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EFFECTS OF SEAWEED EXTRACT (SE) APPLICATIONS ON SEED GERMINATION CHARACTERISTICS OF WHEAT IN SALINITY CONDITIONS

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Abstract
This study was carried out to determine the effects of seaweed extract applications on seed germination and some growth parameters in wheat. Wheat seeds were kept in pure water and seaweed extract of 0-25-50% and 100% concentrations at 20 °C for 24 hours. Then, the seeds were washed with pure water, and 50 seeds were placed in the a petri dish and left to germinate at three different salt concentrations (0, 75 and 150 mM) at 20 °C for 10 days. The seed germination rate (%) and time (day) were calculated, and radicle and shoot length (cm), fresh and dry weights (g) were determined at the end of the study. In the study, as salt level increased, seaweed extract (SE) applications negatively affected the total germination rate and germination time, while 25% SE application increased the dry weight, and length of shoot and radicle.

Key words: Wheat, salinity, seaweed extract, germination

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INTRODUCTION

Since ancient times, human beings have benefited from wheat in different ways. Especially wheat has great importance in meeting the need for food. In the world, wheat cultivation was 218 million ha in 2017 (Anonymous, 2018). The soil or water salinity, which is considered to be a major problem of wheat cultivation areas, is one of the leading stress factors and can affect plant production significantly in a negative way. Some factors such as the inhibition of water intake from roots (osmotic effect) of plants grown in salinity conditions, especially the toxicity caused by Na^+ and Cl^- ions and antagonism (specific ion effect) have a negative effect on plant growth and yield. In addition, as taking K^+, Na^+, Cl^- and $SO4^=$ into the plant and moving them to stem, not all of these ions can be moved (Iqbal et al., 2001; Parida and Das, 2005).

It is a known fact that wheat agriculture is now at its end limit, even in marginal areas that are not suitable for wheat agriculture. Safe providing the basic food requirements of people is possible by increasing agricultural production.

Determination of the salinity resistance of wheat cultivars, investigation of the types that will yield at economical level, and determination of the ways to prevent stress factors was important to increase wheat yield, and many studies were carried out on these subjects. There are a large number of studies on the tolerance of wheat against salt in various development times such as germination and shoots development times (Alamri et al., 2018; Feng et al., 2018; Namvar et al., 2018). In addition to these studies, various applications, including especially plant hormones and plant growth regulators, are being used to increase the germination and emergence of seeds in abiotic stress conditions. For example, the use of humic acids, fulvic acids, amino acids and the use of liquid seaweed fertilizers has become important in agriculture. Seaweed that can be used as fertilizer containing plant nutrients is beneficial to plants (Craigie, 2011).

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Unlike chemical fertilizers, seaweed extracts are biologically degradable, non-toxic, non-polluting and non-hazardous living organisms. Seaweed contains new secondary metabolites and has potential applications in different areas (Elgubbi et al., 2019). Red and dark brown-looking seaweed is a kind of simple water plant that lives in the sea. Seaweed is used as a food source, for humans and animals, or as a fertilizer. It has been used directly or in compost form since ancient times to increase the efficiency of products in coastal areas (Craigie, 2011). It is rich in bioactive substances that stimulate germination of seeds such as proteins, peptides, amino acids, lipids, pigments, phenols, polysaccharides, cytokines, auxin, gibberellin, abscisic acid, increasing plant growth and productivity (Norrie and Keathley, 2006; Liu et al., 2013; Pérez et al., 2016; Ghaderiardakani et al., 2018). Seaweed provides strong root development in plants and helps plants take more nutrients and water from the soil. In addition, it accelerates the seed germination process, provides rapid and strong developments of shoots. It has a stimulating effect on the development and proliferation of beneficial soil microorganisms. It also increases plant efficiency and also enhances quality. Seaweed is used extensively especially in developed countries in organic agriculture practices such as increasing the intake of inorganic nutrients from the soil and increasing resistance to stress conditions (Blunden, 1991; Hong et al., 1995).

Seaweed extracts were also used in tomatoes to increase germination, fruit weight and yield (Sutharsan et al., 2014). In a study investigating the effect of C*ladophoropsis gerloffii* aqueous extract, a seaweed, on tomatoes (*Solanum lycopersicum* L.), the seeds were soaked with different concentrations (0, 0.025, 0.05, 0.075 and 0.1 g/100 ml) of *C. gerloffii* aqueous extract and the maximum germination rate (100%) was obtained from 0.1 g/100 ml (Elgubbi et al., 2019).

In a study, the effects of Brown seaweed at different levels of NaCl concentrations (5, 10, 25 and 50%) on the germination and growth characteristics of wheat were investigated, consequently, seed germination and growth parameters increased significantly in 25% seaweed aqueous extract application (Latique et al., 2017). However, Mzibra et al., (2018) tried to determine the effect of seaweed polysaccharides of 17 different species in green, red and brown colors on seed germination and plant growth, so, a positive effect of *Ulva rigida, Codium decorticatum, Gigartina sp., Chondracanthus acicularis, Fucus spiralis and Bifurcaria bifurcata* seaweed on seed germination and plant development were determined, while the red seaweed (*Gigartina pistillata*) inhibited the seed germination.

MATERIAL AND METHODS

In the present study, wheat (*Triticum durum* L.) seeds were used as the material. The seeds were thoroughly washed with pure water after 10 min sterilization in 1% sodium hypochlorite solution. Seaweed extract of 10 g was prepared and completed to 100 ml with pure water, so the solution was prepared in 1:10 concentration. Then this stock solution was diluted with pure water in different ratios (0%-25%-50% and 100%). The seeds were kept in prepared solutions and in pure water at 20 ^{o}C for 24 hours. Then the seeds were thoroughly washed with pure water. For germination tests, the seeds were placed between two germination papers with 50 seeds in each of the Petri dishes with 9 cm diameter. Humidification was ensured with 3 different NaCl doses (0-75 and 150 mM) during the trial, and the seeds were germinated at 16/8 hours light/dark phototime at 20 ^{o}C. After the seeds were placed in the germination media, the germination rate (%) (Bewley and Black, 1994) (seeds with root length of 1 mm and above were considered germinated) and average germination time (day) were calculated by counting them for 10 days (Bewley and Black, 1994). In addition, the root and shoot lengths (cm) of the young shoots were determined by measuring the root and shoot lengths of 10 germinated seeds taken from each germination media at the end of the experiment. Fresh weights (g) were determined using 10 plants of each petri dish, then dry weights (g) were determined after drying them in drying-oven for 48 hours at 70 ^{o}C. The study was arranged in 10 replications according to a factorial trial plan in random plots. The data were analyzed in the SAS package software. Significant differences were determined in MSTAT-C software. Transformation was applied to the obtained percentage values.

RESULTS AND DISCUSSION

Germination rate (%)

The effect of seaweed extract with different concentration on the germination rate of wheat in salinity conditions was not statistically significant in the study. According to the general averages, the ratio of wheat germination ranged from 49.00-91.50% (Table 1). In the study, as seaweed extract and salt concentrations increased, the germination rate decreased significantly. The germination rate of the seeds in which 100% seaweed extract was treated was determined as 49.00% in 150 mM NaCl. Generally, increasing doses of NaCl and seaweed were observed to have adverse effects on germination rate compared to the control group.

Table 1. Effect of seaweed extract (SE) applications on germination rate (%) of wheat seed undersalinity conditions

NaCl doses (mM)	Applications (SE)				
	%0	%25	%50	%100	Mean
0 mM	91.50	81.00	78.00	79.00	82.38 A
75 mM	81.50	77.50	78.50	77.00	78.63 A
150 mM	81.00	67.50	72.50	49.00	67.50 B
Mean	84.67 *a*	75.33 *bc*	76.33 *b*	68.33 *c*	

LSD NaCl**: 6.557 SE**: 7.572 NaCl x SE: non significant

**: significant at %1

Contrary to our results, (Timothy, 2006) the seaweed extract contains some growth-promoting substances in the body and has a positive effect on germination (Sivritepe and Sivritepe, 2008), in their study in pepper, determined that the seed germination rate was increased by seaweed extract application. In the present study, seaweed extract might have prevented water intake in the seed due to the salt it contained, and also the presence of Na^+ and Cl^- ions in the content of seaweed extract might have caused toxicity. For all these reasons, the germination rate and the germination time might have been negatively affected.

Mean germination time (day)

The mean germination time changed between generally 1.87-2.50. Germination time increased in SE and NaCl application in wheat, the longest germination time was determined in seaweed extract application of 100%. Again, the dose of 150 mM NaCl delayed the germination of seeds. SE of 25% accelerated mean germination time compared to the other applications. SE applications of 25% and 50% in 75 mM NaCl dose numerically shortened the time of germination compared to the 0% SE. In parallel with the increasing salt concentration, the mean germination time also increased, regardless of the applications of SE (Table 2).

Table 2. Effect of seaweed extract (SE) applications on mean germination time (day) of wheat seed under salinity conditions

NaCl doses (mM)	Applications (SE)				
	%0	%25	%50	%100	Mean
0 mM	1.87	1.86	2.03	2.01	1.94 C
75 mM	2.15	2.05	2.14	2.19	2.13 B
150 mM	2.28	2.30	2.44	2.50	2.38 A
Mean	2.10 *bc*	2.07 *c*	2.21 *ab*	2.23 *a*	

LSD NaCl**: 0.1392 SE*: 0.1199 NaCl x SE: non signifcant

**: significant at %1, *: significant at %5

Fresh weight (g/plant*)*

The effect of SE and SExNaCl applications on the fresh weight of wheat seeds was not statistically significant (Table 3). According to the dose of SE, the fresh weight values of wheat were determined to change between 0.58-0.70 g/plant. In 3 different concentrations of salt, fresh weight was found to be statistically significant at 1%, the amount of fresh weight decreased significantly as the dosage increased.

Table 3. Effect of seaweed extract (SE) applications on fresh weight (g) of wheat seed under salinity conditions

NaCl doses (mM)	Applications (SE)				
	%0	%25	%50	%100	Mean
0 mM	1.15	1.29	1.01	1.23	1.17 A
75 mM	0.61	0.61	0.58	0.49	0.57 B
150 mM	0.17	0.21	0.15	0.18	0.18 C
Mean	0.64	0.70	0.58	0.63	

LSD NaCl**: 0.1103 SE: non significant NaCl x SE: non significant

**: significant at 1%

Dry weight (g/plant)

The effect of the interaction of applications on the dry weight of wheat is statistically significant ($p < 0.01$) according to Table 4. With the increase in salt concentrations, a decrease emerged in the dry weight values of wheat. As a result of the study, the dry weight values of wheat changed between 0.05-0.20 g/plant according to the concentrations of SE. The highest value was obtained from 0 mM NaCl + 25% SE and 0 mM NaCl + 100% SE applications (0.20 and 0.19 g respectively); the lowest values were observed in 150 mM NaCl + all SE dosage applications (Table 4).

Table 4. Effect of seaweed extract (SE) applications on dry weight (g) of wheat seed under salinity conditions

NaCl doses (mM)	Applications (SE)				
	%0	%25	%50	%100	Mean
0 mM	0.17 b	0.20 a	0.17 b	0.19 ab	0.18 A
75 mM	0.12 c	0.12 cd	0.12 c	0.10 d	0.11 B
150 mM	0.06 e	0.06 e	0.05 e	0.05 e	0.05 C
Mean	0.12	0.12	0.11	0.11	
LSD NaCl**: 0.0119 SE: non significant NaCl x SE**: 0.0238					

**: significant at 1%

Shoot length (cm)

As a result of applying various SE to wheat seeds, different reactions to salt concentrations occurred (Table 5). The effect of SE applications on the length of the shoot was statistically significant ($p < 0.01$). Based on the applications, the change in the length of wheat shoots was determined as 0.68-11.57 cm. According to the Table 5, in the application of 25% SE to wheat seeds, the shoot length was high (5,79 cm) and was included in the same group of 100% SE dose. All SE applications with 150 mM NaCl doses gave similar results, but 100% SE application numerically increased the length of shoot. Also, the length of shoot decreased as the concentration of only salt application increased.

Table 5. Effect of seaweed extract (SE) applications on shoot length (cm) of wheat seed under salinity conditions

NaCl doses (mM)	Applications (SE)				
	%0	%25	%50	%100	Mean
0 mM	9.49 b	11.57 a	9.82 b	11.32 a	10.55 A
75 mM	5.10 c	5.06 c	0.41 e	2.70 d	3.32 B
150 mM	0.87 e	0.75 e	0.68 e	1.47 de	0.94 C
Mean	5.15 *a*	5.79 *a*	3.64 *b*	5.16 *a*	
LSD NaCl**: 0.6293 SE**: 0.7267 NaCl x SE**: 1.259					

**: significant at 1%

Radicle length (cm)

Table 6 shows that the effect of SE applications on radicle length of wheat is significant ($p<0.01$). As a result of the study, wheat radicle length values were determined between 1.39-7.16 cm according to different doses of NaCl and SE. In the study, radicle length decreased generally in parallel with the increase in salt concentration. The maximum radicle length (7.16 cm) was achieved in 0 mM salt concentration and in the application of 25% SE. As a result of the application of various SE and salt concentrations, the highest value was achieved in the application of 0 mM NaCl + 25% SE, followed by 0 mM NaCl + 100% SE implementation (6.97 cm). In 75 mM NaCl conditions, SE application (25% and 100%) numerically increased the length of radicle compared to the control groups, but there was no significant difference between them (Table 6).

Table 6. Effect of seaweed extract (SE) applications on radicle length (cm) of wheat seed under salinity conditions

NaCl doses (mM)	Applications(SE)				
	%0	%25	%50	%100	Mean
0 mM	5.30 cd	7.16 a	5.61 bc	6.97 ab	6.26 A
75 mM	3.30 e	4.22 cde	0.47 f	4.05 de	3.01 B
150 mM	1.39 f	1.55 f	1.68 f	0.72 f	1.33 C
Mean	3.33 *bc*	4.31 *a*	2.58 *c*	3.91 *ab*	
LSD NaCl**: 0.6855 SE**: 0.7915 NaCl x SE**: 1.371					

**: significant at 1%

NaCl applications of 0-75 and 150 mM alone prevented plant growth. With the application of 25% SE to the seeds germinated at 75 mM NaCl, the toxic effect of salt decreased and the length of shoot and radicle were positively influenced. Through the application of SE in saline conditions, it has been reported that the cytokine and plant growth promoting substances contained in the SE increase plant growth and yield against some environmental stress factors such as salinity (Ramu and Nallamuthu, 2012; Vijayakumar et al., 2018; Carrasco-Gil et al., 2019), which supports our findings in the present study. Again, the dose of 25% of the brown seaweed aqueous extract significantly increased the growth parameters of wheat in various NaCl concentrations (5, 10, 25 and 50%) (Latique et al., 2017).

CONCLUSIONS

According to the results obtained from the research, 25% SE application in the wheat grown under the salt stress had a positive effect on the dry weight, length of the shoot and radicle, so it can be used in agriculture as an organic substance. The number of research needs to be increased on this issue because there is not enough work to be done on the issue until today.

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