrients, and their use has increased in recent years [14].

The nutrients supply can occur in several ways. Usually, in crop grains and fibers, one uses a foliar nutrients, especially to correct deficiency symptoms of elements. Studies on the effects of the mode of application of fertilizers containing micronutrients are still very incipient in Brazil, especially considering that the use of these nutrients is still questioned [5].

Micronutrients are essential elements for the growth and development of plants and are characterized by being absorbed in small amounts, unlike the macronutrients (N, P, K, Ca, Mg and S). This is due the fact that they do not participate in plant structures, but the formation of enzymes and then act as their activators [7]. Another important factor is the appropriate nutritional balance, which in addition to providing direct gains, may play a role in secondary factors such as tolerance to diseases and pests[8]. Therefore, the balance of whatever nutrient should be studied, and so measures to minimize its unbalanced use should be adopted to allow the manifestation of the productive potential of the species. This condition aims to gain greater investments in technology application of folia fertilizers arises as a viable alternative.

Among these foliar fertilizers, we highlight those stemmed seaweed *Ascophyllum nodosum* as it contains essential natural compounds that plants can express their productive potential balanced improving rooting fixation of flowers and fruits and promoting greater accumulation of carbohydrates during the life cycle of the plant [1, 9].

A. nodosum used in commercial form can be considered like a bio-stimulant to promoted vegetative growth, better exploitation of the mineral nutrients and can promote tolerance to biotic and abiotic stresses [13, 15].

Ascomaxx® is a growth regulator derived from alga *A. nodosum,* which contains organic osmolites, amino acids, mineral nutrients, and vitamin precursors, as most seaweed extract [2]. The seaweed extracts have been applied to many crop plants, and important answers about growth and development of plants are being obtained [1]. The improvement in the condition of development of soybean can provide greater competitive culture and consequently biggest gains for producers.

Thus, the implementation of practices that seek experimental results and answers to issues related to fertilizer use and management of foliar fertilization, are arguably relevant.

The objective of this research was to evaluate the effect of Ascomaxx® (seaweed extract) fertilizer, applied as seed treatment, as seed treatment followed by foliar application and foliar only, the development and yield of soybean.

Materials and Methods

The experiment was conducted at the experimental station Terra Paraná Pesquisa e Treinamento Agrícola, in Assis Chateaubriand, PR (S 24° 17' 39.78" W 53° 35' 16.56", 315 m asl). The climate is classified as Cfa by Köeppen, mesothermal humid subtropical, with hot summers, and infrequent frosts trend of rainfall concentrated in the summer months without a defined dry season[4]. The soil of the experimental had pH in $CaCl_2$ 4.20; $H^{+}+Al^{+3}$ 7.20 $cmol_c\ dm^{-3}$ soil; Ca^{+2} 2.18 $cmol_c\ dm^{-3}$; Mg^{+2} 1.21 $cmol_c\ dm^{-3}$; K^{+} 0.34 $cmol_c\ dm^{-3}$; P 29.57 mg dm^{-3}; organic matter 14.53 g dm^{-3} ; 15% of the sand; 12.5% of silt and 72.5% of clay.

The seeding of soybean cultivar Syngenta V-top 1059 RR, was held on October 30, 2013, with the fertilizer application of 206 $kg.ha^{-1}$ of formulated 02-20-18 (NPK) as recommended and need of crop. The seeding rate was 18 seeds per metre and the spacing was 43 cm between rows. Applications maintenance consisted of one application of insecticide teflubenzurom (50 ml $kg.ha^{-1}$) for the control of caterpillars, two applications of fungicide piraclostrobina + epoxiconazol (600 $kg.ha^{-1}$), and two applications of insecticide imidaclaprido + beta-ciflutrina (1000 $kg.ha^{-1}$) for the control of stink bugs and caterpillars.

The experimental design was a randomized block with four replications and eight treatments (Table 1), and experimental units were plots with dimensions of 5.0 m wide by 6.0 m long (30.0 m^2). The application of seaweed extract by seed treatment before seeding was carried out with the aid of a mixer of seeds. Foliar applications were made in R2 and R4 stages of crop on the dates of 12/23/2013 and 1/10/2014 respectively and were applied by spraying constant pressure based on CO_2, equipped with 5-pointed bar type range XR-110.02, under pressure of 2.0 kgf cm^{-2} which provided a spray volume of 200 L ha^{-1}. In both foliar applications climatic conditions were ideal and conducive to spraying schedules were respected.

The characteristics evaluated were: 1) stand of crop at 7 and 14 days after emergence (DAE) and pre-harvest two plants by 4 m in length; 2) plant height and number of pods on 10 plants per plot in the pre-harvest; 3) grain yield adjusted to 14% humidity, considering six core by 4 feet long lines. With the data of number of pods and productivity, we determined the relative gain compared to control. Data were submitted to analysis of variance by F test, and means were compared by the Scott-Knott test at 5% probability.

Table 1. Treatments evaluated in the experiment with Ascomaxx® (seaweed extract). Assis Chateaubriand - PR, 2013/2014.

	Treatments		
	Sowing	Flowering (R2)	Pods (R4)
T.1	Control treatment	----------------	----------------
T.2	Ascomaxx 200 ml/100 kg of seed	----------------	----------------
T.3	Ascomaxx 200 ml/100 kg of seed	Ascomaxx 500 $ml.ha^{-1}$	----------------
T.4	Ascomaxx 200 ml/100 kg of seed	----------------	Ascomaxx 500 $ml.ha^{-1}$
T.5	Ascomaxx 200 ml/100 kg of seed	Ascomaxx 500 $ml.ha^{-1}$	Ascomaxx 500 $ml.ha^{-1}$
T.6	----------------	Ascomaxx 500 $ml.ha^{-1}$	----------------
T.7	----------------	-	Ascomaxx 500 $ml.ha^{-1}$
T.8	----------------	Ascomaxx 500 $ml.ha^{-1}$	Ascomaxx 500 $ml.ha^{-1}$

Results and Discussion

Table 2 shows the data regarding the stand of soybean evaluated at 7 and 14 days after crop emergence (initial stand) and pre-harvest (final stand). By analyzing the initial stand to 7 and 14 DAE, the treatments 2, 3, 4 and 5 did not differ from the control, demonstrating that Ascomaxx® (200 $ml.ha^{-1}$) applied via seed did not affect the initial stand of crop soybeans.

Similar results were observed in final stand, in this condition, all treatments containing Ascomaxx®, both via seeds and /or foliar,

Table 2. Effect of treatments at the stand (m) evaluated at 7 and 14 days after emergence of soybean (DAE), and pre-harvest in the experiment with Ascomaxx®. Assis Chateaubriand - PR, 2013/2014.

Treatments	Stand 7 DAE	Stand 14 DAE	Stand pre-harvest
Control	12.75	13.50	14.00
T.2	11.75	14.00	15.75
T.3	11.50	13.00	14.75
T.4	11.00	12.75	14.50
T.5	11.75	13.75	14.50
T.6	11.75	12.75	14.75
T.7	12.50	12.75	13.50
T.8	12.50	13.25	15.50
F	0.44^{NS}	0.69^{NS}	0.45^{NS}
VC(%)	14.24	9.46	14.83

^{NS} insignificant difference. VC: variation coefficient; F: F test.

were not different from control in the assessment carried out in the pre-harvest. As a consequence, Ascomaxx® presented as safe option for use on soybeans. There were no failures in development or plant mortality, and considering that the booth is one of the variables related to productivity, it can be said that this factor was positive, demonstrating the safety in use. Table 3 shows that treatments with Ascomaxx® did not differ from the control in relation to plant height on sampling carried out in the pre-harvest soybeans. However, there was a tendency of higher averages in treatments with Ascomaxx®, especially in Treatment 6, which received only one application Ascomaxx® (500 ml ha^{-1}) when soybean was at R2 stage. This application has provided a mean increase of 10.75 cm in height compared to the control.

Table 3. Effect of treatments on the variables plant height, number of pods per plant and productivity in the experiment with Ascomaxx® in soybean. Assis Chateaubriand - PR, 2013/2014.

Treatments	Stature (cm) pre-harvest		Number of pods per plant pre-harvest		Productivity ($kg.ha^{-1}$)	
Control	61.25	a	40.50	b	2413.25	c
T.2	68.50	a	43.75	b	2649.75	b
T.3	68.25	a	44.00	b	2727.75	b
T.4	69.00	a	43.00	b	2815.25	b
T.5	68.00	a	42.75	b	2645.25	b
T.6	72.00	a	53.75	a	3201.75	a
T.7	69.75	a	54.25	a	2869.,25	b
T.8	64.75	a	56.75	a	3131.25	a
F	0.63^{NS}		3.51**		16.96**	
VC (%)	11.23		14.45		4.51	

Obs.: Means followed by the same letter in the column do not differ by Scott-Knott test at 5% probability. ** indicates differences significant at 0.01. ^{NS} insignificant difference. VC: variation coefficient; F: F test.

By means of the number of green beans, treatments containing Ascomaxx® only foliar application (T.6, T.7 and T.8) were superior to other treatments including the control. This result suggests that the best yields can be obtained when Ascomaxx® foliar applications were applied exclusively compared to seeds and / or followed by foliar applications.

For productivity variable, average had similar value to those estimated for the 2013/2014 season by CONAB [6], however, the means were considered low due to the drought period in February which might have limited the expression of crop production potential in the treatments. All treatments in which the product Ascomaxx® was used were significantly superior to untreated control productivity, this case is important to note that foliar fertilization can moderate the problems faced by a deficiency.

The behavior of tolerance to biotic and abiotic factors was also observed by Vernieri *et al.*[15] and Spinelli *et al.*[12]. In this context, it can be said that the extract applied can provide the plant protection in conditions of adverse factors.

It is noted in this context that Treatment 6 result was conducted only with a foliar application Ascomaxx® when the soybean was in R2, and Treatment 8 which was composed of an application when the soybean was at R2 and another when soybean was at R4, had the best yields higher than the other treatments. The application time of nutrients exerts great influence on grain yield. The highest yield observed for these treatments is probably associated with the occurrence of fertilization during periods of increased need for nutrients for the plant, which according to Rosolem and Boareto [10] takes the stages R1 to R5.

It can be also noted that the best results observed under the conditions of these treatments may be related to problems faced by the drought, i.e. foliar application performed in the period of greatest need of plants, the absorption difficulties faced by plants that had no foliar applications in R2 and R4.

Table 4 shows the relative increase in the number of pods and produce compared to the control. Regarding the relative increase in the number of pods, treatments containing Ascomaxx® increased by at least 5.55% the number of pods, especially the T.6, T.7 and T.8 that gave rise 32.71 %, 33.95% and 40.12%, respectively.

Table 4. Effect of treatments on relative increase in the average number of pods per plant in pre-harvest and produce in the experiment with Ascomaxx® in soybean. Assis Chateaubriand - PR, 2013/2014.

Treatments	Increase in the number of pods (%)	Increase productivity (%)
Control	0.00	0.00
T.2	8.02	9.80
T.3	8.64	13.03
T.4	6.17	16.65
T.5	5.55	9.61
T.6	32.71	32.67
T.7	33.95	18.89
T.8	40.12	29.75

To the relative increase in productivity, we found similar behavior, with Ascomaxx® treatments provided at least 9.80% increase in productivity, and T.6 and T.8 treatments had distinguished with increase of 32.67% and 29.75%, respectively. In general, the application of Ascomaxx®, either through seed treatment and/or followed by foliar applications, or foliar application only, provided significant effect related to the productivity of soybean variables, as well as productivity gains. It is noted that foliar applications made in R2 (T.6), and R2 plus R4 (T.8) stood out over the others in yield.

Importantly, when treatments with Ascomaxx® were applied only foliar, the result obtained by applying (T.7) at R4 stage of the soybean crop was lower than the results achieved with the T.6 and T.8, noting the importance of starting the application from the R2 stage to achieve the best results.

The results of this experiment are consistent with Carvalho *et al.* [3] that pursuant to extract algae in irrigation system, observed positive effect on growth, development and yield of wheat, but with the crop or variations according to the time of application no positive effect was observed.

Variations in productivity and development of plants can be explained by the high number of compounds present in the extract, resulting in the ability to stimulate plant, among this auxins, gibberellins and alginate can be highlighted [9].

Conclusions

Ascomaxx® applied through seed treatment and/or foliar application did not affect the stand of soybeans; all treatments containing Ascomaxx® had significantly increased the productivity of soybean in relation to the control; the seaweed only in foliar applications showed greater relative productivity increase.

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