Seaweed extract *Ascophyllum nodosum* (L.) on the growth of watermelon plants

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ABSTRACT

Aims: The objective of the research was to evaluate the influence of the seaweed extract applications, *Ascophyllum nodosum* (L.) to the productive development and quality of watermelon plants.
Study design: Two experiments were carried out. For experiments I and II, the completely randomized design was applyed in factorial schemes 2x6 and 2x4, respectively, with five replications each.
Place and Duration of study: The experiments was carried out at the Department of Plant Sciences (DPS) of the Rural Federal University of Semi-Arid (UFERSA), Campus Mossoró – RN, from January to May 2014.
Methodology: Experiment I consisted on seed treatments [soaking in potable water and Acadian®] and application of six doses (0, 1, 2, 3, 4 and 5 mL L^{-1}); experiment II, a combination of two seed treatments [soaking in potable water and Acadian®] and four periods (0, 7, 10 and 14 days) under the dose of 3.0 mL L^{-1}.
Results: The interaction between seed treatment and application of different doses, presented highest values observed for the variables, plant height, fresh shoot weight and fresh root weight were for A. nodosum (L.). More effects for seed treatment when there is no application of Acadian® is observed. It can be inferred that there is interaction among the factors, since the different parts of the plant respond in different ways to the treatment of seeds and the different periods of application. Also highlighted, when submitted to applications with Acadian®, watermelon plants had a similar effect, with closer values, excluding only the applications spaced in 7 days, which showed more interaction factors.
Conclusion: Seed treatment with Acadian® and the doses of 3.0 and 4 mL L^{-1} were more efficient in the watermelon seedlings production. Applications in intervals of 7, 10 and 14 days were most promising, regardless the seed treatment.

Keywords: Ascophyllum nodosum (L.); Biofertilizers; Citrillus lanatus; Stimulate plant growth

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1. INTRODUCTION

Watermelon is one of the main olericulture species cultivated in Brazil, standing out as a product of great importance for the agribusiness of the country, occupying the 8th position in the ranking of the most exported fruits in 2009, with 28,261.7 tons exported, yielding about $ 12.4 million [1]. The production in the country is distributed among the Northeast, South and North regions, being the first region the main producer, responsible for over 34% of the national production, and the states of Bahia (338,365 t), Pernambuco (103,615 t) and Rio Grande (76,872 t) are the largest states producers [2].

In the state of Rio Grande do Norte, in the Mossoró-Assú region, the watermelon stands out for its be one of the most produced and exported crop, no longer being exploited only during the rainy season, become a technified activity practiced for small, medium and large companies that send their production to large markets such as CEAGESP-SP and to the external market [3].

Improving cultivation techniques or introducing new technologies can result in a better agronomic performance of a cultivated species. In this context, to enhance the techniques that can provide cost reduction and maintain the ideal physiological and productive characteristics to the plant has an extreme significance for the northeast region in Brazil, which despite an adequate edaphoclimatic characteristics for the crop development, presents high cost of agricultural inputs and lack of good crop traits practices [4].

The consumer market is increasingly demanding for healthier foods, free of pesticides and fertilizers, therefore studies are being carried out to develop new technologies that reduce the use of agricultural inputs, and provide improvements to the physical, chemical and biological soil characteristics, in addition to maintain a good production and quality of the fruits [5]. In this context, an alternative distinct from chemical inputs would be the use of macroalgae as a biofertilizer.

The macroalgae have in their composition, nutrients, amino acids, vitamins, cytokinins, auxins and abscisic acid (ABA) that act as plant development promoters [6]. Marine algae have direct activity in plant protection against phytopathogens, and also promote the production of bioactive molecules capable to induce resistance in plants [7]. The species *Ascophyllum nodosum* (L.) Le Jolis is the most researched in the agriculture [8]. The extract stimulates plant growth due to its composition rich in macro and micronutrients, carbohydrates, amino acids, and plant hormones specific from algae [9].

Commercial products based on *A. nodosum* (L.) seaweed extract, such as Acadian®, present 13.0 to 16.0% organic matter, 1.01% amino acids (alanine, aspartic and glutamic acid, glycine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, tyrosine, tryptophan and valine), carbohydrates, and concentrations of nutrients N, P, K, Ca, Mg, S, B, Fe, Mn, Cu and Zn. They also present growth hormones (auxins, gibberellins, cytokinins, abscisic acid), resistance elicitors and micronutrient transport aids, which stimulate plant growth and improve fruit quality [10].

In several regions of the world, algaes have been used to increase productivity and food production, and this is due to its beneficial effects when applied to the crops.

According to Mazzarino and Bortolossi [11] the use of algae extract *A. nodosum* (L.) in cucumber crop to evaluate productivity, presented a significant difference regarding fruit uniformity and quantity. However, for fruit weight, length and diameter, no significant difference was obtained between the treatments tested. Oliveira *et al.* [12], applied the algae

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extract, A. *nodosum* (L.) on the production of yellow passion fruit seedlings, and could verified that dose of 4 mL L^{-1} of the product Acadian®, *A. nodosum (*L.), provided increase in height growth and number of leaves per plant, being efficient in the production of yellow passion fruit seedlings.

Studies made by Oliari *et al.* [13], has proved that the use of algae extract applications in the dose of 6% of Acadian®, for production and quality of plum cv. Pen 7, promoted increase to productive and chemical aspects of the plum, with higher ratio value what is an important characteristic in the fruit flavor.

The use of the extract of *A. nodosum* (L.) for commercial crops in general, is in a fully expansion, with more precise information needs to achieve the adequate use. In this context, the objective of the present work was to evaluate the production and quality of watermelon treated with the commercial product of algae extract *A. nodosum* (L.), Acadian®.

2. MATERIAL AND METHODS

2.1 General Data of the Experiments

The experiments were carried out from January to May 2014, with two trials conducted in the greenhouse at the Department of Plant Sciences (DPS) of the Rural Federal University of Semi-Arid (UFERSA), Campus Mossoró - RN.

2.1.1 Soil collecting and analysis

The seaweed extract is composed of: N (0.8-1.5%); P (1-2%); K (17-22%); Ca (0.3-0.6%); Mg (0.2-0.5%); S (1-2%); B (75-150 ppm); Cu (1-5 ppm); Fe (75-250 ppm); Mn (5-20 ppm); Zn (25-50 ppm) and Na (3-5%); potassium hydroxide, with 61.48 g L^{-1} of K 2 O; 69.60 $g.L^{-1}$ of total organic carbon; pH 8.0 and a density of 1.16 $g.dm^{-3}$.

2.1.2 Soil collecting and analysis

Soil samples were collected from UFERSA 's didactic garden at 0 - 20 cm, dried, and then sieved in a 2 mm mesh. Subsequently, they were submitted to a chemical analysis at the Chemistry and Fertility Soil Laboratory of UFERSA and presented the following results: pH (H_2O) = 7.0; MW = 0.26%; P = 210 mg dm^{-3}; K = 0.43 cmolc dm^{-3}; Na = 0.15 cmol / dm^{-3}; Ca = 3.3 cmolc dm^{-3}; Mg = 1.8 cmol-dm^{-3}; Al = 0.00 cmolc dm^{-3}. Santos *et al.* [14], in previous work, classified this soil as abrupt eutrophic red-yellow argisol and sand texture. All soil samples of the two greenhouse experiments were previously autoclaved for 50 min at 121 °C and 1.2 ATM working pressure. The 'Vida Verde' commercial substrate 'Tropstrato HT', which had the following characteristics: moisture = 60% w / w, water retention capacity, was also used in these experiments, only or in a mixture with previously autoclaved soil, 130% w / w, dry basis density = 200 kg m^{-3}, wet basis density = 500 kg m^{-3} and pH = 5.8. The watermelon seeds used in both experiments were Quetzali cultivar.

Prior to the installation of the field trial, soil samples were taken at depths of 0 - 20 cm, which were air dried and sieved in 2 mm mesh, then sent to the Instituto Campineiro de Análise de Solo e Adubo LTDA, in Campinas - SP. The soil analyzed had the following characteristics: pH (water 1: 2.5) = 7.7; PH (CaCl2) = 6.8; M.O. = 10 g / kg; SB = 36.7 cmolc dm^{-3}; CTC = 44.7 cmolc dm^{-3}; Ca = 2.4 cmolc dm^{-3}; Mg = 0.7 cmolc dm^{-3}; K = 0.36 cmolc dm^{-3}; Na = 49 mg dm^{-3} and P = 100 mg dm 3. The watermelon seeds used for this assay were from the cultivar Quetzali.

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The product based on the extract of A. nodosum (L.), Acadian®, used in this experiment was produced by Acadian Seaplants Ltd. and purchased from VALEAGRO, located in the city of Petrolina-PE, Brazil.

2.2 Conduction of the experiments

2.2.1 Experiment I: Watermelon growth under different doses of Acadian® and seed treatment

The present work was carried out from January to May 2014, in a greenhouse, in the Plant Sciences Department (DPS) at the Rural Federal University of Semi-Arid (UFERSA), Campus Mossoró - RN. The experiment was conducted in a completely randomized design with twelve treatments and five replications in a 2 x 6 factorial scheme. The treatments consisted on the combination of two seed treatments (potable water imbibition and Acadian ®), with application of six different treatments doses (0, 1, 2, 3, 4 and 5 mL L^{-1}) (Table 1).

Table 1. Seeds treatment and doses of Acadian® used in watermelon seedlings. Mossoró - RN, 2014.

Treatments	Doses[1]	Seed treatment
T1	0 mL L^{-1} (100 mL pl^{-1})	Potable water
T2	1 mL L^{-1} (100 mL pl^{-1})	Potable water
T3	2 mL L^{-1} (100 mL pl^{-1})	Potable water
T4	3 mL L^{-1} (100 mL pl^{-1})	Potable water
T5	4 mL L^{-1} (100 mL pl^{-1})	Potable water
T6	5 mL L^{-1} (100 mL pl^{-1})	Potable water
T7	0 mL L^{-1} (100 mL pl^{-1})	Acadian®
T8	1 mL L^{-1} (100 mL pl^{-1})	Acadian®
T9	2 mL L^{-1} (100 mL pl^{-1})	Acadian®
T10	3 mL L^{-1} (100 mL pl^{-1})	Acadian®
T11	4 mL L^{-1} (100 mL pl^{-1})	Acadian®
T12	5 mL L^{-1} (100 mL pl^{-1})	Acadian®

[1] *Reference value for 12,500 watermelon plants.*

Plastic containers with capacity of 500 mL were filled with the substrate 'Tropstrato HT'. Subsequently, watermelon seeds cv. 'Crimson Sweet' were sown at approximately two centimeters deep, being two seeds per container. After seven days of sowing, only one plant was left per container. The application of the solution with the product was directly to the soil, and the doses used were the recommended to the treatment (Table 1).

Fifteen days after sowing, the plants were removed from the containers carefully, washed in running water to remove substract particles and avoiding broken roots. Posteriorly, pictures of the material were taken and the analisis observed were: shoot length (cm), fresh shoot weight (g), root lenth (cm), fresh root weight (g), and dried root weight (g).

2.2.2 Experiment II: Watermelon growth under different ranges of Acadian® application and seed treatments

The experiment was conducted as a completely randomized design with eight treatments and five replications in a 2 x 4 factorial scheme. The treatments consisted on the combination of two seed treatments (potable water imbibition and Acadian®), with four application intervals (0, 7, 10 and 14 days after sowing) (Table 2).

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Table 2. Extract of *Ascophyllum nodosum* (L.), Acadian®, applied to watermelon in different periods of application and seed treatment. Mossoró - RN, 2014.

Treatments	Application intervals[1]	Seed treatment[2]
T1	0	Potable water
T2	7+7+7+7	Potable water
T3	10+10+10	Potable water
T4	14+14	Potable water
T5	0	Acadian®
T6	7+7+7+7	Acadian®
T7	10+10+10	Acadian®
T8	14+14	Acadian®

[1]Days after emergency (DAE). [2] Soaking for a period of 1 hour.

Plastic vases with capacity of 3.0 kg were filled with the mixture of autoclaved soil (item 2.1.1), quartz sand and commercial substrate 'Tropstrato HT', in a ratio of 1: 1: 1 of volume. Watermelon cv. 'Crimson Sweet' seeds were sown at approximately two centimeters deep, two per containers, equidistant from the edges of the vases. After seven days of sowing, thinning was realized leaving one plant per container or experimental unit. The application of the product occurred with application of the solution directly to the soil being the treatment dose recommended by hectare (Table 2).

After 40 days of sowing, the plants were carefully removed from the containers to avoid breaking the root system, and washed in running water until the roots were free of the substrate particles. Afterwards pictures were taken and following analisis were done: length (cm) and weight (g) of aereal part, dry aeroal part weight (g), root length (cm), fresh root weight (g), dry root weight (g).

2.4 statistical analysis of data

The data obtained in this experiment were submitted to analysis of variance for the characteristics evaluated using statistical software ASSISTAT, version 7.7 Beta [15]. In the cases where the treatment data presented significant differences, the F test was applied to the 5% probability level. The mean test was used to compare the means, at the 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Experiment I: Watermelon growth under different doses of Acadian® and seed treatment

According to the results, the doses of the extract of *A. nodosum* (L.) were differentiated by the F test (*P* <0.01), for all variables analyzed. When analyzing the different treatments of seeds, only compresses of weight and dry weight of root have been influenced positively of the treatment with Acadian®. A positive interaction was observed among the factors, doses of *A. nodosum* (L.), Acadian ®, seed treatment, for variables shoot height, fresh shoot weight and fresh root weight, indicating that there is a dependence among these factors for the characteristics, by the F test (*P* <0.01) (Table 3).

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Table 3. Summary of variance analysis for the variables: shoot length (SL), fresh shoot weight (FSW), root length (RL), fresh root weight (FRW) and dry root weight (DRW) of watermelon plants under different doses and seed treatment (TS). Mossoró - RN, 2014.

F.V.1	GL	SL	FRW	RL	FRW	DRW
F1	5	4.0149**	0.27253**	21.1907**	1.1974**	0.0005**
F2	1	0.4075^{ns}	0.00729^{ns}	68.5966**	0.0001ns	0.0002**
F1 x F2	5	0.0002**	0.00001**	0.0926^{ns}	0.0000**	0.0000^{ns}
Resíduo	48	0.67448	0.012140	0.06638	0.04825	0.00000
CV (%)	-	5.05	5.17	1.03	13.37	5.45

*Test F: ** significant at 1% probability level (P <0.01); * Significant at 5% probability level (P <0.05); ^{ns}Not significant.*
[1]F1 - Doses of extract A. nodosum (L.), Acadian®: 0, 1, 2, 3, 4 and 5 mL L^{-1}; F2 - Seed treatment: treated seeds (soaking in extract of A. nodosum (L.), Acadian®) and untreated (imbibition in potable water) / 1 h before sowing.

Observing the different doses of the commercial product, Acadian®, the highest mean values of the variables are observed in doses of 3 and 4 mL L^{-1} (Table 4). Also the dose above this range (5 mL L^{-1}) influenced negatively the development of the seedlings, with the exception of the SL variable. In oder words, when applied in adequate doses, Acadian® increases the development of watermelon seedlings.

In this work, root length increases of 15.70% and 17.03% for doses of 3 and 4 mL, respectively, when compared to the control treatment. There was also an increase of 6.84% for the same variable when the seedlings were submitted to a higher dose (5 mL L^{-1}). However, this increase was proportionally lower than that obtained by doses of 3 and 4 mL.

Table 4. Variables average: shoot length (SL), fresh shoot weight (FSW), root length (RL), fresh root weight (FRW), and dry root weight (DRW) of watermelon plants with different doses of the seaweed extract *Ascophyllum nodosum* (L.), Acadian®. Mossoró - RN, 2014.

Variables / Doses	SL (cm)	FRW (g pl^{-1})	RL (cm)	FRW (g pl^{-1})	DRW (g pl^{-1})
0 mL L^{-1}	14.862b	1.859c	19.372e	1.162c	0.036d
1 mL L^{-1}	15.145b	2.057b	19.847d	1.369c	0.037d
2 mL L^{-1}	15.409b	2.156b	18.945f	1.329c	0.039c
3 mL L^{-1}	16.869a	2.451a	22.980b	2.197a	0.045b
4 mL L^{-1}	16.523a	2.367a	23.360a	2.178a	0.056a
5 mL L^{-1}	15.975a	2.160b	20.796c	1.623b	0.031e

Averages followed by the same letter do not differ from each other by the Scott-Knott Test at 5% significance

These results can be explained by Crozier *et al.* [16], when they report that the extract of the algae *A. nodosum* (L.), has in its composition, several plant hormones, among them auxin, cytokinin and gibberellin. They affirm that the effects promoted by the cytokinins include the inhibition or stimulation of several physiological and biochemical processes in the plants, in association with the auxins, and as a function of the cytokinin: auxin ratio. Also involved in the process of growth and differentiation, including cell division, apical dominance, organ formation, chlorophyll break retardation, development of chloroplasts and maintenance of juvenile plant organs. Salisbury and Ross [17], on the other hand, affirm that high

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concentrations of auxins can prevent or reduce the root growth of the plants, which justifies the phenomenon observed when the dose of 5 mL L^{-1} is applied.

Analyzing the seed treatment factor separated, there are no statistical differences for the variables presented, except for root length and root dry weight, which differed at 5% level of significance by the Scott-Knott test, presenting higher values for seeds treated with the commercial Acadian® product (Table 5).

Table 5. Variables average: shoot length (SL), fresh shoot weight (FSW), root length (RL), fresh root weight (FRW) and dry root weight (DRW) of watermelon plants under different seed treatments. Mossoró - RN, 2014.

Variables / S.T.[1]	SL (cm)	FSW (g pl^{-1})	RL (cm)	FRW (g pl^{-1})	DRW (g pl^{-1})
Potable water	16.851a	2.161a	19.503b	1.645a	0.038b
Acadian®	16.822a	2.189a	22.264a	1.641a	0.047a

[1]Seed treatment: treated seeds (soaking in extract of A. nodosum (L.), Acadian®) and untreated (imbibition in potable water) / 1 hour before sowing.

The results of this research corroborate the results obtained by Carvalho [18], working with different doses of *A. nodosum* (L.) seaweed extract, for corn development and productivity showed that treated seeds, with 50 and 100 mL of the extract, presented root length superior to the control (increments of 23.26 and 53.63%, respectively); While those plants generated from seeds treated with 250 and 500 mL presented roots with lower length, presenting reductions of 8.30 and 13.57%.

Kumar and Sahoo [19] carried out a study using *A. nodosum* extract (L.) in wheat plants, verified a 6.7% increase in the height of the aerial part of the plants treated with the extract, in comparison to the control treatment. Matysiak *et al.* [20] reported also a significant increase in the dry mass of the aerial part of the corn (increment of 11 to 34% compared to the control) when treated with the extract of the brown algae *E. maxima* and *Sargassum* spp.

The interaction between seed treatment and application of different doses, presented highest values observed for the variables, plant height, fresh shoot weight and fresh root weight were for *A. nodosum* (L.), Acadian® at the doses of 3 and 4 mL L^{-1}, respectively. Also verified that the application of the extract of *A. nodosum* (L.), stimulated those seedlings that did not have the seeds treated with the product. Therefore, there are no significant differences between the material treated with drinking water or Acadian®. Those most concentrated solutions of the product (seeds treated with Acadian® and applied at the dose of 5 mL L^{-1}) negatively affected the fresh root weight of watermelon plants (Fig. 1).

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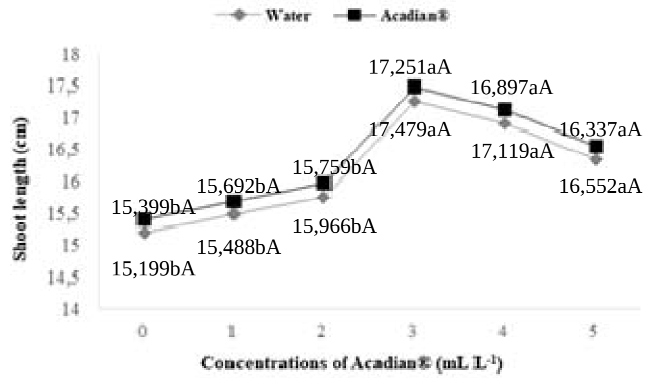
A



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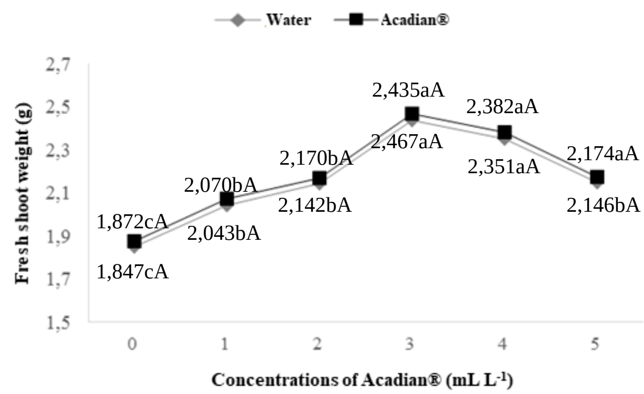

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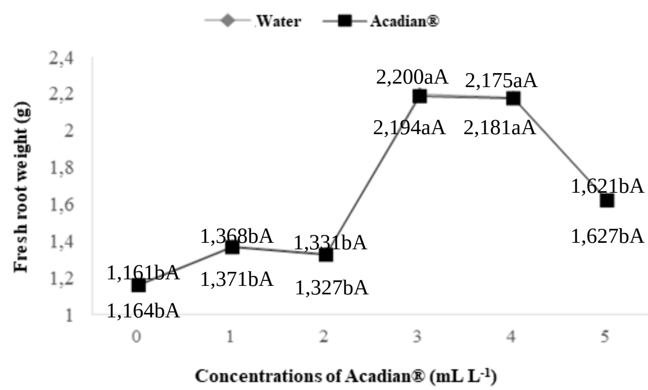

Fig. 1. Variables average: shoot length (SL), fresh shoot weight (FSW) and fresh root weight (FRW) of watermelon plants under different doses and seed treatment (ST). Mossoró - RN, 2014.

Averages followed by the same lowercase letter within treatments and upper case between treatments do not differ by Scott-Knott's test at 5% significance. Doses of extract A. nodosum (L.), Acadian®; Seed treatment: treated seeds (soaking in extract of A. nodosum (L.), Acadian®) and untreated (imbibition in potable water) / 1 hour before sowing.

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For Khan *et al.* [21] and Craigie [22], although in small amounts of *A. nodosum* (L.) extract can cause positive effect on plant development, due to biostimulants derived from this alga are constituted by several hormones [23,24] having also other unidentified compounds with similar activity to plant hormones, being able to alter plant development.

As observed in this study, Oliveira *et al.* [25] working with yellow passion fruit seedlings using doses of the Acadian®, verified a quadratic behavior for the applied doses, and also a reduction in performance when using a dose higher than 4 mL L^{-1}. For Rodrigues [26], plant organs are morphologically altered by the application of biofertilizers, in a way that growth and development are promoted or inhibited by the dose, which influences the physiological processes, and exerts control of the meristematic activity

3.2 Experiment II: Watermelon growth under different ranges of Acadian® application and seed treatments

A positive interaction was observed between the *A. nodosum* (L) extract, Acadian ® application interval and the seed treatments used in the watermelon plants for the variables SFW, RL and FRW, indicating that there is a dependence between these factors. However, there was no interaction for SL, DSW and DRW by the F test (*P* <0.01) (Table 6).

Table 6. Variables variance analysis summary: shoot length (SL), fresh shoot weight (FSW), dry shoot weight (DSW), root length (RL), fresh root weight (FRW) and dry root weight (DRW) of watermelon under different application intervals and seed treatments. Mossoró - RN, 2014.

F.V.[1]	GL	SL (cm)	FSW (g pl^{-1})	DSW (g pl^{-1})	RL (cm)	FRW (g pl^{-1})	DRW (g pl^{-1})
F1	3	2766.3333*	892.1788**	6.7337**	37.5562^{ns}	22.3253**	0.0743^{ns}
F2	1	2.5000^{ns}	307.5812**	12.8403**	28.0562^{ns}	0.1836^{ns}	0.0987^{ns}
F1 x F2	3	645.5000^{ns}	250.9652**	0.4256^{ns}	387.5229**	9.2760*	0.0038^{ns}
Resíduo	32	771.7000	29.9442	0.2544	49.7875	3.0286	0.0387
CV (%)	-	23.38	13.80	12.41	15.63	28.42	25.42

*P <0.01, F test; * P <0.05, F test; Ns Not significant.*
[1]F1 - Application intervals: 0, 7, 10 and 14 days (solution with 3 mL L^{-1} Ascophyllum nodosum (L.) extract, - Acadian®); F2 - Treatment of seeds: treated seeds (soaking in extract of A. nodosum) and untreated (imbibition in water) / 1 hour before sowing.

According to the results of variance analysis, the Acadian® intervals of application presented significant differences by the F test (*P* <0.01), for almost all variables analyzed, except for RL and DRW. Also when evaluated the different treatments of seeds, there are only significant differences, by the test F (*P* <0.01), for FSW and DSW analisis. However, no interaction observed among the range of application and treatment of seeds, for the variables SL, DSW and DRW.

Analyzing the application interval factor alone, it was observed that the treatments that received Acadian® application presented better performance when compared to the control, which did not receive application of the product, by the Scott-Knott test at 5% significance (Table 7).

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Table 7. Variables average: shoot length (SL), fresh shoot weight (FSW), dry shoot weight (DSW), root length (RL), fresh root weight (FRW) and dry root weight (DRW) of watermelon at different application intervals (AI) of the seaweed extract *Ascophyllum nodosum* (L.), Acadian®. Mossoró - RN, 2014.

Variables / A.I.[1]	SL (cm)	FSW ($g\ pl^{-1}$)	DSW ($g\ pl^{-1}$)	RL (cm)	FRW ($g\ pl^{-1}$)	DRW ($g\ pl^{-1}$)
0	100.100b	26.119c	2.892b	43.100a	4.683b	0.669a
7+7+7+7	114.400b	40.328b	4.769a	47.750a	5.231b	0.855a
10+10+10	140.200a	47.017a	4.155a	44.600a	8.034a	0.833a
14+14	134.500a	45.112a	4.441a	45.100a	6.543a	0.740a

Averages followed by the same letter do not differ from each other by the Scott-Knott Test at 5% significance.
[1]Application intervals: 0, 7, 10 and 14 days (solution with 3 mL L^{-1} extract of Ascophyllum nodosum (L.), Acadian®).

The CR and PSR variables presented similar behavior, in which the application intervals 0, 7, 10 and 14 days did not differ among themselves, using the Scott-Knott test at 5% significance level. In general, watermelon plants submitted to applications at 10 and 14 days of intervals were superior to those that received weekly applications (7 days). Therefore, according to the analysis of the results, the choice of the application interval of fourteen days reduce the amount of product volume, which may promote a significant reduction in crop management costs.

According to Salisbury and Ross [17], *A. nodosum* (L.) extract is rich in plant hormones, including auxin, responsible for cell stretching and growth promotion. However, when applied at high concentrations or high frequency, auxins can prevent or reduce root growth. Possibly the plants that received more applications of the product, in this case the interval of 7 days, may have presented a reduced growth, due to greater quantity of auxins accumulation, thus causing a reduction in the growth when compared to the other intervals od application.

Regarding the treatment of seeds with extract of *A. nodosum* (L.), Acadian®, the variables SL, RL, FRW and DRW did not present significant differences when compared to control (potable water). Suggesting that the effect of seed treatment with Acadian® may be more effective in the seedling phase. However, the variables FSW and DSW were higher when treated with *A. nodosum* extract (L.), presenting an increase of 13.07 and 24.46%, respectively (Table 8).

Table 8. Variables average: shoot length (SL), fresh shoot weight (FSW), root length (RL), fresh root weight (FRW) and dry root weight (DRW) under different seed treatments. Mossoró - RN, 2014.

Variables / S.T.[1]	SL (cm)	FSW ($g\ pl^{-1}$)	DSW ($g\ pl^{-1}$)	RL (cm)	FRW ($g\ pl^{-1}$)	DRW ($g\ pl^{-1}$)
Potable water	118.550a	36.871b	3.498b	44.300a	6.190a	0.724a
Acadian®	119.050a	42.417a	4.631a	45.975a	6.055a	0.824a

Averages followed by the same letter do not differ from each other by the Scott-Knott Test at 5% significance.
[1]Seed treatment: treated seeds (soaking in extract of Ascophyllum nodosum (L.), Acadian®) and untreated (imbibition in drinking water) / 1 hour before sowing.

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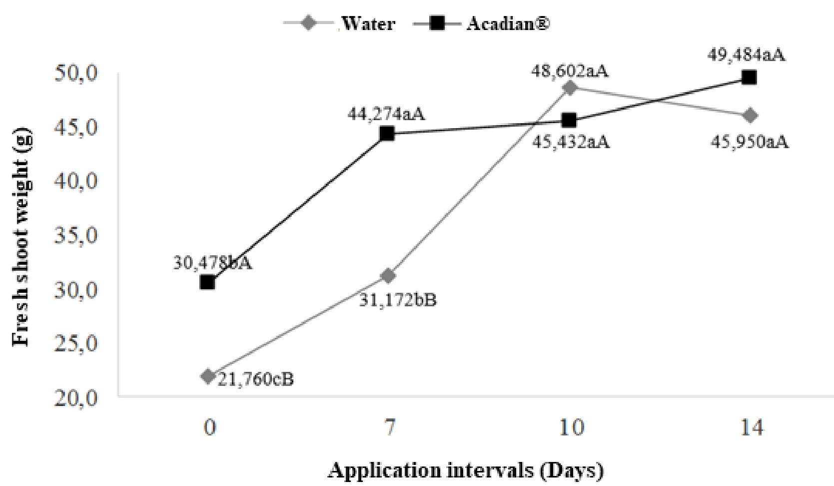
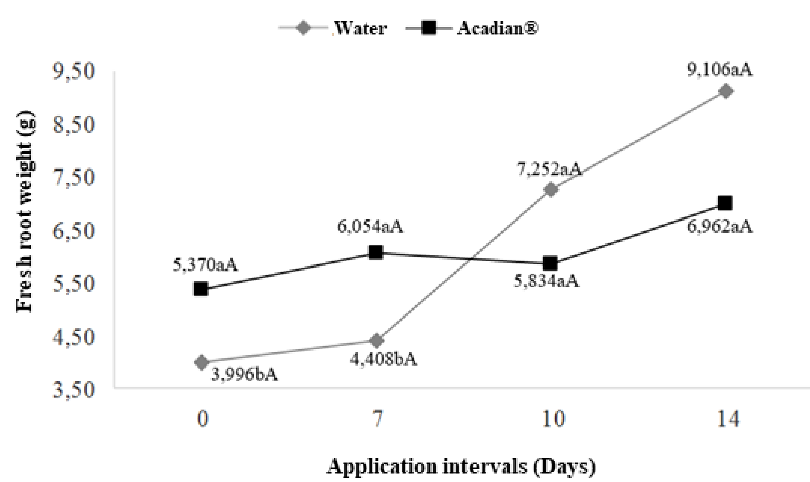
These results corroborate with Marcos Filho *et al.* [27] report, which indicate that seeds treated with algae extract have high metabolic activity, with high seedlings growth rates and rapid emergence in the field, possibly due to the capacity of reserves translocation to the development of the embryonic axis, bringing rapid germination and vigor with subsequent development of the aerial part of the plant.

A relation to the results of the study with the possible increase in the production of endogenous cytokinin that is induced by the extract of *A. nodosum* (L.) is possible, as proposed by Khan et al. [21], when studied the effect of the extract of this alga on plants of Arabidopsis thaliana. Thus, cytokinin is a hormone synthesized in greater amounts in the roots of the plants, being transported by the xylem to the plant aerial part, stimulating its development [17]. Sivasankari [28], in a work using the extract of the brown alga *Sargassum wightii* in the treatment of *Vigna sinensis* seeds, verified greater development of the aerial part of the seedlings treated with the algae extract. The interaction between application interval and seed treatment, presented values generally superior when applied to Acadian®, regardless of seed treatment for watermelon plants (Fig. 2).

A



B



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C

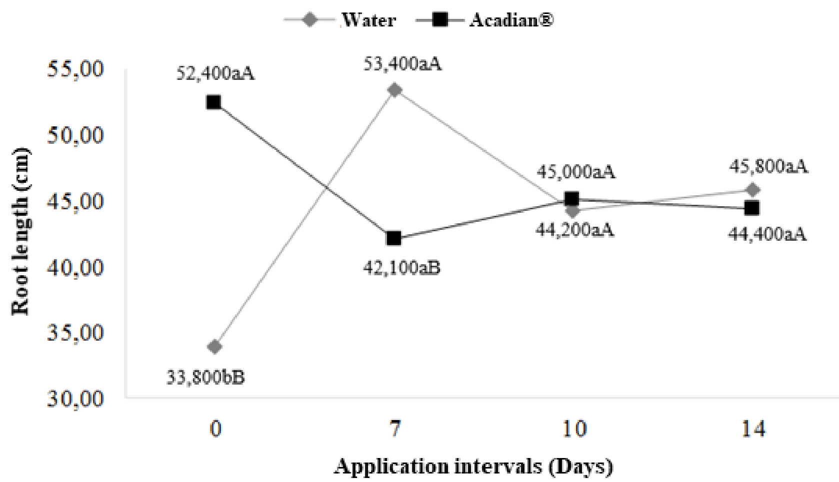

Fig. 2. Variables average: dry shoot weight (DSW), fresh root weight (FRW) and dry root weight (DRW) of watermelon under different application intervals (AI) and seed treatment (ST). Mossoró - RN, 2014.

Averages followed by the same lowercase letter within treatments and upper case between treatments do not differ by Scott-Knott's test at 5% significance.

More effects for seed treatment when there is no application of Acadian® (AI - 0) is observed. It can be inferred that there is interaction among the factors, since the different parts of the plant respond in different ways to the treatment of seeds and the different periods of application. Also highlighted, when submitted to applications with Acadian®, watermelon plants had a similar effect, with closer values, excluding only the applications spaced in 7 days, which showed more interaction factors (Fig. 3).

Thus, when the appropriate application interval is determined, the effect of the seed treatment is suppressed. However, when there is no application of Acadian® or there is an excess, the treatment of seeds influences the growth and development of watermelon plant.

A

B

Fig. 3: A: Immersion in potable water; No periodic application of Acadian®; B: Immersion in potable water; Application of Acadian® every 7 days

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4. CONCLUSION

The seed treatment with Acadian®, as well as the applications in concentrations of 3 and 4 mL L^{-1} were efficient in the production of watermelon seedlings. By positively increasing the evaluated parameters, shoot length, fresh shoot weight, root length, fresh root weight and dry root weight.

The watermelon plants submitted to applications at intervals 7, 10 and 14 days were superior to those that did not receive application, independently of the sed treatment.

AUTHORS' CONTRIBUTIONS

Authors may use the following wordings for this section: "'Author A' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Author B' and 'Author C' managed the analyses of the study. 'Author C' managed the literature searches…… All authors read and approved the final manuscript."

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