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Organic Priming with Seaweed Extract (*Ascophyllum nodosum*) Affects Viability of Pepper Seeds

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Availability of using seaweed extract (as an organic material) in priming technique, which provides physiological improvement to seeds and can be conducted a variety of osmotic solutes, was investigated. The seeds of pepper (cv. California Wonder) were subjected to priming treatments, by the use of 1:1, 1:5, 1:10, 1:25, 1:50, 1:100, 1:250, 1:500 and 1:1000 dilutions of seaweed extract (Maxicrop) and also H_2O, for 1, 2 and 3 d at 20 °C. Their effects on total germination and mean germination time were examined. Consequently, total germination rate increased while mean germination time decreased due to a decrease in seaweed extract concentration and prolonged treatment period. Regarding the negative correlation between total germination rate and mean germination time, the best results were obtained from the 1:500 concentration of the seaweed extract solution. The positive effects also maintained in the 1:1000 and H_2O treatments. It was concluded that seaweed extract could also be used as an osmotic agent in organic priming of pepper seeds.

Key Words: *Capsicum annuum*, Seeds, Seaweed extract, Organic priming, Total germination, Mean germination time.

INTRODUCTION

Seaweed extracts and suspensions derived from marine brown algae are marketed for use in agriculture and horticulture. In Europe and North America, the alga most commonly utilized is *Ascophyllum nodosum* although other species are used in addition, for example *Fucus ceratus* and *Laminaria* species[1]. It is well known that brown seaweeds are good organic fertilizers, but the costs of collection, drying and transportation of seaweeds restrict their widespread use.

The major biologically-active compounds of the *Ascophyllum nodosum* extract are plant growth regulators, such as auxins and cytokinins. Studies have also strongly indicated the potential role of betaines[1]. Moreover, minerals, carbohydrates and antibiotics are active ingredients of the seaweed extract[2].

A wide range of beneficial effects has been reported from the use of seaweed extracts, including increased crop yield and quality, resistance to frost, uptake of inorganic nutrients from the soil, resistance to stress conditions and improved seed germination[1,3-5]. In addition, reduced incidence of fungal and insect attack, also lower storage losses were detected[1,3]. Of these effects, improved seed germination is an attractive result for seed technology.

The initial stage of vegetable growing is seed sowing and germination or emergence of seedlings. However, seedling emergence in soil could be suppressed by a number of unfavourable environmental conditions. Different pre-sowing seed treatments have been utilized to obtain fast and uniform germination or emergence. One of the most important pre-sowing treatments is known as seed priming. The general purpose of seed priming is to partially hydrate the seed to a point where germination processes are begun but not completed. Most priming treatments involve imbibing seed with restricted amounts of water to allow sufficient hydration and advancement of metabolic processes but preventing germination. Its correct application induce more rapid, uniform and higher rate of germination, resulting in a decrease of the mean germination time (which could be used as the indicator of seed vigour) when seeds are transferred into germination conditions[6-9]. Various seed priming techniques have been developed, including hydropriming (soaking in water), halopriming (soaking in inorganic salt solutions), osmopriming (soaking in solutions of different osmotica such as PEG-8000), thermopriming (treatment of seed with low or high temperatures), solid matrix priming (treatment of seed with solid matrices) and biopriming (hydration using biological compounds). Each treatment has advantages and disadvantages and may have varying effects depending upon plant species, stage of plant development, concentration/dose of priming agent and incubation period[9].

Therefore, any treatment which arrests seed germination could possibly be used as a priming treatment. Although very little work has been carried out on the priming of seeds with seaweed extracts and its effect on seed viability and the rate of germination, promising results have obtained in diverse species.

One of the initial researches was conducted to investigate the effect of various seaweed extracts on the subsequent respiratory activity of beet seeds and their ultimate germination potentials. At the end of one week, the germination rate of beet seed treated with seaweed extract was 84 % as compared to 0 % for the control. Another experiment was conducted at the same time to study the effects of soaking beet seeds in seaweed extracts on possible enhancement in seed viability. The prior soaking treatments for 0.5 h increased the germination of beet seeds by 25 % over the control[2].

Treatments conducted to seeds of several species (*i.e.*, tomatoes, peas, turnip, radish, white pine, loblolly pine, Ligustrum, cotton and tobacco) greatly accelerated their respiratory activity. The germination percentages of the treated seeds were also increased. The concentrations varied from the pure extract through 1:5, 1:10, 1:25, 1:50, 1:100, 1:200, 1:300, 1:400 and 1:500 (part of seaweed extract:part of water). The optimum concentration varied depending upon seeds of difference species. The optimum was generally at a concentration between 1:25 and 1:50 treatments[2].

In the present study, availability of using seaweed extract (as an organic material) in priming technique was investigated in pepper seeds. Moreover, it was aimed to produce a protocol for physiological enhancement of pepper seeds by the use of seaweed extract priming as an organic method.

EXPERIMENTAL

The seeds of pepper (cv. California Wonder) were stored in a fridge at 3 °C until required for experimentation. The seaweed (*Ascophyllum nodosum*) extract (Maxicrop; Maxicrop International Ltd., UK) used in the priming experiments was purchased from a local chemical company in Bursa, Turkey.

The 10 % solution of *Ascophyllum nodosum* powder was prepared as prescribed by Senn[2]. It was also called as the stock solution and different concentrations were prepared by its dilution. Then the seeds were subjected to priming treatments in an incubator running at 20 ± 0.5 °C (since it was determined as the optimum temperature for priming of pepper seeds in our preliminary experiments) by the use of 1:1, 1:5, 1:10, 1:25, 1:50, 1:100, 1:250, 1:500 and 1:1000 dilutions of the seaweed extract stock solution and also H_2O, for 1, 2 and 3 d. Untreated seeds were evaluated as the control. In order to remove the seeds of all the treatment groups on the same day, priming was set up at days 0, 1 and 2 for 3, 2 and 1 day treatments, respectively. Once all the treatment groups were removed from the 20 °C incubator at day 3, the seeds of each treatment were put in a wire mesh strainer and washed with tap water for 3 min and then rinsed with distilled water. Following this, the seeds were dried between two filter papers. The same procedure was also applied to the control and H_2O treatment groups.

Then the seeds of all the treatment groups were set to germinate in an incubator running at 25 ± 0.5 °C and 70 ± 5 % RH. Germination tests were set up using a Factorial Randomized Plots Design. The percentage viability (*i.e.*, total germination rate) of the control and primed seeds was determined according to the International Seed Testing Association (ISTA) Rules[10] except that only 200 seeds (4 replicates × 50 seeds) per treatment were tested in Petri dishes containing wet filter papers and distilled water was added to each treatment group during the test period when necessary.

Germination test results were recorded daily until day 14. Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts[11]:

$$MGT = \Sigma(Dn)/\Sigma n$$

where D = number of days counted from the beginning of the germination test and n = number of seeds which germinate on day D.

Statistical analyses of variance and LSD tests (mean separation of significant differences) were conducted at 0.05 confidence level by the use of BARNES and MSTAT-C computer programmes, respectively.

RESULTS AND DISCUSSION

The effects of priming treatments conducted with different concentrations of seaweed extract on total germination rate and mean germination time in seeds of pepper (cv. California Wonder) were given in Table-1.

The results of the germination tests showed that the effects of priming treatments, treatment periods and the interaction of these two factors on total germination rate and mean germination time were statistically significant ($p < 0.05$). As a general trend, a decrease in seaweed extract concentration and an increase in treatment period caused an increase in total germination rate and a decrease in the mean germination time.

The present results on pepper seeds are in parallel to those obtained in seeds of lettuce and barley, following the seaweed priming treatments[12,13]. Previously, it has been shown that seaweed extracts, which belong to *Ascophyllum nodosum*, cause physiological enhancements and increases in performance of seeds due to their hormonal components such as cytokinins and amino acid contents such as betains and also their hygroscopic characteristics and antibiotic effects[1,12-14]. Therefore, it is clear from the results that the seaweed extract treatments have also positive effects on physiological enhancement of pepper seeds.

The results of the present study suggested that in pepper seed priming treatments that were high in seaweed extract concentration caused a decrease or an unchanged trend in total germination rate and an increase in mean germination time. In other words, seed viability reduced due to the higher concentrations of the seaweed extract.

Regarding the negative correlation between total germination rate and mean germination time, the best results were obtained from the 1 day treatment of the 1:500 concentration. These promising results were maintained in the 1:1000 concentration and H_2O treatment groups.

Consequently, it has been shown here for the first time that priming with an organic agent such as the seaweed extract could also be used in pepper seeds for physiological enhancement. Although this has been the

TABLE-1
EFFECTS OF PRIMING TREATMENTS, CONDUCTED WITH DIFFERENT CONCENTRATIONS OF SEAWEED EXTRACT, ON TOTAL GERMINATION RATE AND MEAN GERMINATION TIME OF PEPPER (CV. CALIFORNIA WONDER) SEEDS

Seed priming treatment	Treatment period (d)	Total germination rate (%)	Mean germination time (d)
Control	–	91 fg *	7.0 jk
1:1	1	87 h	12.2 bc
	2	81 i	12.6 b
	3	75 j	13.4 a
1:5	1	93 efg	12.0 c
	2	94 def	11.4 d
	3	90 gh	10.8 e
1:10	1	92 fg	9.6 f
	2	94 def	8.4 g
	3	93 efg	8.1 gh
1:25	1	94 def	7.7 hi
	2	95 cde	6.6 klm
	3	94 def	6.6 klm
1:50	1	95 cde	7.3 ij
	2	96 bcd	6.7 klm
	3	96 bcd	6.6 klm
1:100	1	95 cde	6.8 kl
	2	96 bcd	6.7 klm
	3	94 def	6.5 lm
1:250	1	94 def	6.7 klm
	2	96 bcd	6.5 lm
	3	94 def	6.3 mn
1:500	1	99 a	5.8 o
	2	98 ab	5.6 o
	3	96 bcd	5.6 o
1:1000	1	97 bc	5.9 no
	2	96 bcd	5.7 o
	3	96 bcd	5.6 o
H_2O	1	98 ab	5.6 o
	2	96 bcd	5.5 o
	3	96 bcd	5.6 o
ANOVA			
Seed priming treatments (A)		**	**
Treatment period (B)		**	**
A × B		**	**

*Values not associated with the same letter are significantly different ($p < 0.05$).
**Significant at 0.05 level.

first attempt, the results are convincing evidence that seaweed extract priming of pepper seeds could be used to improve seed quality and performance. Therefore, this study suggests that the seaweed extract priming procedure of pepper seeds could be used as follows:

The concentration of the priming solution should be adjusted as diluting the stock solution (*i.e.*, 10 % seaweed extract) to 1:500. The priming temperature should be set to 20 °C and the treatment should be conducted for one day.

The use of seaweed extract priming should further be studied in seeds of other agricultural and horticultural species to produce specific protocols. Moreover, possibilities of using seaweed extract priming should also be evaluated in organic seeds prior to organic seedling production and plant growing since *Ascophyllum nodosum* and other seaweeds are valuable organic materials for organic agriculture practices.

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