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A Study of Effects of Organic Origin Liquid Seaweed on Germination Radicle and Plumule Growth in Winter Cereal Genus

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Abstract: In this study, it was aimed to determine the effects of liquid seaweed on seed germination and radicle and plumule growth in some winter cereal species [Triticale (T), Barley (B) and Wheat (W)] were investigated. In the study, 6 different doses [Control (D0), 1000 ppm L^{-1} (D1), 2000 ppm L^{-1} (D2), 4000 ppm L^{-1} (D3), 8000 ppm L^{-1} (D4) and 16000 ppm L^{-1} (D5)] of seaweed were used. Germination index , radicle and plumule fresh weight (g), radicle and plumule dry weight (g) and germinated seed number (number) were measured during the 14-day development period of cereal species at all seaweed doses. According to the study findings, apart from the "number of germinated seeds in cereal species" and "germination index in species x dose interaction"; significant differences were found between the average values of all the properties examined in the grain types, fertilizer doses and species x dose interactions. Wheat among cereals had the highest values concerning radicle dry weight and radicle fresh weight. D2 dose from the doses of seaweed fertilizer form has the highest values in germinated seed number, radicle dry weight, plumule dry weight, and radicle fresh weight, while D5 dose was the lowest. In terms of species x dose interaction, radicle fresh weight was found to be high in T x D1 interaction. Germinated seed number and plumule fresh weight were found to be high in H x D0 interaction. Germinated seed number and radicle dry weight were found to be high in W x D2 interaction. As a result, in the germination study with liquid seaweed, D2 dose for wheat, D1 and D2 doses for triticale, D0, D1 and D2 doses for barley were found as encouraging.

Farklı Organik Kökenli Sıvı Deniz Yosunu Dozlarının Serin İklim Tahıl Cinslerinde Çimlenme Radikula ve Plumula Gelişimi Üzerine Etkilerinin İncelenmesi

Anahtar Kelimeler
Çimlenme indeksi,
Çimlenen tohum,
Doz,
Serin iklim tahılları,
Organik sıvı deniz yosunu

Öz: Bu çalışmada, sıvı deniz yosununun bazı serin iklim tahıl cinslerinde [Tritikale (T), Arpa (B) ve Buğday (W)] tohum çimlenmesi ile radikula ve plumula gelişimi üzerine etkilerinin belirlenmesi amaçlanmıştır. Çalışmada 6 farklı dozda [Kontrol (D0), 1000 ppm L^{-1} (D1), 2000 ppm L^{-1} (D2), 4000 ppm L^{-1} (D3), 8000 ppm L^{-1} (D4) ve 16000 ppm) ppm L^{-1} (D5)] deniz yosunu kullanılmıştır. Tahıl türlerinin 14 günlük büyümedöneminde tüm deniz yosunu dozlarında çimlenme indeksi, radikula ve plumula yaş ağırlığı (g), radikula ve plumula kuru ağırlığı (g) ve çimlenen tohum sayısı (adet) ölçülmüştür. Çalışma bulgularına göre, "tahıl türlerinde çimlenen tohum sayısı" ve "tür x doz interaksiyonunda türler çimlenme indeksi" dışında; tahıl türleri, gübre dozları ve tür x doz interaksiyonlarında incelenen tüm özelliklerin ortalama değerleri arasında önemli farklılıklar bulunmuştur. Tahıllar içinde buğday, radikula kuru ağırlığı ve radikula yaş ağırlığı en yüksek değerlere sahip olmuştur. Deniz yosunu gübre formunun dozlarından D2 dozu; çimlenen tohum sayısı, radikula kuru ağırlığı, plumula kuru ağırlığı ve radikula yaş ağırlığında en yüksek değerlere sahipken, D5 dozu en düşük olarak bulunmuştur. Tür x doz interaksiyonu açısından radikula yaş ağırlığı T x D1 interaksiyonunda yüksek bulunmuştur. H x D0 etkileşiminde çimlenen tohum sayısı ve plumula yaş ağırlığı yüksek bulunmuştur. G x D2 etkileşiminde çimlenenen tohum sayısı ve radikula kuru ağırlığı yüksek bulunmuştur. Sonuç olarak, sıvı deniz yosunu ile çimlendirme çalışmasında buğday için D2 dozu, tritikale için D1 ve D2 dozları, arpa için D0, D1 ve D2 dozları teşvik edici bulunmuştur.

1. INTRODUCTION

Cereals in the Poaceae family are important cultural plants because they are mainly used as a source of carbohydrates and proteins in human and animal nutrition. In the structure of winter cereals, there is approximately 79.5% carbohydrates, 13.6% protein, 2.3% crude oil, 2.5% cellulose and 2.1% ash [1]. Therefore, it is an important food source for human and animal nutrition. Apart from human and animal nutrition, it has an important place in the country's economy since it is also used in industry with value-added products.

Winter and spring cereals have an important place for cultivation area and production in the world and Türkiye. Especially, the cultivation of spring cereals such as bread and durum wheat, barley, oat, rye and triticale cultivars are carried out intensively in Türkiye.

According to TURKSTAT [2], cereal sufficiency was 80.3% in 2021 in Türkiye. However, sufficiency in wheat was the highest with 87.3% and sufficiency in durum wheat with 151.8%. As of 2022, the cultivation area of wheat was 5423779 ha. Wheat production was 16000000 tons for grain and 310966 tons for green grass. In wheat yield, grain was 2930 kg ha^{-1} and green grass was 18480 kg ha^{-1}. The cultivation area of barley was 3085617 ha in grain and 29273 ha in green grass. In addition, while the production of barley was 8100000 tons in grain and 482665 tons in green grass, its yield was 2630 kg ha^{-1} for grain and 16520 kg ha^{-1} for green grass. The cultivation area of triticale was 99640 ha for grain and 61919 ha for green grass. Triticale production was recorded as 320000 tons for grain and 1072635 tons for green grass, triticale yield was recorded as 3210 kg ha^{-1} for grain and 17320 kg ha^{-1} for green grass. Increasing the yield and quality values of winter cereals in proportion to the increasing population is important for more adequate and balanced nutrition for people and animals. Yield and quality vary according to the variety, environmental factors and agricultural methods applied. Türkiye, which is the gene center of many species, has the more importance for cereals. The existence of many registered cultivars, especially in the wheat, is an important place for Türkiye. However, the measures taken to protect and sustain it are not sufficient [3]. Fertilizer is one of the most important inputs in agricultural production, thus providing efficient and high-quality products and supporting the economic sustainability of agriculture [4]. Although there has been a significant increase in the use of chemical fertilizers and chemical pesticides by farmers to increase the fertility of the soil in parallel with the rapid increase in the world population after the Industrial Revolution [5], conventional agriculture in which excessive use of chemical fertilizers and pesticides is considered that it will not be sustainable due to cause problems such as deteriorates the soil organic matter, environmental and soil pollution, contributes to global warming, deterioration of the ecological balance and has problems with food security. [6,7]. For this reason, the necessity of alternative methods in agricultural production is inevitable One way to eliminate the negative effects of chemical fertilizers, which are used intensively, is to use organic fertilizers more in agriculture. Organic-origin liquid seaweed fertilizer is one of the mentioned organic fertilizers. Organic fertilizers or fertilizer forms provide root development by increasing the oxygen content of the soil and its water-holding capacity and also protect the structure of the soil by decreasing salinity in the soil [8]. Seaweed, which is an organic fertilizer form, increases germination, helps root development, and prolongs the life of the plant by protecting plants against diseases and pests [9]. This study was carried out to determine the effects of liquid seaweed doses on germination, radicle and plumule growth in wheat, barley and triticale, which have an important place in terms of cultivation and production.

2. MATERIAL AND METHOD

In the study carried out, organic-origin liquid seaweed obtained from "Kristal AG Kimya Tarım Sanayi ve Ticaret Ltd. Şti." was used. Information on liquid seaweed is given below (Table 1).

Table 1. The organic-origin liquid seaweed fertilizer's content and amount

Seaweed Fertilizer Content	Amount
Organic Matter (%)	15.0
Organic Carbon (%)	10.0
Total Nitrogen (%)	1.0
Water-soluble Potassium Oxide (K_2O) (%)	2.0
Alginic Acid (%)	1.5
Gibberellic Acid (ppm)	0.4
pH	4.0-6.0

This study was carried out in the climate cabinet in the laboratory of Department of Field Crops, Faculty of Agriculture, Kahramanmaraş Sütçü İmam University in April 2021in Türkiye. In the research, T (Triticale: Ayşehanım variety), B (2-row barley: Novosadski 565 variety), and W (Bread wheat: Balkoni variety), which are winter cereal species, were used as seeds.

In the research, organic-origin liquid seaweed fertilizer form was applied in 6 different ways as D0 (Control: tap water) and 5 doses (1000 ppm L^{-1}:D1, 2000 ppm L^{-1}:D2, 4000 ppm L^{-1}:D3, 8000 ppm L^{-1}:D4, 16000 ppm L^{-1}:D5) [8]. In the study, symbolizing the doses of the species is done by adding the symbol of the species to the beginning of the dose. For example, the 2000 ppm L^{-1} (D2) dose of triticale (T) is symbolized as TD2. Tap water was used as a control and for the preparation of other doses. The experiment was carried out according to the randomized plot design with 3 replications. 120 mm petri dishes were used, the bottom of these petri dishes was covered with 2 layers of blotting paper, and then blotting papers were wetted with 12 ml of prepared solutions. 25 healthy seeds from each cereal species were subjected to surface sterilization in 5% NaOCl (sodium hypochlorite) solution for 5 minutes. The seeds of the cereal species subjected to surface sterilization were washed in tap water and sown in petri dishes by adding different doses of solutions. Petri dishes were covered with parafilm (PM-992) to prevent evaporation of the applied solutions at different doses. Afterwards, it was left to germinate for 14 days in an incubator at 20±2 °C. Measurements for germination and radicle and plumule growth were made on the 15th day.

In the experiment, in winter cereal species; properties such as germination index (GI), radicle fresh weight (RFW) (g), plumule fresh weight (PFW) (g), radicle dry weight (RDW) (g), plumule dry weight (PDW) (g) and germinated seed number (GSN) (number) were investigated. Images of the research are given below (Figure 1-6).

Figure 1. First and 6th dose of wheat (23.04.2021)

Figure 2. In barley 4th dose 1st and 3rd recurrence (01.05.2021)

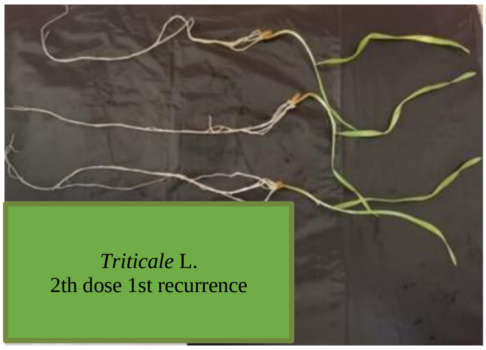

Figure 3. In triticale 2th dose 1st recurrence (06.05.2021)

Figure 4. In wheat 3. dose 1. Recurrence (06.05.2021)

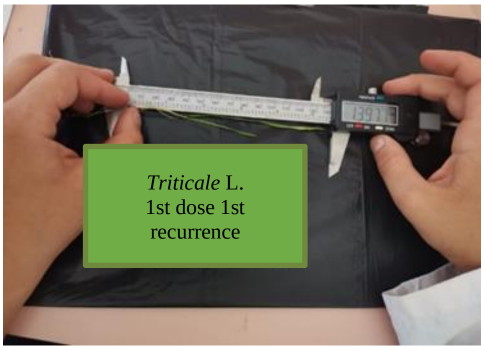

Figure 5. In triticale 1. Döşe 1. recurrence (06.05.2021)

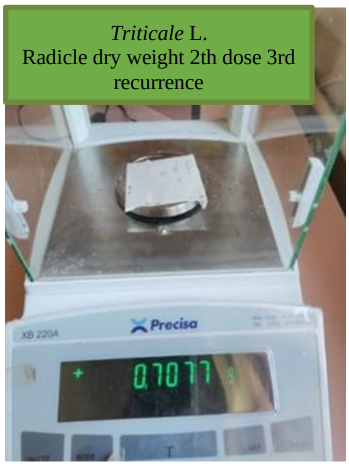

Figure 6. Radicle dry weight of triticale was measured in the laboratory (15th day after placing) (07.05.2021)

The germinated seed number from the examined traits was found by counting the germinated seeds from 25 seeds planted in the petri dish. Counts were made every 24 hours from the second day to the fourteenth day to find the germination index. Germination index (GI) values were calculated using the germinated seed number [10].

$$GI = \Sigma (Gi / Tt) \quad (1)$$

GI= Germination index, Gi= seed germinated number on the "t. day", Tt= day number of the "t. day"

Scales with a sensitivity of 0.001 grams were used to measure the radicle and plumule fresh weight. The radicle and plumule fresh weights were weighed. Then, the dry weight of radicula and plumula was calculated when they reached constant temperature in the oven at 70 °C.

2.1. Statistical analysis of data

The statistical analysis of all data was made using the SAS (v. 9.0, 2002) statistical package programme according to the Completely Randomized Experimental Design. The mean of data was compared by least significant difference (LSD) multiple comparison test [10].

3. RESULTS AND DISCUSSION

The average values of the effects of different seaweed doses on the germination and seedling growth of wheat, barley and triticale seeds are given in Tables 2,3 and 4.

Table 2. Mean values of GSN, GI, RFW, PFW, RDW and PDW in organic-origin liquid seaweed doses.

	Doses (ppm L^{-1})													
Features	**D0**		**D1**		**D2**		**D3**		**D4**		**D5**		**Dose average**	**LSD (0.05)**
GSN (number)	25.00	a	25.00	a	24.78	a	24.44	a	23.00	b	23.00	b	24.20	0.830 **
GI	18.41	b	19.89	a	18.94	ab	18.37	b	15.85	c	12.69	d	17.36	1.376 **
RFW (g)	1.59	a	1.60	a	1.60	a	1.44	b	1.31	c	1.10	d	1.44	0.119 **
PFW (g)	2.05	bc	1.95	c	2.10	ab	1.96	bc	2.21	a	1.78	d	2.01	0.142 **
RDW (g)	0.10	b	0.07	d	0.17	a	0.04	e	0.09	c	0.04	e	0.09	0.009 **
PDW (g)	0.11	b	0.11	b	0.13	a	0.11	b	0.11	b	0.12	b	0.12	0.009 **

GSN: Germinated Seed Number, **GI:** Germination Index, **RFW:** Radicle Fresh Weight, **PFW:** Plumule Fresh Weight, **RDW:** Radicle Dry Weight, **PDW:** Plumule Dry Weight, **Fertilizer Doses D0:** Kontrol, **D1:** 1000 ppm L^{-1}, **D2:** 2000 ppm L^{-1}, **D3:** 4000 ppm L^{-1}, **D4:** 8000 ppm L^{-1}, **D5:** 16000 ppm L^{-1}**, the same letters in each line are in the same group.**

Table 3. Mean values of GSN, GI, RFW, PFW, RDW and PDW across species.

	Species (S)							
Features	**T**		**B**		**W**		**S average**	**LSD (0.05) S**
GSN (number)	24.61		24.00		24.00		24.20	-
GI	19.48	a	14.60	c	18.00	b	17.36	0.97**
RFW(g)	1.52	a	1.32	b	1.48	a	1.44	0.08**
PFW(g)	2.05	a	2.11	a	1.86	b	2.01	0.10**
RDW(g)	0.05	c	0.06	b	0.14	a	0.08	0.00**
PDW (g)	0.12	b	0.13	b	0.10	a	0.12	0.00**

T: Triticale, **B:** Barley, **W:** Wheat, **GSN:** Germinated Seed Number, **GI:** Germination Index **RFW:** Radicle Fresh Weight, **PFW:** Plumule Fresh Weight, **RDW:** Radicle Dry Weight, **PDW:** Plumule Dry Weight, **CV:** Coefficient of Variation, **S:** Species.

3.1. Germinated Seed Number (Number)

The results of variance analysis showed that although the difference between the doses (P<0.01) and species x dose interaction (P<0.05) were statistically significant for the germinated seed number, the difference between cereal species was found to be insignificant (Table 2, Table 3,Table 4). It was determined that the doses of germinated seeds varied between 22.00 and 25.00. The highest germinated seed number was found in the doses D0, D1, D2 and D3 (25.00, 25.00, 24.78, and 24.44, respectively) doses, and the least germinated seeds were in the D4 and D5 (23.00) doses. Among the doses, D4 and D5 seem to have a limiting effect on the germinated seed number (Table 2). It was determined that the germinated seed number of the species x dose interaction varied between 23.00 and 25.00. Within the species x dose interaction, the highest germinated seed number was in TD0, TD1, TD2, TD3, TD4, BD0, BD1, WD0, WD1, WD2, WD3 (25.00), followed by BD2 and BD3 (24.00) the least germinated seed number was obtained in BD4 and WD4 (22.00) (Table 4). Kaya and Erdönmez [8], in their research to determine the effect of 6 different doses (D0, D1, D2, D3, D4 and D5) of seaweed on soybean germination and seedling development; the highest germinated seed number was determined at a dose of 22.00 with D1 (1000 ppm L^{-1}), and the least germinated seed number at a fertilizer dose of 5.00 with D5 (16000 ppm L^{-1}). Kaya and Coşkun [11], in their research to determine the effect of 6 different doses (D0, D1, D2, D3, D4, D5) of liquid seaweed on rapeseed germination and seedling development; it was determined that the highest germinated seed number in the D0 application and D1 (23.78 pieces and 22.67 pieces, respectively), the least germinated seed number was 4.33 at D3, germination did not occur in D5. As seen in previous studies, the number of germinating seeds varies according to plant species.

3.2. Germination Index

According to the results of the analysis of variance; In terms of germination index, the difference between cereal types and doses was statistically significant (P<0.01), while the difference between species x dose interaction was found to be insignificant (Table 2., Table 3., Table 4.). The germination index of cereal species varied between 14.60-19.48. Among the species, the highest germination index was found in the T type (19.48), and the lowest germination index was found in the B type (14.60) (Table 3). The germination index of the doses varied between 12.69-19.89. The highest germination index was observed in the D1 dose, and the lowest germination index was observed in the D5 dose (Table 2). D1 dose seems to be more encouraging in terms of germination index. The germination index of the species x dose interaction ranged from 11.64 to 22.00. Kaya and Erdönmez [8], who carried out to determine the effect of 6 different doses (D0, D1, D2, D3, D4 and D5) of seaweed on soybean germination and seedling development; reported that the highest germination index in the materials they applied seaweed at 6.39% to D1 dose, and the lowest germination index at 1.39% to D5 fertilizer dose. In the study, it was observed that the germination index decreased with the increase of the seaweed fertilizer dose, except for the D0 application, and this is consistent with our findings.

Table 4. Mean GSN, GI, RL, PL, SL and RFW values in the organic-origin liquid seaweed doses of species.

Species	Doses (ppm L^{-1})	GSN (Number)		GI	RFW (g)		PFW (g)		RDW (g)		PDW (g)	
T	**D0**	25.00	a	22.00	1.52	a-d	1.83	cd	0.09	bcd	0.10	def
	D1	25.00	a	22.00	1.87	a	2.14	abc	0.08	de	0.12	cde
	D2	25.00	a	19.92	1.74	ab	2.31	ab	0.06	ef	0.17	a
	D3	25.00	a	20.89	1.64	abc	2.20	abc	0.01	g	0.11	def
	D4	25.00	a	18.23	1.26	def	2.24	abc	0,05	ef	0.13	cd
	D5	23.00	ab	13.82	1.07	fg	1.60	de	0,04	fg	0.08	fg
B	**D0**	25.00	a	13.74	1.38	c-f	2.38	a	0.09	bcd	0.14	bc
	D1	25.00	a	16.67	1.29	def	1.93	cd	0.05	f	0.12	de
	D2	24.00	a	16.87	1.45	bcd	2.23	abc	0.04	f	0.16	a
	D3	24.00	a	15.09	1.23	def	1.62	de	0.03	fg	0.09	f
	D4	22.00	b	13.57	1.19	ef	2.20	abc	0.10	bc	0.10	ef
	D5	23.00	ab	11.64	1.40	cde	2.28	ab	0.05	f	0.16	ab
W	**D0**	25.00	a	19.47	1.86	a	1.94	cd	0.00	b	0.09	fg
	D1	25.00	a	21.01	1.63	abc	1.78	d	0.09	cd	0.09	f
	D2	25.00	a	20.02	1.61	abc	1.75	d	0.41	a	0.07	g
	D3	25.00	a	19.14	1.45	cd	2.05	bc	0.09	cd	0.13	cd
	D4	22.00	b	15.75	1.48	bcd	2.18	abc	0.10	bc	0.11	de
	D5	23.00	ab	12.61	0.82	g	1.46	e	0.04	f	0.12	de
Overall Average		24.22		17.36	1.44		2.01		0,08		0,12	
LSD (0.05) T x D		2.49*		-	0.36**		0.43**		0.03**		0.03**	
CV (%)		3.58		8.27	8.65		7.39		11.21		8.43	

T: Triticale, **B:** Barley, **W:** Wheat, **GSN:** Germinated Seed Number, **GI:** Germination Index **RFW:** Radicle Fresh Weight, **PFW:** Plumule Fresh Weight, **RDW:** Radicle Dry Weight, **PDW:** Plumule Dry Weight, **CV:** Coefficient of Variation, **D:** Dose, Fertilizer Doses; **D0:** Control, **D1:** 1000 ppm L^{-1}, **D2:** 2000 ppm L^{-1}, **D3:** 4000 ppm L^{-1}, **D4:** 8000 ppm L^{-1}, **D5:** 16000 ppm L^{-1}. There is no statistical difference between the same capital letters in the same column. There is no statistical difference between the same lowercase letters in the same column.

3.3. Radicle Fresh Weight (g)

In the analysis of variance, the statistical difference (P<0.01) between cereal types, doses and species x dose interaction was found to be very significant for radicle fresh weight (Table 2, Table 3 and Table 4.). The fresh radicle weight of the cereal species varied between 1.32 and 1.52 g. The highest radicle fresh weight was found in T and W types (1.52 and 1.48 g, respectively) among cereal species, and the lowest radicle fresh weight was determined in B type (1.32 g).

It was observed that the doses ranged from 1.10 g to 1.60 g fresh weight of the radicle. While the highest radicle fresh weight was observed in the D1, D2 and D0 doses (1.60, 1.60 and 1.59 g, respectively) among the doses, the lowest radicle fresh weight was observed in the D5 dose.

It has been determined that D5 has a limiting effect on the fresh weight of the radicle within the doses. The radicle fresh weight of the species x dose interaction ranged from 0.82 g to 1.87 g. Among the species x dose interaction, the highest radicle fresh weight was found in TD1 and WD0 (1.87 and 1.86 g, respectively), while the lowest radicle fresh weight was found in WD5. Bat et al. [13]investigated the effects of seaweed doses (0, 2, 4 and 6 cc L^{-1}) applied in viols on echinacea plant under drought stress. As a result of the research, the highest radicle fresh weight of 5.93 g and 6 cc L^{-1} seaweed dose was determined in the echinacea plant, and the lowest radicle fresh weight was 4.26 g at the control dose, and they reported that seaweed had a positive effect on the radicle fresh weight.

Kara et al. [12], investigated the effect of seaweed applications (control, 2, 4 and 6 cc L^{-1}) on salt stress (control, NaCl, KCl and $CaCl_2$) in echinacea plant. As a result of the research, they observed that the highest average radicle fresh weight was obtained from 4.35 g and 6 cc L^{-1} seaweed dose, and the lowest average radicle fresh weight was obtained from 3.46 g and 2 cc L^{-1} dose.

3.4. Plumule Fresh Weight (g)

In the analysis of variance, the difference ($P<0.01$) between cereal types, doses and species x dose interaction in terms of plumule fresh weight was found to be statistically very significant (Tables 2, 3 and 4). The plumule fresh weight of the cereal species varied between 1.86 and 2.11 g. Among the species, the highest plumule fresh weight was obtained in B and T (2.11 and 2.05 g, respectively) species, and the lowest plumule fresh weight was obtained in W species (1.86 g).

It was determined that the fresh weight of the plumule of the doses varied between 1.78 and 2.21 g. The highest plumule fresh weight was observed in the D4 dose, and the lowest plumule fresh weight was observed in the D5 dose. It was observed that the species x dose interaction varied between 1.46-2.38 g plumule fresh weight. Among the species x dose interaction, the highest plumule fresh weight was found in BD0, and the lowest plumule fresh weight was found in WD5 (Table 4).

Bat et al. [13] investigated the effects of seaweed doses (0, 2, 4 and 6 cc L^{-1}) applied in viols on echinacea plant under drought stress. As a result of the research, the highest plumule fresh weight of 6.35 g and 6 cc L^{-1} seaweed was observed in the echinacea plant, and the lowest plumule fresh weight was observed in the control application with 5.11 g. Steveni et al. [14] determined that the seedling weight increased by 56% to 63% in the application of seaweed material in winter barley. Kara et al. [12] investigated the effect of seaweed applications (control, 2, 4 and 6 cc L^{-1}) on salt stress (control, NaCl, KCl and $CaCl_2$) in echinacea plant. As a result of the research, they observed that the highest average plumule fresh weight was obtained from 3.38 g and 6 cc L^{-1} seaweed dose, and the lowest average plumule fresh weight was obtained from 2.45 g and 2 cc L^{-1} dose.

3.5. Radicle Dry Weight (g)

In the analysis of variance, the difference ($P<0.01$) between cereal species, doses and species x dose interaction in terms of radicle dry weight was found to be statistically very significant (Table 2, Table 3 and Table 4.). The radicle dry weight of the cereal species ranged from 0.05 g to 0.14 g. Among the species, the highest radicle dry weight was found in the W type, and the lowest radicle dry weight was found in the T type (Table 3.). The radicle dry weight of the doses ranged from 0.04 g to 0.17 g. The highest radicle dry weight was found in the D2 dose, and the lowest radicle dry weight was determined in the D3 and D5 doses (Table 2). The radicle dry weight of the species x dose interaction ranged from 0.01 g to 0.41 g. Among the species x dose interaction, the highest radicle dry weight was observed in WD2, and the lowest radicle dry weight was observed in TD3 (Table 4). Bat et al. [13] investigated the effects of seaweed doses (0, 2, 4 and 6 cc L^{-1}) applied in viols on echinacea plant under drought stress. As a result of the research, the highest radicle dry weight of 1.04 g and 6 cc L^{-1} seaweed was observed in the echinacea plant, and the lowest radicle dry weight was observed in the control application with 0.71 g. Kara et al. [12] investigated the effect of seaweed applications (control, 2, 4 and 6 cc L^{-1}) on salt stress (control, NaCl, KCl and $CaCl_2$) in echinacea plant.

As a result of the research, they observed that the highest average radicle dry weight was obtained with 0.81 g and 6 cc L^{-1} seaweed dose, and the lowest average radicle dry weight was obtained in the control application with 0.58 g. Kaya and Coşkun [11], in their research to determine the effect of 6 different doses (D0, D1, D2, D3, D4, D5) of liquid seaweed on rapeseed germination and seedling development; found that the highest radicle dry weight was 1.914 mg with D4, the lowest radicle dry weight was 0.535 mg with D1, and germination did not occur at D5 dose.

3.6. Plumule Dry Weight (g)

In the analysis of variance, the difference ($P<0.01$) between cereal types, doses and species x dose interaction in terms of plumule dry weight was found to be statistically very significant (Table 2, Table 3 and Table 4.). The plumule dry weight of the cereal species varied between 0.10-0.13 g. Among the species, the highest plumule dry weight was obtained in B species, and the lowest plumule dry weight was obtained in W species (Table 3.). The plumule dry weight of the doses ranged from 0.11 g to 0.13 g. Among the doses, the highest plumule dry weight was found in the D2 dose, and the lowest plumule dry weight was found in the D0, D1, D3, D4 (0.12 g) and D5 (0.12 g) doses (Table 2).

The plumule dry weight of the species x dose interaction ranged from 0.07 g to 0.17 g. Among the species x dose interaction, the highest plumule dry weight was found in TD2 and BD2 (0.17 and 0.16 g, respectively), and the lowest plumule dry weight was found in WD2 (Table 4.). Bat et al. [13] investigated the effects of seaweed doses (0, 2, 4 and 6 cc L^{-1}) applied in viols on echinacea plant under drought stress. As a result of the research, the highest plumule dry weight of 1.21 g and 4 cc L^{-1} seaweed was determined in the echinacea plant, and the lowest plumule dry weight was determined as 0.84 g in the control application. Kara et al. [12] investigated the effect of seaweed applications (control, 2, 4 and 6 cc L^{-1}) on salt stress (control, NaCl, KCl and $CaCl_2$) in echinacea plant. As a result of the research, they observed that the highest average plumule dry weight was obtained with 0.81 g and 6 cc L^{-1} seaweed dose, and the lowest average plumule dry weight was obtained with 0.62 g in the control application. Kaya and Coşkun [11], in their research to determine the effect of 6 different doses (D0, D1, D2, D3, D4, D5) of liquid seaweed on rapeseed germination and seedling development; determined that the highest plumule dry weight was 7.880 mg with D2, the lowest plumule dry weight was 4.591 mg with D1, and germination did not occur at D5.

4. CONCLUSION

Germination studies on organic liquid seaweed and seeds of cereal species have not been very much. With this study, the effect of organic-origin liquid seaweed material on the germination and growth of radicle and plumule in cereal species will be determined and will guide many future studies.

In the study, it was observed that the data on the germination and radicle and plumule growth of the cereal species of seaweed doses were statistically significant. D2 (2000 ppm L^{-1}) dose gave the highest values in terms of germinated seed number, radicle dry weight, plumule dry weight and radicle fresh weight, while the D5 (16000 ppm L^{-1}) dose gave the lowest values. Among the cereal types, wheat reached the highest values for germination index, radicle fresh weight and plumule fresh weight.

As a result, the D2 (2000 ppm L^{-1}) dose of seaweed organic material is generally recommended for wheat from cereal species; while D1 (1000 ppm L^{-1}) and D2 (2000 ppm L^{-1}) dose in triticale; D2 (2000 ppm L^{-1}) dose are recommended as incentives in barley.

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