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EFFECT OF SOIL CONDITIONERS APPLIED TO SEED ON GRAIN YIELD AND YIELD CHARACTERISTICS IN WHEAT

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ABSTRACT

This study, researching the effect of seed treatment with liquid soil conditioners on yield properties of bread wheat varieties, was carried out during 2017 and 2018 years in the experimental field of Tekirdag Namik Kemal University Faculty of Agriculture, Department of Field Crops. The experiments were conducted with 3 bread wheat varieties and 4 soil amendments (control + 3 different liquid soil amendments) in 3 repetitions. In the experiment, 4 different treatments including 3 different soil regulators and 1 control (T1: Control; T2: 13-5-8+glycine betaine; T3: 15% organic matter, 15% humic and fulvic acid+0.03% potassium and T4: 25% organic matter + 65% humic acid + 6% potassium (T4) were made. Seeds treated with a spray and then dried were sown as split plot experimental design. In the study, the variations in the plant height (PH), spike length (SL), number of spikelets per spike (NSS), number of grains per spike (NGS), grain weight per spike (GWS), spike fertility index (SFI), harvest index (HI) and grain yield (GY) parameters were investigated for the bread wheat varieties. According to the research results, all soil conditioners applied to seeds were determined to affect the investigated characters at a statistically significant level. For the PH parameter, T3 treatment caused a significant increase, while for the SFI parameter, T2 treatment caused a significant increase. For the HI parameter, treatments T2 and T3 had the highest effect. Spike characteristics like SL, NSS and NGS increased compared to controls with all soil conditioner treatments, while parameters like GWS and SFI differed according to variety. Grain yield, the most important parameter for wheat, provided the highest results in different soil conditioner treatments depending on the varieties. T4 treatment caused clear increases in the SL, NSS, NGS, GWS and GY parameters. According to the data obtained was evaluated, soil conditioner applications caused a significant increase in the parameters examined in wheat. T4, which contains 25% organic matter + 65% humic acid + 6% potassium, was determined as the most effective soil conditioner for many parameters.

Keywords: Humic substance, soil conditioner, *Triticum aestivum* L., yield

INTRODUCTION

The yield properties of agricultural soils are weakening from year to year due to reasons such as temperature, mistaken agricultural practices and erosion, which make sustainable agricultural production impossible. Increasing the yield of agricultural land by using appropriate cultivation techniques is an important requirement for sustainable agriculture. Within the sustainable agriculture approach, organic farming techniques and organic fertilizer have an important place (Turhan, 2005). The basic principle in organic farming is to use organic fertilizers instead of chemical fertilizers. With the use of organic fertilizer, the organic matter content of soils increases and thus, the yield capacity of soils increases with enhanced physical, chemical and biological traits (Oksel et.al., 2022). Producers aware of the importance of organic matter use a variety of organic materials, sold commercially and called soil conditioners, for this purpose. The effects of organic soil conditioners used in agricultural soils are proposed to largely come from the humic substances (HS) they contain (Liu and Cooper, 2000).

HS greatly affect soil quality due to its role in several complex chemical and biochemical reactions in soil and has vital importance in preserving soil yield. Humic substances are basic components of the terrestrial ecosystem and humic substances comprise 60% of soil organic matter (Shah et al., 2018). While HS may reach 5-7% in soils rich in terms of humus, it may exceed 80% in materials like leonardite (Bezuglova and Klimenko, 2022). The main fraction of humic substances is humus and it typically

occurs in organic waste, agricultural by-products, fresh plant and animal organic matter and from fermentation of coal. Fermentation of these substances under conditions with controlled temperature, water, aeration and time comprise the soil biota (Canellas and Olivares, 2014). Weber et. al. (2018) reported that HS have bio-stimulating effects on plant growth and interest in HS has increased with this awareness. Canellas and Olivares, (2014) stated that HS primarily affects root development and growth dynamics. HS increases the development of plant roots and hence is known as a supporter of plant growth on a broad scale. Generally, one of the expected traits of HS may be said to be that they will increase intake by the plant by increasing the bioavailability of macro and micronutrients (Garcia et al., 2016; Shah et al., 2018). Additionally, among their important traits are the improvement in the physical, chemical and biological traits of soil (Weber et al. 2018; Senesi et al., 1996) and mineral nutrition that encourage root and shoot growth (Shah et al., 2018; Ramos et al., 2015). It was determined that glycine betaine also had a positive effect on the plant traits examined in canola (Safdari-Monfared et al., 2020).

Wheat is the agricultural product with the highest production in Turkiye and additionally the highest consumption of 179.3 kg per person annually according to 2021 data (TUIK, 2023). Due to reasons such as the high yield linked to suitable climate and soil structure, cultivation being suitable for mechanized farming and hence lack of excess labour needs, wheat cultivation is performed in large areas of Thrace (Turkiye) (Ozturk et al., 2009). According to 2021 data, a total of 445,042 ha area was farmed for wheat in Thrace (Tekirdag, Kırklareli, Edirne) and 2,208,211 tons of wheat were produced (TUIK, 2023). Producers in this region implement intensive fertilization programs to be able to obtain maximum product from the agricultural area. With the conceptualization of the importance of organic farming in recent periods and additionally the use of support from the Ministry of Agriculture, the importance given to organic fertilization within this fertilization program has rapidly increased. With this aim, the use of organic soil conditioners sold commercially and containing HS has been popularized. In a variety of studies about the wheat plant, the use of humic substances for wheat was shown to have a positive impact on plant development and product amounts (Arduc et al., 2020; El-Hashash et al., 2022; Pacuta et al., 2021). Humic substances may be classified as humic acids, fulvic acids and humins according to their solubility in water at different pH levels. Humic acids (HA) do not dissolve in water under acid conditions (pH <2); however, they dissolve at highly alkaline pH. Fulvic acid is soluble in water at all pH levels, while humins are humic substances that are not water soluble at any pH (Zavarzina et al., 2021). Humic substances (especially humic acids) may be applied to the plant from soil with irrigation and from the leaves. In recent periods, the use of HS applied to seeds before planting has become more common in the Thrace region. However, research on this topic is limited in our country. As a result, this study was aimed to investigate the effect on yield and yield properties of different liquid soil conditioners, commonly used in wheat-growing areas of the Thrace region and containing HS, applied to seeds of different wheat varieties before sowing.

MATERIALS AND METHODS

The research was completed as a 2-year field experiment in 2016-2017 and 2017-2018 growing years at Tekirdag Namik Kemal University, Faculty of Agriculture, Department of Field Crops. The soil properties of the experiment area are given in Table 1.

Table 1. Soil characteristics of the experimental area

Dept	O.M.	pH	EC	$CaCO_3$	Texture (%)				Available elements (ppm)				
(cm)	(%)		(dSm^{-1})	(%)	Clay	Silt	Sand	T. Class	P	K	Fe	Zn	Mn
0-20	1,08	6.25	0,33	0.01	42,50	24,2	33,30	C	16	169	27	0,32	25
20-40	1,11	6.52	0,30	0.01	43,00	24,9	32,10	C	15	164	25	0,41	20

O.M: Organic matter (%); EC: Electrical conductivity ($dS.m^{-1}$)

The soils in the experiment area have low organic matter, mildly acid-neutral pH, no salt, low lime, class clay (C) texture, adequate available P, adequate available K, high available Fe, low available Zn and adequate available Mn.

Soils in the research area had organic matter (%) determined with the modified Walkley-Black method (Jackson, 1979), and pH and soil salinity (EC) identified in saturation paste (Soil Survey Lab. Staff, 1992). The amount of $CaCO_3$ (%) was determined with the Scheibler Calcimetry Method (Soil Survey Lab. Staff, 1992), available P was extracted according to Olsen and Sommers (1982), and detected with ICP-OES and available K was extracted in solution with 1 N ammonium acetate and detected with ICP-OES (Soil Survey Lab. Staff, 1992). Microelements (Fe, Zn and Mn) were extracted in solution with DTPA and detected with ICP-OES (Lindsay and Norvell, 1978). For sand (%), silt (%) and clay (%) proportions (texture), the Bouyoucos hydrometer method was used (Gee and Bauder, 1986). Assessment of soil analysis results used classifications stated in Schlichting and Blume (1966) for organic matter and lime, Richards (1954) for pH and EC, FAO (1990) for available P and K, and Lindsay and Norvel (1969) and Follett (1969) for Fe, Zn and Mn.

In Tekirdag, where the experiment area is located, is dominated by the Mediterranean climate in coastal regions; however, different snowfall may be observed. Interior sections have a continental climate with hot summers and cold winters. According to long-term data (1970-2023), the

mean temperature is 14.1 ℃ (maximum 18.1 ℃, minimum 8.9 ℃) and the mean annual rainfall is 583.5 mm. (MGM, 2023).

The average temperature and rainfall during the wheat growing period are highly effective on grain yield. The amount of precipitation and its distribution, especially in April and May, which include the heading and grain filling periods, significantly affect quality and yield. While the total precipitation received during the growing period of the wheat in 2016 was 395 mm, the total precipitation in April-May was 53.5 mm. The total amount of precipitation received in the 2017 growing season was 478.8 mm, and the total precipitation in April-May was 77.8 mm. In 2017, the rainfall during the growing period was 83.8 mm and 24.3 mm higher in April-May. While the average temperature was 16.5 ºC in the 2016-2017 growing period, when the experiment was conducted, it was 15.7 ºC in the 2017-2018 growing period. When these values are compared with long-term averages, they were 2.4 ºC higher in 2016-2017, while the temperature was 1.6 ºC higher in the 2017-2018 growing period. Plant material in the experiment was used Flamura 85, Selimiye and Esperia bread wheat varieties commonly sown in Thrace. Flamura 85 is a variety resistant to cold, with winter planting, good tillering capacity, moderate or high yield potential (350-600 kg da^{-1}), red hard-semi hard grains with large size and good bread quality. Selimiye is a variety recommended for sowing in a variety of regions and soil structures, are used for winter sowing due to good resistance to cold. Tillering capacity is good and yield potential is moderate or high (350-600 kg da^{-1}). Grains have red color, with hard and large structure and good bread quality. Esperia is a quality variety of winter wheat that can resist cold, and with high yield in excess tillering and wet conditions.

The experiment was performed with 3 replications according to the split plot experimental design, with main parcels assigned to varieties and soil conditioners applied to sub-parcels. Three different, commonly sold soil conditioners were used in the experiment. Attention was paid to the manufacturer's instructions relating to the amounts of soil conditioners applied to the varieties. The conditioners, contents and amounts used are given in Table 2.

Table 2. Soil conditioner treatments and contents for seeds

Treatments	Soil conditioner (amount per 1 kg seed)	Soil Conditioners
T1 (Control)	0 (Control)	
T2	3 ml/1 liter	13-5-8+glycine betaine
T3	5 ml/1 liter	15% organic matter, 15% humic and fulvic acid+0.03% potassium
T4	2 g/1 liter	25% organic matter+65% humic acid+6% potassium

In the experiment, 4 different treatments including 3 different soil regulators and 1 control (T1: Control; T2: 13-5-8+glycine betaine; T3: 15% organic matter, 15% humic and fulvic acid+0.03% potassium and T4: 25% organic matter + 65% humic acid + 6% potassium (T4) were made. Soil regulators were dissolved in 1 liter of distilled water in the amounts given in Table 2. As soil conditioners in the research, T2 was used 3 ml kg-1 seed, T3 5 ml kg-1 seed and T4 2 g kg-1 seed and sprayed on all seeds in a container. In the control application, the seeds were soaked in only 1 liter of distilled water. Seeds were left in the laboratory environment at room temperature to dry. Seeds treated with soil conditioner and dried were sown in 5 m rows, 17 cm apart in 6 rows with 500 seeds m^{-2} using a seeder. Additionally, all parcels had 20 kg da^{-1} 20.20.0 composite fertilizer applied during sowing, 17 kg da^{-1} urea applied during the tillering period and 20 kg da^{-1} ammonium nitrate (26%) applied in the bolting period. To prevent weed development, insecticide was applied with no intervention performed for diseases and pests. The second year phase of the experiment was carried out on the same land, in a different parcel, by performing the same procedures as in the first year. The plants were harvested with a HEGE-160 parcel combine harvester with analyses performed for plant height (PH), spike length (SL), number of spikelets per spike (NSS), number of grains per spike (NGS), grain weight per spike (GWS), spike fertility index (SFI), harvest index (HI) and grain yield (GY).

Analysis of Data: Data obtained from the research in the split plot experimental design had variance analysis performed with the JUMP 5.0 statistical package. Significance levels of differences between the means were determined with the minimum least significant difference (LSD) test.

RESULTS AND DISCUSSION

The effects of soil conditioners applied to seeds in the research on PH, SL, NSS, NGS, GWS, SFI, HI and GY of the bread wheat varieties were investigated. The results obtained in the study and statistically evaluated were presented below.

According to variance analysis of the data obtained in the research (Table 3), the effects of soil conditioner treatments on PH were statistically significant at 0.01 level for varieties (V), year x variety interaction (YxV), variety x treatment interaction (VxT) and year x variety x treatment interaction (YxVxT), while the effect was statistically significant at 0.05 level in terms of treatment (T). For SL, the Y, V, YxV interaction and T were significant at 0.01 level, while the VxT interaction and YxVxT interaction were significant at 0.05 level. The soil conditioners had a significant effect on NSS in terms of Y, V, YxV interaction,

T and VxT interaction at 0.01 level. For NGS, the V, YxV interaction, T, YxT interaction and YxVxT interaction were significant at 0.01 level, while Y was significant at 0.05 level. When the temperature and precipitation values obtained in the second year of the experiment were examined, the statistical difference between the years was caused by the higher average temperature and total precipitation in the months of April-May, which are important for both the growing period and the product yield and quality in the second year.

Table 3. Mean squares related to grain yield and some yield characters

Variation resource	PH (cm)	SL (cm)	NSS (unit)	NGS (unit)	GWS (g)	SFI (%)	HI (%)	GY (kg ha^{-1})
Block	1.470	0.036	0.032	1.150	0.059	0.136	0.584	1074.764
Year (Y)	233.460	38.749**	526.501**	110.509*	3.516**	3217.223**	1053.023**	1795512.5**
Error$_1$	18.946	0.003	0.195	4.858	0.036	1.365	0.957	2244.042
Variety (V)	1095.723**	2.555**	3.565**	411.202**	0.304**	503.672**	53.623**	38446.181**
Y x V	14.862**	1.725**	24.708**	157.032**	0.110*	94.685**	23.230**	28519.292**
Error$_2$	1.435	0.032	0.222	1.612	0.024	1.197	0.938	327.382
Treatment (T)	10.469*	0.694**	3.668**	9.029**	0.019	301.440**	16.608**	2915.111**
Y x T	2.561	0.097	0.417*	13.806**	0.020	128.885**	12.257**	855.315
V x T	27.201**	0.178*	0.578**	1.304	0.038	96.700**	8.109**	5515.292**
Y x V x T	22.899**	0.151*	0.156	6.901**	0.025	125.610**	3.245**	4944.662**
Error	2.945	0.055	0.097	1.325	0.018	3.463	0.807	397.278

PH: Plant high (cm); SL: spike length; NSS: Number of spikelets per spike (unit); NGS: Number of grains per spike (unit); GWS: Grain weight per spike (g); SFI: Spike fertility index (%); HI: Harvest index (%); GY: Grain yield (kg ha^{-1})

For GWS, Y and V were significant at 0.01 level, while the YxV interaction was significant at 0.05 level. For SFI, HI and GY parameters, the Y, V, YxV interaction, T, YxT interaction, VxT interaction and YxVxT interaction were significant at 0.01 level (apart from YxT for GY).

Significance was tested for characteristics that were statistically significant as a result of variance analysis of the obtained data. Mean values and significance groups are given in Table 4.

Table 4. Treatment and variety mean values related to grain yield and some yield traits

Treatment	PH (cm)	SL (cm)	NSS (unit)	NGS (unit)	GWS (g)	SFI (%)	HI (%)	GY (t ha^{-1})
T1 (Control)	90.15 b	9.47 c	20.82 b	45.18 c	1.94	68.47 d	42.59 c	7.37 c
T2	91.21 ab	9.71 b	20.98 b	45.65 bc	1.99	78.28 a	44.82 a	7.57 ab
T3	91.83 a	9.67 b	20.97 b	46.21 ab	2.00	71.62 c	44.27 a	7.54 b
T4	90.43 b	9.95 a	21.81 a	46.82 a	2.01	73.05 b	43.60 b	7.68 a
LSD$_{0.05}$	1.160	0.159	0.210	0.778		1.258	0.607	13.474
Variety								
Flamura 85	96.77 a	10.05 a	20.73 b	47.97 a	2.12 a	76.38 a	43.72 b	7.64 b
Selimiye	92.43 b	9.64 b	21.21 a	41.20 b	1.91 b	67.68 c	42.38 c	7.10 c
Esperia	83.51 c	9.41 c	21.49 a	48.72 a	1.94 b	74.52 b	45.36 a	7.88 a
LSD$_{0.05}$	1.160	0.119	0.314	0.845	0.103	0.728	0.645	12.045

PH: Plant high (cm); SL: spike length; NSS: Number of spikelets per spike (unit); NGS: Number of grains per spike (unit); GWS: Grain weight per spike (g); SFI: Spike fertility index (%); HI: Harvest index (%); GY: Grain yield (kg ha^{-1})

According to the research results, the treatment of seeds with soil conditioners had statistically significant effects on yield and all yield parameters (apart from GWS) in terms of both variety and treatment.

The highest effect for the plant PH parameter was for Flamura 85 variety (96.77 cm) on a variety basis, followed by Selimiye and Esperia varieties. On a treatment basis, the highest value was obtained with the T3 treatment (91.83 cm), followed by the T2 treatment in the same statistical group. The T4 treatment and T1 (control) treatment had close results and were included in the same group statistically.

For the SL values, Flamura 85 variety was in first place with a value of 10.05 cm, followed by Selimiye in second place and Esperia in third place. On a treatment basis, T4 treatment had the highest effect with a value of 9.95 cm. This was followed by T2 and T3 treatments. The control dose was in last place.

On a variety basis, the NSS parameter was highest for the Selimiye and Esperia varieties (21.21 and 21.49) with the lowest effect for Flamura 85. On a treatment basis, the highest value was found with the T4 treatment (21.81), while the other treatments were included in a different statistical group with similar effect.

For the NGS parameter, the Flamura 85 and Esperia varieties (47.97 unit and 48.72 unit) had the highest effect in the same statistical group, while the Selimiye variety was in last place. Among treatments, the T4 treatment had the highest effect with a value of 46.82 unit, and this was followed by the T3 treatment in the same statistical group. The control treatment was in last place.

For the GWS parameter, data obtained on a treatment basis were not statistically significantly different, with the highest value for T4 (2.01 g) followed by T3. On a variety basis, the highest value was for Flamura 85 (2.12 g), followed by Esperia and Selimiye varieties.

For the SFI parameter, the Flamura 85 variety was in first place at 76.38% with the most statistically significant effect, followed by the Esperia variety. On a treatment basis, the T2 treatment (78.28%) was very different to the other treatments with the most significant statistical effect. The T2 treatment was followed by T4 treatment with the control treatment in last place.

For the HI parameter, the Esperia variety had the highest effect of 45.36%, followed by the Flamura 85 variety. Among treatments, T2 (44.82%) and T3 (44.27%) treatments were in the same statistical group with the highest results and the control treatment was in last place.

The highest effect for the GY parameter was 7.88 t ha^{-1} for the Esperia variety, followed by Flamura 85 variety with a value of 7.64 t ha^{-1} included in a different statistical group. Among treatments, T4 treatment provided the highest result of 7.68 kg ha^{-1}, as with several parameters, followed by T2 treatment with a value of 7.57 kg ha^{-1} included in the same statistical group. The lowest value in terms of grain yield was obtained from the control treatment which did not apply soil conditioners.

The V x T interactions and mean values for grain yield and some yield characteristics are given in Table 5. As can be understood from investigating the table showing the impact rates of varieties from treatments, the highest and most significant effect for the PH parameter was for the Flamura 85 variety with the T4 treatment (99.13 cm). This was followed by the Flamura 85 variety and T2 treatment (96.78 cm) in the same statistical group. For the SL parameter, the V x T interaction was highest for the Flamura 85 variety with the T4 treatment (10.48 cm), followed by the T2 treatment (10.01 cm).

Table 5. Variety x treatment interaction means and significance groups related to yield traits

Var.	Treat.	PH (cm)	SL (cm)	NSS (unit)	NGS (unit)	GWS (g)	SFI (%)	HI (%)	GY (t ha^{-1})
Flamura85	T1	95.09 bc	9.88 bc	20.22 g	47.15 c	2.13 ab	65.87 g	42.96 fg	7.23 ef
	T2	96.78 ab	10.01 b	20.90 de	47.50 bc	2.07 abc	83.73 a	43.65 e	7.57 cde
	T3	96.12 b	9.83 bc	20.47 fg	48.80 a	2.20 a	77.66 cd	45.70 b	8.06 a
	T4	99.13 a	10.48 a	21.33 bc	48.42 abc	2.07 abc	78.25 bc	42.58 gh	7.698 cd
Selimiye	T1	93.96 bcd	9.48 de	21.30 bcd	40.27 e	1.80 e	68.84 f	40.56 ı	7.21 ef
	T2	92.00 de	9.63 cde	20.73 ef	40.68 e	1.92 cde	70.88 ef	43.54 e	6.98 gh
	T3	94.18 bcd	9.76 bcd	21.10 cde	41.23 de	1.88 de	65.60 g	42.19 h	6.80 h
	T4	89.57 e	9.67 cde	21.70 b	42.63 d	2.04 a-d	65.40 g	43.23 ef	7.410 def
Esperia	T1	81.45 g	9.04 f	20.93 cde	48.12 abc	1.90 cde	70.71 ef	44.25 d	7.67 cd
	T2	84.84 f	9.48 de	21.30 bcd	48.77 ab	2.00 bcd	80.25 b	47.28 a	8.15 a
	T3	85.18 f	9.42 e	21.33 bc	48.60 abc	1.93 cde	71.61 e	44.94 c	7.76 bc
	T4	82.58 g	9.68 cde	22.40 a	49.40 a	1.93 cde	75.50 d	44.98 c	7.93 ab
$LSD_{0.05}$		2.204	0.301	0.400	1.478	0,172	2.390	0.489	25.59

Var.: Variety, Treat.: Treatment.
PH: Plant high (cm); SL: spike length; NSS: Number of spikelets per spike (unit); NGS: Number of grains per spike (unit); GWS: Grain weight per spike (g); SFI: Spike fertility index (%); HI: Harvest index (%); GY: Grain yield (kg ha^{-1})

The highest effect of soil conditioner treatment on NSS was for the Esperia variety with the T4 treatment (22.40 unit), followed by the Selimiye variety with the T4 treatment (21.70 unit). When the obtained data are investigated, for the NSS parameter, the T4 treatment provided the highest values for all varieties. This situation shows the positive effect of the T4 treatment on NSS.

For NGS results, the highest value was for the Esperia variety with the T4 treatment (49.40 unit) and the Flamura 85 variety with the T3 treatment (48.80 unit). These were followed by the T2 treatment of Esperia variety, T4 treatment of Flamura 85 variety and T3 treatment of Esperia variety in the same statistical group. According to the data obtained, the T4 and T3 treatments had higher values for the NGS parameter.

When the effect of soil conditioners on the GWS parameter is investigated, the highest effect was for the Flamura 85 variety with T3 treatment (2.20 g), followed by Flamura 85 variety with T1 treatment (2.13 g) in second place. These were followed by T2 and T4 treatments of Flamura 85 variety and T4 treatment of Selimiye variety in the same statistical group. In terms of the GWS characteristics, the T3 treatment of Flamura 85 variety, T4 treatment of Selimiye variety and T2 treatment of Esperia variety provided the highest values, showing that the

varieties displayed different positive reactions to this treatment.

For the SFI parameter, the highest effect of soil conditioners applied to seeds was for Flamura 85 variety with T2 treatment (83.73%). This was followed by Esperia variety with T2 treatment (80.25%). For the SFI parameter, T2 treatment provided the highest results for all bread wheat varieties.

For HI results, the highest value among the three varieties was for Esperia with T2 treatment (47.28%), with Flamura 85 variety and T3 treatment (45.70%) in second place. T4 treatment of Flamura 85 variety (42.58%) provided lower results compared to the T1 (control) treatment. The highest harvest index values for the Selimiye and Esperia varieties were obtained with the T2 treatment, while it was highest with the T3 treatment for the Flamura 85 variety. This reveals that for this parameter, the Flamura 85 variety gave a different result compared to the other treatments.

GY, which is the most important parameter among the yield characteristics of bread wheat, gave high results in three varieties in different treatments. The highest result was obtained in the Esperia variety (8.15 t ha^{-1}) applied to T2, followed by the Flamura 85 variety to which T3 was applied, which is in the same statistical group (8.06 t ha-1). The highest value for the Selimiye variety was found with the T4 treatment (7.41 t ha^{-1}).

According to the results obtained, soil conditioner applications generally gave statistically higher results than the control application for the parameters. While Flamura 85 gives the highest result among the varieties, T4 gave the highest result in soil regulators.

Among soil conditioner treatments, T4 treatment provided the highest results for 5 parameters and was in 2nd place for 3 parameters. The T2 and T3 treatments had the highest effect for two parameters each. The soil conditioners used in the research had different contents. The T3 and T4 treatments contained more organic material, while the T2 treatment contained mineral matter and glycine betaine. Though the content of the T3 and T4 treatments were similar, T4 contained more OM and humic substance concentrations. Accordingly, T4 treatment with the highest organic matter and humic substance content can be said to have a positive effect on the yield parameters. Humic substances affect the root development of plants and increase the growth of the above-soil portions, support nutrient element intake and increase the yield of agricultural products by an average of 30-90% linked to the fertilizer given (Bezuglova and Klimenko, 2022). The treatment dose of humic acid may be important in terms of yield characteristics. Studies about this topic observed that just as humic acid treatment with different proportions provided similar results, it also provided different results. The researchers stated that humic substances had stimulating effects on plants (Weber 2018, Chen and Aviad, 1990), while the increase in humic substance concentration reduced this effect (Chen and Aviad 1990). In a study of the yield characteristics of wheat, Kaya et al., (2005) reported that humic acid treatment caused a reduction in PH. As a result, it is important to pay attention to the concentration of HS contained within the soil conditioners.

According to the mean values obtained in the research (Table 4), high results related to spike traits like SL, NSS, NGS and GWS were found for the T4 treatment and generally the Flamura 85 variety. However, while the SFI parameter was highest for the Flamura 85 variety, similar to the other varieties, on a treatment basis high values were found with T2 treatment. The reason for the high SFI value with the T2 treatment, different to the other spike traits, maybe that SFI shows the general traits of the spike and is based on general traits like spikelet number, grain number and grain size on the spike. Ozen and Akman (2014) reported that the number of spikelets on the spike positively affected the number of grains and hence spike grain yield. When the variety x soil conditioner application interaction was examined in grain yield, the highest yield was found in Esperia (T2) and Flamura (T3) varieties, which are in the same statistical group. These were followed by T4 application in the Esperia variety. The lowest data were determined in T2 and T3 applications in Selimiye variety. These data obtained showed that the response of the varieties to the soil conditioner application was different, while the response of the Esperia variety was good, the response of the Selimiye variety was low.

The spike length and grain yield had parallel increases in the study and the T4 treatment provided the highest results. According to researchers, spike length is generally linked to the genetic structure of the variety (Bilgin and Korkut, 2005) and there is a positive and significant correlation between spike length with grain yield. Due to the excess spike length of cereals and the dense arrangement of spikelets on the spike axis, in the grain-filling period, there is the opportunity for grains to fill out more easily and grain weight to increase. Some researchers reported that spike length is a trait increasing grain yield (Bilgin and Korkut, 2005; Ozen and Akman, 2014).

In the research, there was generally a negative variation between PH and GY results (Table 4). Generally, treatments with high PH values had lower GY results. For the PH parameter, the T4 treatment provided lower results compared to the T2 and T3 treatments, while it provided higher results for the GY parameter. When assessed in terms of varieties, linked to genetic traits, the Flamura 85 variety had the highest values in terms of PH, while the Esperia variety had the lowest values. However, in terms of GY, the highest results were obtained with the shortest variety of Esperia. The reason for this is that the higher PH value leads to more expenditure of nutrient elements produced as a result of photosynthesis on plant height development, and as a result, fewer photosynthesis products are available for yield and yield traits. Some studies have reported results showing a negative correlation between PH and GY (Korkut and Bilgin, 2005; Naneli et al., 2015). As a result, in plant cultivation studies performed for grain yield, tall plant height should not be chosen. This is because tall plant height causes excess consumption of

photosynthesis products as well as causing more lodging and disease problems in plants.

CONCLUSION

Wheat cultivation is performed in a large area of the Thrace region and this is a region with intense commercial fertilizer use. Tekirdag is in first place within this region. The amount of organic fertilization in fertilization programs implemented in the region has increased over time. Producers beginning organic fertilization to increase yield apply soil conditioners with organic sources and a variety of content to the soil. In recent periods, for wheat agriculture, planting after wetting seeds with liquid soil conditioners has become popular. However, research on this topic is limited. In this study, performed with this aim, the seeds of the Flamura 85, Selimiye and Esperia bread wheat varieties were treated with 3 different soil conditioners commonly used in Thrace. According to the mean treatment and variety values obtained from the research results (Table 4), all soil conditioners applied to seeds generally caused differences compared to control. The T4 treatment especially caused a pronounced positive effect on the SL, NSS, NGS, GWS and GY parameters. For the PH parameter, T3 caused a significant effect, while for the SFI parameter, the T2 treatment provided a significant effect. For the HI parameter, T2 and T3 treatments both had the highest effect. According to the mean variety x treatment interaction mean values related to yield traits (Table 5), the T4 treatment for the Flamura 85 variety increased plant height, reduced plant height for the Selimiye variety and was not statistically significant for the Esperia variety. For all treatments, spike traits like SL, NSS and NGS increased compared to controls, while suitable soil conditioner treatment caused variation according to a variety of parameters like GWS and SFI. For the HI results, the T2 treatment of the Selimiye and Esperia varieties and the T3 treatment of the Flamura 85 variety provided highest results. Grain yield, one of the most important parameters in wheat, had the highest results with different treatments linked to variety, with the most pronounced effect for Esperia with T2 treatment, Flamura 85 with T3 and Selimiye with T4. When the data obtained was evaluated, soil conditioner applications caused a significant increase in the parameters examined in wheat. T4, which contains 25% organic matter + 65% humic acid + 6% potassium, was determined as the most effective soil conditioner for many parameters

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