

Seaweed Extract Improves the Vigor and Provides the Rapid Emergence of Dry Bean Seeds

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Abstract: Homogeneous stands can be obtained with the use of seaweed extracts on seeds, providing better establishment in the field and reducing losses in the production. The objective of this study was to evaluate the effects of *Ascophyllum nodosum* extract on the germination, vigor and early development of 'Alvorada' bean seeds. The seeds were immersed in a solution containing *A. nodosum* extract at a concentration of 0.8 mL L⁻¹ for 5, 10, 15 and 20 minutes. For comparison, some seeds were also soaked in water for 5, 10, 15 and 20 minutes and seeds that received no treatment (control) were also evaluated. Germination tests in paper roll and sand were performed to evaluate the dry mass and percentage of normal seedlings and the speed index of germination and emergence. Seeds soaked in seaweed extract showed the percentage of normal emerging seedlings higher than the control (28.45%, $p < 0.0001$), regardless the time of immersion. However, only seeds immersed in seaweed extract for 15 minutes exhibited speed index of emergence higher than control (8.61%, $p = 0.0157$). It is concluded that the vigor of 'Alvorada' bean seeds are increased after immersion in solution with extract of *A. nodosum* for 15 minutes, due to the increase in number of seedlings, which establish potentially in the field and reduce the emergence time.

Key words: Common bean • *Ascophyllum nodosum* • Crop establishment • Plant development

INTRODUCTION

The dry bean (*Phaseolus vulgaris* L.) is a relevant economically crop for developing countries, especially for India and Brazil, which are the largest producers in the world [1, 2]. Due to its nutritional properties, such as the high content of proteins, fibers, vitamins and carbohydrates, the dry bean is also used in diets to combat the hunger and the malnutrition [1].

There are several studies that show positive effects of the algae extract application on crops, since the early germination of the seeds and their establishment up to the improvement of the plant performance and productivity [3, 4]. The biostimulants derivate from seaweed extract of *Ascophyllum nodosum* (L.) Le Jolis contain cytokinins,

auxins and gibberellins [3, 5]. However, there are unidentified compounds that act similarly to some plant hormones [6]. Even in small quantities, this extract can have positive effect on the plant growth and development [3, 4], increasing the germination and seed vigor of barley, tomatoes, pepper and, eggplant [6, 7].

As the germination test, a conceptualized method to assess the ability of seed germination, does not inform the vigor and field emergence [8, 9], two or more different tests of vigor should be used [10]. In order to increase the percentage of germination and vigor of seeds, the objective of this study was to evaluate the effects of immersion time of 'Alvorada' bean seeds in solution with *A. nodosum* extract when subjected to germination and emergence tests in paper roll and sand.

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MATERIALS AND METHODS

The study was carried out in the Laboratories of Seed and Image Analysis of the Plant Production Department, at the College of Agriculture "Luiz de Queiroz" from 21 May to June 5, 2011.

Treatments: In this experiment, seeds of dry bean cv. Alvorada were used in the nine treatments, which were compounded by untreated seeds (control- time 0) and seeds immersed in water or in a commercial extract of *A. nodosum* (Acadian®) solution at a 0.8 mL L⁻¹ concentration for 5, 10, 15 and 20 minutes. Afterwards, the seeds were dried on the lab bench at environmental temperature and humidity, for 30 minutes. Then, the seeds were evaluated by germination and emergence tests in paper roll and sand, respectively, as described below.

Germination Test: The germination test was carried out in a germination chamber at 25 ± 2°C and 24 hour light, having four replications of 50 seeds for each treatment [8]. The seeds were distributed homogeneously on two pieces of towel papers and covered with a third sheet (paper roll), which are moistened with a water volume equivalent to 2.5 times the weight of the dry towel. The evaluations were made on the 5th and 9th days after sowing. The seedlings that developed all embryo essential structures were classified as normal, according to criteria set out in the Rules for Seed Analysis [8]. The results were expressed as percentage of normal seedlings for each treatment.

Seedling Emergence Test: To test seedling emergence, four replicates of 50 seeds per treatment were sown at 2 cm depth in plastic boxes with sand, which was washed, sterilized at 105 °C and watered up to 60% of its water retention capacity. This test was carried out in a greenhouse, where the average maximum and minimum temperatures were 24.9 and 10.0 °C, with light for 24 hour. The assessments were started on the 6th day after sowing. The results were expressed as percentage of normal seedlings, which have all essential structures, such as well developed, completed, proportionated and healthy ones [8].

Speed Indexes: The speed of germination was evaluated concurrently to germination and emergence tests and was daily assessed at the same time. The speed index of germination and emergence was calculated, using the daily number of normal seedlings according to Maguire

[11]. The evaluations were performed until the 7th day after sowing for the germination test and the 11th for the emergence test.

Dry Mass of Seedlings: To obtain the dry mass of seedlings, four replications of 10 seeds were used. This test was carried out in a germination chamber in the same conditions of temperature and light as the germination test. The seedlings were collected on the 4th day after sowing, then were packed in paper bags and taken to a stove (for 72 h at 60 °C), to determine the shoot, root and total dry mass, which were expressed in grams (g).

Statistical Procedures: The data were analyzed according to a completely randomized design and subjected to analysis of variance (ANOVA) at 5% probability. Afterwards, the Duncan test ($\alpha \leq 5\%$) was used in order to compare the means among treatments, by SAS statistical software [12]. The data regarding the speed emergence index were changed into $x=IVE^{6.3}$ to be according to statistical assumptions to perform the ANOVA. After analysis, the data were converted back to the original scale, to facilitate comparison of results among treatments.

RESULTS AND DISCUSSION

The percentage of germinated (at the initial and final evaluations) and emerging seedlings (final evaluation), the speed index of germination and the seedling dry mass were not affected by the seed treatments (Table 1).

Although there were no significant differences between treatments for the variables shown in Table 1, it was observed an increase up to 7.23% in the percentage of germinated seeds and 5.13% in emerging seedlings by the treatment of seeds with seaweed extract. These increases are economically important for farmers, which potentially can have a higher number of plants per area sown due to the elevated germination percentage.

A remarkable increase of the germination and allocated biomass of seedlings were also reported when *Vigna sinensis* seeds were treated with the *Sargassum wightii* extract [13]. Nevertheless, these results were obtained from laboratory tests using a methodology that approaches the germination test, an established method to evaluate the germination capacity, but it does not inform about the vigor, longevity and field emergence of seeds [10].

Table 1: Effects of immersion time in the *A. nodosum* extract (ANE) or in the water on the germination, emergence and dry mass of seedlings after the treatment the 'Alvorada' bean seeds

| Treatments | Variables | | | | | | |
|----------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
| | PES | PGF | PGL | SIG ¹ | RDM ² | SDM ² | TDM ² |
| Control 0 min. | 83 ± 2.2 | 78 ± 3.4 | 86 ± 1.1 | 13.9 ± 0.19 | 0.11 ± 0.01 | 0.25 ± 0.01 | 0.36 ± 0.02 |
| Water 5 min. | 78 ± 6.9 | 81 ± 1.0 | 88 ± 3.5 | 14.3 ± 0.44 | 0.12 ± 0.01 | 0.26 ± 0.03 | 0.38 ± 0.04 |
| Water 10 min. | 83 ± 3.5 | 78 ± 3.3 | 86 ± 1.1 | 14.2 ± 0.42 | 0.08 ± 0.01 | 0.19 ± 0.01 | 0.27 ± 0.02 |
| Water 15 min. | 85 ± 3.1 | 79 ± 2.4 | 86 ± 1.1 | 13.7 ± 0.35 | 0.11 ± 0.00 | 0.23 ± 0.01 | 0.34 ± 0.01 |
| Water 20 min. | 75 ± 6.1 | 73 ± 4.6 | 79 ± 3.7 | 12.8 ± 0.65 | 0.11 ± 0.01 | 0.20 ± 0.02 | 0.31 ± 0.03 |
| ANE 5 min. | 87 ± 1.3 | 82 ± 1.9 | 88 ± 1.5 | 14.3 ± 0.23 | 0.12 ± 0.01 | 0.26 ± 0.03 | 0.38 ± 0.04 |
| ANE 10 min. | 84 ± 1.0 | 82 ± 1.9 | 90 ± 3.4 | 14.5 ± 0.47 | 0.11 ± 0.01 | 0.25 ± 0.02 | 0.36 ± 0.03 |
| ANE 15 min. | 89 ± 1.3 | 80 ± 3.5 | 89 ± 2.2 | 14.4 ± 0.40 | 0.12 ± 0.01 | 0.24 ± 0.03 | 0.36 ± 0.04 |
| ANE 20 min. | 85 ± 5.2 | 77 ± 3.7 | 86 ± 1.1 | 13.9 ± 0.21 | 0.12 ± 0.02 | 0.24 ± 0.04 | 0.36 ± 0.06 |
| C.V. (%) | 9.26 ^{ns} | 7.53 ^{ns} | 5.63 ^{ns} | 5.83 ^{ns} | 20.26 ^{ns} | 21.57 ^{ns} | 20.83 ^{ns} |

Percentage of emerging seedlings (PES), germinated at first (PGF) and last (PGL) evaluation, speed index of germination (SIG), root dry mass (RDM), shoot dry mass (SDM) and total dry mass (TDM). Mean ± standard error; ns: not significant; ¹seedlings day⁻¹ and ²g seedling⁻¹.

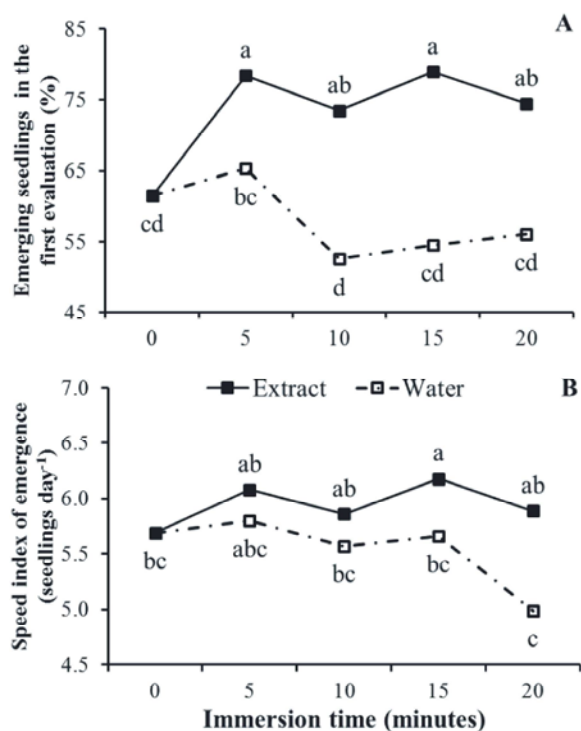


Fig. 1: Effects of immersion time in the *Ascophyllum nodosum* extract or in the water on the percentage of emerging seedlings in the first evaluation (A) and the speed index of emergence (B) of 'Alvorada' bean seeds. Means followed by different letters differ by Duncan test ($\alpha=5\%$).

The seeds which have similar germination capacity when evaluated by germination test may have different performance on the field, so there is a need to supplement the information using vigor tests [10]. The vigor, which

can be based on seedling performance, is defined as a set of properties that determine the potential for a rapid and uniform seedling emergence under various environmental conditions [9]. Therefore, the first count of germination test, the speed index of germination and the seedling dry mass can be used to assess the seed vigor [10]; however these variables were not affected after treatments (Table 1).

Nevertheless, seeds soaked in seaweed extract had the percentage of emerging seedlings in the first assessment higher than the control (up to 28.45%, $p<0.0001$), regardless immersion time (Figure 1). Furthermore, seeds immersed in the *A. nodosum* extract for 15 minutes showed the highest speed index of emergence ($p=0.0157$), as shown in the Figure 1.

Due to the existence of plant hormones and other bioactive compounds in the *A. nodosum* extract, small amounts of the extract can affect the plant metabolism, influencing the growth and development positively [3, 4, 14]. Seeds that have high metabolic activity originate high growth rates and fast emergence seedlings in the field, possibly due to the ability to translocate their reserves to the embryonic axis development [9, 10]. Consequently, fast germination and high vigor seeds originate plants that cover the soil rapidly, using more efficiently the radiation, promoting the formation of homogeneous stand, decreasing the possibility of weed occurrence and therefore avoiding the reduction of grain production [16].

Moreover, the predisposition of seeds and seedlings to adverse environmental conditions and pathogen attack due to slow germination tends to decrease [10], since the *A. nodosum* extract provides rapid emergence of high numbers of 'Alvorada' bean seedlings.

CONCLUSIONS

It is concluded that the vigor of 'Alvorada' bean seeds are improved after immersion in the solution with extract of *A. nodosum* 0.8 mL L⁻¹ for 15 minutes, due to the increase in the number of seedlings, which establish potentially in the field and reduce the emergence time.

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