Soil Studies 14(2), 82-92
http://doi.org/ 10.21657/soilst.1839467

RESEARCH PAPER

Effects of conditioner applications on organic matter and nitrogen content in sandy and clay loam textured soils

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How to cite

Kop Durmuş, Ö.T. & Özdemir, N. (2025). Effects of Conditioner Applications on Organic Matter and Nitrogen Content in Sandy and Clay Loam Textured Soils. *Soil Studies 14* (2), 82-92. http://doi.org/10.21657/soilst.1839467

Article History
Received 19 September 2024
Accepted 21 July 2025
First Online 10 December 2025

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Keywords
Soil texture
Organic matter
Total nitrogen
Polyacrylamide
Humic acid

Abstract

This study aimed to investigate the effects of polyacrylamide (PAM) and humic acid (HA), wheat straw (WS) and hazelnut husk (HH) application on wheat yield, soil organic matter and nitrogen content of sandy and clay loam texture under greenhouse conditions. The study was conducted according to the experimental design of the randomized complete block experimental design. Wheat straw and hazelnut husk were applied at 0%, 2% and 4% doses, polyacrylamide at 0 ppm, 30 ppm, 60 ppm and 90 ppm, and humic acid at 0 ppm, 200 ppm and 1000 ppm. After five months of incubation period, wheat plants were grown in pots. The study was completed in a total of 312 days along with the incubation period. It was determined that the treatments affected the organic matter and total nitrogen content. As a result of the applications, it was determined that the organic matter content was more affected in clay loam textured soil, but the nitrogen content and wheat yield were more affected in sandy loam textured soil. It has been determined that the application of synthetic conditioners together with plant residues is the most effective application in increasing organic matter and nitrogen content.

Introduction

Soil carbon is important in preventing the effects of degradative processes (erosion, pollution, acidification, salinization) in the soil, maintaining its fertility and reducing carbon flow to the atmosphere. Most of the carbon, which can be found in different forms, is formed by the decomposition products of dead plant and animal tissues and microbial masses living in the soil (Aşkın et al., 2014; Jangir et al., 2019). In today's conditions, agricultural practices to meet the needs of the increasing population and developing economies negatively affect soil quality, reduce productivity and lead to the need for more fertilization, irrigation and pesticides.

Soil organic carbon is significantly affected by land use and agricultural practices. Dengiz et al. (2015), who investigated the effects of land use and land cover on organic matter stocks in Madendere Basin, determined that soil organic carbon was significantly affected by land use and land cover, and the land use patterns in terms of density were forest (6.30 kg/m^2), pasture (5.17 kg/m^2), orchard (4.69 kg/m^2) and cultivated land (3.85 kg/m^2), respectively. Yimer et al. (2006) examined the changes in soil organic carbon and total nitrogen stocks depending on topography and vegetation in Bale Mountain in Ethiopia. They found that higher altitudes had more organic carbon and nitrogen than lower

Published by Soil, Fertilizer and Water Resources Central Research Institute, Ankara, Türkiye

altitudes. Özdemir and Bülbül (2024), in a study conducted on agricultural lands, found that soil organic matter content was significantly affected by basic soil properties and land use patterns. The researchers determined that eight different land use types on organic matter content were effective in the order of sugar beet < pasture < meadow < sunflower < orchard < wheat < alfalfa.

In recent years, synthetic soil conditioners have been widely used, along with organic-based fertilizers, to maintain and improve the functional properties of soil and increase the organic carbon content. For this purpose, barnyard manure (Balik et al., 2023), residential wastes (Pedra et al., 2007; Özdemir et al., 2014), composted materials (Tejada at al., 2003), post-harvest crop residues (De Neve at al., 2000), organic by-products of agro-industrial enterprises (Madejon et al., 2001; Iqbal et al., 2019) and the combined use of inorganic and organic fertilizers are emphasized. The physical and chemical properties of soils are positively affected by these materials' application; their erosion resistance increases, and soil organic carbon increases (Zhang et al., 2019; Liu et al., 2024). Leaungvutivirog et al. (2002) examined the effects of chemical and organic fertilizers on the chemical and microbiological properties of soils and the yield of maize plants. Tamer et al. (2016) evaluated the effects of organic source fertilizer application on sunflower plants' soil properties and yield components. As a result of the study, they determined that 30 kg ha^{-1} humic acid + chemical fertilizer application had the most effect on organic matter content. Moreover, the applications also affected pH, EC, lime, potassium (K) and phosphorus (P) contents.

In today's conditions, synthetic origin conditioners that provide faster results in protecting and improving soil properties, preventing erosion and improving plant production have begun to be emphasized. In this study; the effects of the application of wheat straw and hazelnut husk waste and humic acid and polyacrylamide separately and together with PAM on organic matter and total nitrogen content in the soil were examined.

Materials and Methods

The study was conducted on surface (0-20 cm) soil samples with two different textures (Sandy loam: SL, clay loam: CL) under greenhouse conditions. The samples were taken from two different locations (SL 41°55'-35°86'; CL 41° 61'-35° 90') where agricultural production is practiced in the Bafra region. Bafra Plain is located in the semi-humid humid moisture regime (Ustik) with an average annual temperature of 14.5 ˚C and an average annual precipitation of 716.6 mm (Saygın et al., 2012). Organic wastes, PAM and HA used in the study were obtained from different institutions.

The analysis results of the soils and crop residues used in the study are given in Table 1. As can be seen from the analysis of these data, the sandy loam (SL) soil taken from the Bafra region has a slightly alkaline character, saltless, low organic matter, and nitrogen content. Clay loam texture (CL) has a slightly alkaline character, is salt-free, has moderate organic matter and has high nitrogen content. The pH values of the soils are below 8.5, and there is no alkalinity problem (Soil Survey Manual, 2017).

Table 1. Analysis results of soils and organic residues

Soils	Sand, %	Silt, %	Clay, %	pH (1:2.5)	EC (1:1) (dS m^{-1})	OM (%)	$CaCO_3$ (%)	N (%)	P (ppm)	Ca+Mg (me 100 g^{-1})
Soil (SL)	64.12	27.91	7.97	8.11	0.68	1.12	17.82	0.05	48.07	21.84
Soil (CL)	27.19	41.51	31.30	7.88	0.47	2.85	7.57	0.20	25.45	36.25
Organic wastes	**pH (1:10)**	**EC (1:10) (µmhos cm^{-1})**	**OC (%)**	**Total N (%)**	**C/N**	**Ash (%)**	**P (ppm)**			
Wheat Straw	5.69	2848.50	53.46	0.65	82.25	7.84	2055.00			
Hazelnut husk	6.16	2058.00	46.93	1.86	25.28	19.09	6291.52			

(SL: Sandy loam soil, CL: Clay loam soil)

Wheat straw and hazelnut husk used in the study had C/N ratio values of 82.25 and 25.28, respectively. The PAM used in the study has an anionic character [-CH2CHCONH2-]$_n$ and a molecular weight of approximately 10000 Mg.mol^{-1} with a density value of 1.189 g/cm^3. The experiment used commercially available liquid material containing 13.5% humic acid, 1.5% fulvic acid and 1.5% K_2O.

The factorial study used wheat (*Triticum aestium, pandas variety*) as plant material. Soils were sieved through a 4 mm sieve and transferred to 5.5 kg pots; polymers and organic wastes were added at three different doses (WS 0, 2, 4%; HH 0, 2, 4%; HA 0, 200, 1000 ppm; PAM 0, 30, 60 ppm and 90 ppm) and PAM+conditioner doses. During the experiment, irrigation was applied again when half of the available moisture in the soil was depleted (Field capacity SL:16.84 and CL:6.78). Wheat plants were grown in the pots after five months of incubation. After the plant harvest, soil samples from the pots were analyzed and evaluated.

Soil texture; Bouyoucos hydrometer method (Demiralay, 1993), organic matter content (OM); Walkley-Black method (Kacar, 1995), lime ($CaCO_3$) content by volume; Scheibler calcimeter method (Kacar, 1995), calcium and magnesium; ammonium acetate extraction method (Kacar, 1995), total nitrogen; Kjeldahl method (Bremner, 1965), available phosphorus; Olsen according to pH (Sims, 2009), pH and electrical conductivity (EC) values; pH meter in saturation sludge (Hendershot et al., 1993) and EC meter (Hendershot et al., 1993). SPSS 22 package program and Duncan multiple comparison tests were used to statistically evaluate the data.

Results and Discussion

Organic matter

In this study in greenhouse conditions, synthetic conditioners of organic origin (polyacrylamide, humic acid) and organic wastes of plant origin (wheat straw and hazelnut husk) were applied separately and together to surface soil samples with two different textures (SL, CL) and left for incubation and wheat plants were grown. The organic matter contents results of the analysis of variance are given in Table 2, and the results of Duncan's multiple comparison tests are given in Table 3. There were differences in the post-harvest organic matter content of the soils according to the type and dose of application. Soil organic matter, composed of residues of plant and animal origin, is a dynamic component and is significantly affected by agricultural practices. The organic matter content of the SL in the experiment changed from 1.14% to 2.43% depending on the conditioner applications. When the conditioners were applied separately, it was determined that the organic matter content of the soils increased after the wheat straw and hazelnut husk applications compared to the control soil. At the same time, it decreased after the humic acid and PAM applications compared to the control soil. In terms of the said effect, when the separate application activities of the conditioners used were examined, it was seen that they were ranked as HH>WS>PAM>HA. On the other hand, when the effects of applying the conditioners together were examined, it was determined that they were ranked as HH+PAM>WS+PAM>HA+PAM in terms of the increase in organic matter content.

Table 2. Analysis of variance results for organic matter values

Source of variation		Degrees of freedom	Sum of Squares	Mean Squares	F Value	Significance level
University Soil (SL)	Variable (A)	6	7.668	1.278	77.641	.000
	Treatment (B)	3	.280	.093	5.668	.002
	AxB	18	.714	.040	2.411	.006
	Error	56	.922	.016		
	Total	84	220.642			
Research Soil (CL)	Variable (A)	6	117.413	19.569	613.304	.000
	Treatment (B)	3	1.180	.393	12.332	.000
	AxB	18	6.751	.375	11.755	.000
	Error	56	1.787	032		
	Total	84	1222.333			

P<0.05 (A: Variable, B: Treatment, SL: Sandy loam soil, CL: Clay loam soil)

Table 3. Duncan test results of organic matter values

Treatments	Mean ± Standard deviation			
	University area. (SL)		Research area (CL)	
Control	1.14	± 0.07 l	2.37	± 0.12 ı
%2 WS	1.62	± 0.18 c-e	3.17	± 0.21 h
%4 WS	1.67	± 0.21 cd	5.58	± 0.30 b
%2 HH	1.60	± 0.17 c-f	4.21	± 0.23 f
%4 HH	2.25	± 0.12 a	6.24	± 0.29 a
HA 1.dose	1.17	± 0.01 kl	2.47	± 0.07 ı
HA 2.dose	1.30	± 0.04 h-l	2.47	± 0.08 ı
PAM 1.dose	1.26	± 0.04 j-l	2.42	± 0.03 ı
PAM 2.dose	1.35	± 0.01 g-l	2.43	± 0.01 ı
PAM 3.dose	1.36	± 0.02 f-l	2.47	± 0.03 ı
%2WS+PAM 1.dose	1.27	± 0.14 ı-l	3.16	± 0.10 h
%2WS+PAM 2.dose	1.48	± 0.12 d-j	3.23	± 0.29 h
%2WS+PAM 3.dose	1.51	± 0.08 c-ı	3.65	± 0.24 g
%4WS+PAM 1.dose	1.63	± 0.08 c-e	4.62	± 0.21 de
%4WS+PAM 2.dose	1.65	± 0.08 c-e	4.35	± 0.32 ef
%4WS+PAM 3.dose	1.74	± 0.14 c	5.12	± 0.11 c
%2HH+PAM 1.dose	1.54	± 0.15 c-h	3.78	± 0.16 g
%2HH+PAM 2.dose	1.56	± 0.09 c-g	3.90	± 0.08 g
%2HH+PAM 3.dose	1.74	± 0.26 c	4.61	± 0.12 de
%4HH+PAM 1.dose	2.43	± 0.37 a	5.64	± 0.24 b
%4HH+PAM 2.dose	2.01	± 0.07 b	5.58	± 0.13 b
%4HH+PAM 3.dose	2.35	± 0.14 a	4.73	± 0.15 d
HA 1.dose+PAM 1.dose	1.40	± 0.00 e-k	2.54	± 0.24 ı
HA 1.dose+PAM 2.dose	1.44	± 0.02 d-j	2.44	± 0.17 ı
HA 1.dose+PAM 3.dose	1.54	± 0.01 c-h	2.46	± 0.08 ı
HA 2.dose+PAM 1.dose	1.40	± 0.00 e-k	2.54	± 0.10 ı
HA 2.dose+PAM 2.dose	1.44	± 0.02 d-j	2.45	± 0.13 ı
HA 2.dose+PAM 3.dose	1.54	± 0.01 c-h	2.48	± 0.15 ı

(PAM: polyacrylamide, HA: humic acid, WS: wheat straw, HH: hazelnut husk, SL: Sandy loam soil, CL: Clay loam soil)

The organic matter content of the CL in the experiment, which was 2.37%, changed to 6.01% depending on the conditioners applications. In terms of the said effect, when the separate application efficiency of the conditioners used was examined, it was seen that they were ranked as HH>WS>HA>PAM. On the other hand, when the conditioners were applied together, the ranking of their effect on organic matter content was HH+PAM > WS+PAM > HA+PAM. When the variance analysis results of the effects of conditioner and dose applications on organic matter values in both soil groups were evaluated (Table 2), it was observed that the mean squares of conditioner and application levels were significant ($p < 0.05$). When the results of the Duncan multiple comparison test for the significant sources of variation were analyzed, it was determined that the treatment averages generally differed (Table 3). When the variance analysis results of the effects of conditioner and dose applications on organic matter values in both soil groups were evaluated (Table 2), it was determined that the mean squares of the conditioner and application levels were significant (p<0.05) and the means generally differed according to the Duncan multiple comparison test results (Table 3).

In the SL, the pots in which the second dose of hazelnut husk (%4HH) was applied alone and the pots in which the second dose of hazelnut husk was applied with the first and third doses of polyacrylamide (%4HH+30ppmPAM, %4HH+90ppmPAM) were similar.

When the proportional changes caused by the treatments according to the control organic matter values of the soils were examined, it was determined that the conditioners were more effective in the soil taken from the research land with CL texture than the soil taken from the university land with SL texture. This can probably be attributed to the ability of clay to slow down mineralization and retain organic matter. In many studies in this direction (Parton et al., 1994; Schimel et al., 1994; Lantz et al., 2002), it has been determined that texture, especially clay content, is significantly effective in reducing C binding and losses in soil. At the same time, an increase of 113.15% was realized in the soil of the university land as a result of the treatments compared to the experiment; an increase of 163.29% was realized in the soil of the research land. The most effective dose among the treatments was HH2+PAM1 (%4HH+30ppmPAM) in the soil belonging to the university land, while HH2 (%4HH) in the soil belonging to the research institute.

Agglides and London (2000) reported that compost applied to soils improved the chemical properties of soils and increased soil organic matter. Demir et al. (2006) reported a significant increase in soil organic matter after tobacco waste and hazelnut waste application compared to the control soil. Özdemir and Bülbül (2024), in their study conducted in Turhal conditions, determined that soil organic matter content was significantly affected by basic soil properties and land use type and that eight different land use types were effective in terms of this effect in the form of sugar beet < pasture < meadow < sunflower < orchard < wheat < alfalfa.

Nitrogen

In this study in greenhouse conditions, synthetic organic-based conditioners (polyacrylamide, humic acid) and organic wastes of plant origin (wheat straw and hazelnut husk) were applied separately and together to soils with two different textures and left for incubation and then wheat plants were grown in pots. The nitrogen contents (average) results of the analysis of variance for these values are given in Table 4, and the results of Duncan's multiple comparison tests are given in Table 5. The conditioners applied separately and together in both soil groups showed increases in the total nitrogen contents of the soils after harvesting according to the application type and dose.

The nitrogen contents (average) results of the analysis of variance are given in Table 4, and the results of Duncan's multiple comparison tests are given in Table 5. The conditioners applied separately and together in both soils showed increases in the total nitrogen contents according to the application type and dose.

The nitrogen content of the SL increased from 0.06% to 0.16%, depending on the conditioner applications. When the conditioners were applied

Table 4. Analysis of variance results for total nitrogen values

Source of variation		Degrees of freedom	Sum of Squares	Mean Squares	F Value	Significance level
University Soil (SL)	Variable (A)	6	.041	.007	63.252	.000
	Treatment (B)	3	.001	.000	4.337	.008
	AxB	18	.004	.000	2.081	.019
	Error	56	.006	000		
	Total	84	.902	.		
Research Soil (CL)	Variable (A)	6	.117	.019	106.316	.000
	Treatment (B)	3	.000	7.103E-005	.387	.762
	AxB	18	007	.000	2.039	.022
	Error	56	.010	.000		
	Total	84				

P<0.05 (A: Variable, B: Treatment, SL: Sandy loam soil, CL: Clay loam soil) separately, it was determined that the nitrogen content increased compared to the control soil, and this increase was directly proportional to the increase in the dose of the conditioners. In terms of the said effect, when the effectiveness of the conditioners applied separately was examined, it was seen that they were ranked as HH>WS>HA>PAM. On the other hand, when the effects of the application of the conditioners together were analyzed, it was determined that there was an increase in nitrogen content compared to the control, and only in some doses of HA+PAM applications was there a decrease. Regarding the increase they caused, it was determined that the conditioners were ranked as HH+PAM>WS+PAM>HA+PAM.

Table 5. Duncan test results for total nitrogen values

Treatments	Mean ± Standard deviation			
	University area. (SL)		Research area (CL)	
Control	0.08	± 0.01 j-l	0.15	± 0.00 ı
%2 WS	0.11	± 0.01 e-h	0.16	± 0.01 g-ı
%4 WS	0.11	± 0.02 e-g	0.22	± 0.01 c
%2HH	0.12	± 0.01 c-e	0.21	± 0.02 cd
%4 HH	0.14	± 0.01 ab	0.24	± 0.01 b
HA 1.dose	0.08	± 0.01 ı-k	0.16	± 0.02 hı
HA 2.dose	0.11	± 0.01 e-h	0.16	± 0.01 g-ı
PAM 1.dose	0.08	± 0.01 ı-k	0.16	± 0.01 g-ı
PAM 2.dose	0.08	± 0.01 ı-k	0.16	± 0.01 g-ı
PAM 3.dose	0.09	± 0.00 h-k	0.16	± 0.01 hı
%2WS+PAM 1.dose	0.09	± 0.01 g-j	0.18	± 0.01 f-ı
%2WS+PAM 2.dose	0.09	± 0.00 h-k	0.19	± 0.01 d-g
%2WS+PAM 3.dose	0.10	± 0.01 f-ı	0.18	± 0.01 f-ı
%4WS+PAM 1.dose	0.11	± 0.01 d-f	0.19	± 0.02 d-f
%4WS+PAM 2.dose	0.11	± 0.01 d-f	0.18	± 0.01 e-h
%4WS+PAM 3.dose	0.11	± 0.01 d-f	0.19	± 0.01 c-f
%2HH+PAM 1.dose	0.11	± 0.01 d-f	0.20	± 0.00 c-f
%2HH+PAM 2.dose	0.12	± 0.02 c-e	0.20	± 0.01 c-e
%2HH+PAM 3.dose	0.11	± 0.01 e-h	0.21	± 0.03 cd
%4HH+PAM 1.dose	0.13	± 0.01 b-d	0.27	± 0.03 a
%4HH+PAM 2.dose	0.13	± 0.02 bc	0.28	± 0.00 a
%4HH+PAM 3.dose	0.16	± 0.01 a	0.28	± 0.02 a
HA 1.dose+PAM 1.dose	0.07	± 0.00 kl	0.16	± 0.02 hı
HA 1.dose+PAM 2.dose	0.07	± 0.00 kl	0.16	± 0.02 hı
HA 1.dose+PAM 3.dose	0.06	± 0.01 l	0.16	± 0.01 g-ı
HA 2.dose+PAM 1.dose	0.07	± 0.00 kl	0.16	± 0.01 hı
HA 2.dose+PAM 2.dose	0.08	± 0.01 ı-k	0.15	± 0.01 ı
HA 2.dose+PAM 3.dose	0.08	± 0.01 j-l	0.15	± 0.00 ı

(PAM: polyacrylamide, HA: humic acid, WS: wheat straw, HH: hazelnut husk, SL: Sandy loam soil, CL: Clay loam soil)

The nitrogen content in the soil of control agricultural research land, which was 0.151%, increased to 0.282% depending on the conditioner applications. In terms of the said effect, when the separate application activities of the conditioners used were examined, it was seen that they were ranked as HH>WS>PAM>HA. On the other hand, when the conditioners were applied together, it was determined that they were ranked as HH+PAM>WS+PAM>HA+PAM in terms of their effect on nitrogen content.

When the variance analysis results of the effects of conditioner and dose applications on total nitrogen values in both soil groups were evaluated (Table 4), it was observed that the mean squares of the conditioner and application levels were significant ($p<0.05$). When the results of the Duncan multiple comparison test for the significant sources of variation were analyzed, it was determined that the treatment averages generally differed (Table 5).

As a result of the applications in SL, there was a 110.66% increase compared to the control, while there was an 87.41% increase in CL. This was probably due to increased sand content, which increased mineralization. Wang et al. (2006), in a study investigating the effects of sand size distribution on nitrogen content in soils under different land use conditions, determined that increasing the amount of sand from 5.01 to 8.60% increased nitrogen content from 0.223% to 0.844%. Similarly, a 110.66\% increase was observed in the university land soil compared to the control, while an 87.41\% increase was observed in the research land soil. The most effective dose among the treatments was HH2+PAM3 (%4HH+90ppmPAM) in both the university and the research institute soil.

Coşkun et al. (2006) investigated the effects of tobacco waste (0.0, 2.0, 4.0 and 6.0%) and PAM (0.0, 15.0, 30.0 and 60.0 ppm) applied to soils with different levels of erosion on the nitrogen and phosphorus content available to plants. At the end of the study, it was stated that tobacco waste and PAM applications increased the nitrogen content in the soil, and the increase in nitrogen content was greater in the application of tobacco waste.

Wheat yield

In greenhouse conditions, two different organic synthetics (polyacrylamide, humic acid) and plant-based organic wastes (wheat straw and hazelnut husk) were applied separately and together to incubate and then the yield of the wheat (average) is given in Table 7. According to the results, applications in both soil groups showed differences in yield according to the application and application dose. According to the yield results of wheat plants harvested after applications in sandy loam soil, it was determined that the yield of wheat plants increased after HA1, HA2, FZ1+PAM1, FZ1+PAM2, FZ1+PAM3, HA1+PAM2, HA2+PAM1, HA2+PAM2 and HA2+PAM3 applications. According to these results, it was determined that the individual application efficiencies of the regulators used were as HA>FZ>PAM>PAM. When the regulators were applied together, there was an increase in yield compared to the control, but it was determined that yield decreased in BS + PAM applications. This is probably related to the decomposition process of wheat straw. It was determined that their effects on wheat yield were ranked as FZ+PAM>HA+PAM>BS+PAM.

After the applications in clay loam soil, it was observed that the yield increased compared to the control in pots where only hazelnut husk was applied together with polyacrylamide, and the yield decreased in other applications. This is probably related to the slowing down of the mineralization process in fine-structured soil.

Table 6. Analysis of variance results for wheat yield values

Source of variation		Degrees of freedom	Sum of Squares	Mean Squares	F Value	Significance level
University Soil (SL)	Variable (A)	6	180153.619	30025.603	81.243	.000
	Treatment (B)	3	5702.086	1900.695	5.143	.003
	AxB	18	14061.476	781.193	2.114	.017
	Error	56	20696.333	369.577		
	Total	84	3478402.875			
Research Soil (CL)	Variable (A)	6	153424.509	25570.751		.000
	Treatment (B)	3	3185.048	1061.683		.003
	AxB	18	15887.223	882.624		.017
	Error	56	12158.208	217.111		
	Total	84	4598863.750			

$P<0.05$ (A: Variable, B: Treatment, SL: Sandy loam soil, CL: Clay loam soil)

Table 7. Duncan test results for wheat yield value (kg/da)

Treatments	Mean ± Standard deviation	
	University area. (SL)	Research area (CL)
Control	224.33 ± 23.82 b-d	265.17 ± 16.23 a-d
%2 WS	161.17 ± 2.27 g	204.92 ± 9.64 hi
%4 WS	107.67 ± 8.80 h	139.83 ± 10.03 jk
%2HH	218.75 ± 9.97 c-e	259.83 ± 11.50 a-e
%4 HH	184.75 ± 32.45 e-g	203.33 ± 12.63 hi
HA 1.dose	232.42 ± 15.35 a-d	235.92 ± 8.18 e-g
HA 2.dose	237.5 ± 12.42 a-d	246 ± 24.49 d-g
PAM 1.dose	163.33 ± 35.37 g	247.33 ± 15.26 d-g
PAM 2.dose	206.33 ± 18.57 d-f	243.58 ± 11.67 d-g
PAM 3.dose	216.42 ± 18.06 c-e	264.33 ± 12.79 a-d
%2WS+PAM 1.dose	161.00 ± 22.00 g	190.08 ± 20.08 i
%2WS+PAM 2.dose	171.5 ± 14.51 fg	182.83 ± 15.93 i
%2WS+PAM 3.dose	173.25 ± 12.01 fg	200.67 ± 17.18 i
%4WS+PAM 1.dose	98.25 ± 13.54 h	140.33 ± 9.68 jk
%4WS+PAM 2.dose	107.42 ± 5.03 h	156.75 ± 10.18 j
%4WS+PAM 3.dose	86.5 ± 12.67 h	128.17 ± 7.56 k
%2HH+PAM 1.dose	247 ± 33.00 a-c	278.25 ± 27.15 a-c
%2HH+PAM 2.dose	243 ± 16.20 a-d	281.92 ± 0.80 a-c
%2HH+PAM 3.dose	265.25 ± 10.43 a	286.75 ± 1.95 a
%4HH+PAM 1.dose	208.25 ± 20.81 de	284.17 ± 18.57 ab
%4HH+PAM 2.dose	210.08 ± 17.72 c-e	254.42 ± 26.25 c-g
%4HH+PAM 3.dose	218.17 ± 14.02 c-e	276.42 ± 4.64 a-c
HA 1.dose+PAM 1.dose	184.83 ± 27.19 e-g	246 ± 13.31 d-g
HA 1.dose+PAM 2.dose	238.33 ± 36.17 a-d	229.42 ± 14.51 f-h
HA 1.dose+PAM 3.dose	224.33 ± 5.03 b-d	254.42 ± 4.25 c-g
HA 2.dose+PAM 1.dose	226.5 ± 14.95 b-d	233.83 ± 22.04 e-g
HA 2.dose+PAM 2.dose	257 ± 11.69 ab	227.42 ± 14.22 gh
HA 2.dose+PAM 3.dose	240.83 ± 13.77 a-d	256.58 ± 5.86 b-f

(PAM: polyacrylamide, HA: humic acid, WS: wheat straw, HH: hazelnut husk, SL: Sandy loam soil, CL: Clay loam soil)

When the changes caused by the applications compared to the control were examined proportionally, it was determined that the regulators were more effective in sandy loam soil than in clayey loam soil. As a result of the applications in sandy loam soil, there was an 18.28% increase compared to the control, while there was an 8.10% increase in clayey loam soil. Thenmozhi et al. (2004), In their study investigating the effect of humic acid on the quality characteristics of peanuts, they reported that the best values would be obtained when 20 kg of humic acid per decare was applied together with chemical fertilizer. Erdem et al. (2020) applied humic acid, rhizobacteria and chemical fertilizers in their study investigating the effects of different fertilizer applications on wheat yield. According to the results obtained, they reported that humic acid application increased the number of ears per square meter, plant height, number of grains per ear and grain yield depending on the wheat variety.

As a result of the applications, it was determined that there was a positive relationship between nitrogen and organic matter content in the soil and yield (Table 8). However, this relationship was not found to be statistically significant (*P< 0.05 ** P< 0.01).

Table 8. Correlation between wheat yield, organic matter and nitrogen

n: 28	Soil (SL)		Soil (CL)	
Wheat yield	OM	N	OM	N
	0.103	0.157	0.266	0.108

(SL: Sandy loam soil, CL: Clay loam soil)
(*P< 0.05 ** P< 0.01)

Conclusions

When the effects of the treatments on soil organic matter and total nitrogen content were evaluated after harvesting the plant, it was determined that both total organic matter and total nitrogen contents were affected by the treatments. Regarding the changes in organic matter contents, it was determined that the treatments were more effective in the soil with CL texture than in the soil with SL texture. Indeed, while an increase of 113.15% was realized in the soil belonging to the university land (SL) due to the treatments compared the control, an increase of 163.29% was realized in the soil belonging to the research land (CL). The most effective dose among the treatments was HH2+PAM1 (%4HH+30 ppm PAM) in the soil belonging to the university land, while HH2 (%4HH) in the soil belonging to the research institute. On the other hand, when the changes in the total nitrogen content of the soils were analyzed proportionally, it was determined that the conditioners were more effective in the soil taken from the university land with SL texture than the soil taken from the research land with CL texture. The change occurred depending on the conditioner type and application dose. In the university soil, the highest increase was realized in all of the samples in which the and dose of hazelnut husk (HH2) was applied with polyacrylamide. In the research soil, the highest increase was again determined in the samples in which the 2nd dose of hazelnut husk (HH2) was applied with the 2nd and 3rd doses of polyacrylamide.

As a result, it was determined that separate and combined application of organic conditioners increased the organic matter and nitrogen contents of the soils, and the effects depended on the nature of the organic material and soil properties. It was determined that co-applicating synthetic conditioners with crop residues was the most effective application in increasing organic matter and nitrogen content. It is important to consider soil properties, conditioner properties, doses, and combinations to be applied in applications. The findings were obtained under limited greenhouse conditions, and extending the study to field applications would be useful.

Funding Information

This study was financially supported by the Ondokuz Mayıs University (with the project number 27 of PYO. ZRT.1904.20.005).

Author Contributions

Ö.T.K.D.: Conceptualization, investigation, methodology, software, validation, formal analysis, investigation, resources, data curation, writingoriginal draft preparation, writing-review and editing, visualization, supervision, statistical analysis, project administration. **N.Ö.:** Conceptualization, investigation, methodology, software, validation, formal analysis, investigation, resources, data curation, writingoriginal draft preparation, writing-review and editing, visualization, supervision, statistical analysis, project administration.

Conflict of Interest

The authors declare that they have no known competing financial or non-financial, professional, or personal conflicts that might apper to influence the work reported in this paper.

Acknowledgments

This study was produced from Ömrüm Tebessüm KOP DURMUŞ's Ph. D. Thesis. We thank Ondokuz Mayıs University for their support in the conduct of the study.

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