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ORIGINAL PAPER

EFFECTS OF ORGANIC AMENDMENTS ON SOME PROPERTIES OF XEROCHREPT SOIL AND MINERAL NUTRITION OF TRITICALE

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Abstract

This study was carried out to determine the effect of vermicompost and farmyard manure applications on the growth of triticale plants and on some soil properties of the field. Farmyard manure (FYM) and vermicompost (VC) were applied in three doses: as 0%, 2% and 4%. Some physical and chemical properties of soil samples taken from the 0-20 cm depth were analyzed. The plant growth parameters were measured from harvested plants. Generally, yield criteria improved statistically significantly by increasing manure doses. The lowest values of PNS, PL, SNS, SL, GNS, TGW and GY were 87.00, 64.51 cm, 15.00,10.29 cm, 26.50, 25.70 g and 170.20 kg da^{-1} from the control, while the highest mean values were obtained from the 2% doses of organic amendments, respectively. These increases were found statistically significant for all the investigated yield criteria. Increasing organic material doses increased the SOM content relative to the control. The SOM mean values were 0.63%, 1.06% and 1.76% in control soil and in soil with the 2nd dose of organic soil amendments. The means of FC, AW and AS slightly increased by increasing doses of organic soil conditioners. The lowest FC, AW and AS means were obtained as 25.77%, 10.48% and 51.79% in the control, while the highest ones, at 26.94%, 10.79% and 57.79%, FC, AW and A, respectively, were in soil with the 2nd dose of organic soil conditioners respectively. In contrast, BD decreased from 1.447 g cm^{-3} to 1.338 g cm^{-3} and 1.352 g cm^{-3} by increasing organic material doses. According to analyses of plant nutrients, organic soil conditioners had positive effects on the nutrient content of triticale compared to control, except Na and Cu. The means of Ca, K, Fe, Zn and Cu obtained in FYM applications were higher than those obtained in VC applications. Mean values of Ca, K, Fe, Zn and Cu were obtained as 4167 mg kg^{-1}, 5277 mg kg^{-1}, 396 mg kg^{-1}, 6.52 mg kg^{-1} and 3.71 mg kg^{-1} in FYM applications while these means were 3662 mg kg^{-1}, 5213 mg kg^{-1}, 317 mg kg^{-1}, 6.08 mg kg^{-1} and 3.56 mg kg^{-1} in VC applications, respectively.

Keywords: triticale, yield criteria, soil properties, nutrients, vermicompost, farmyard manure

INTRODUCTION

The use of organic soil conditioners as a source of nutrients on agricultural lands worldwide increases due to high costs of inorganic fertilizers and their negative effects on soil properties, environment and human health, e.g. contamination of groundwater under intensive agricultural conditions (Ayoola, Adeniyan 2006, Khan et al. 2008). The addition of organic matter for the purpose of soil remediation is essential for sustainable land use and crop fertility. Use of organic amendments has been found efficient in the improvement of soil physical and chemical properties, such as aggregation, structure, moisture holding capacity of soils, increased soil microbial activity and cation exchange capacity, and finally, higher crop yields (Albiach et al. 2000, Candemir, Gülser 2007, Tejada et al. 2008, Gülser et al. 2010, Candemir, Gülser 2011). Diacono and Montemorro (2010) and Fageria (2012) reported that organic matter plays an essential role in the sustainability of farming systems. Soil organic matter is also an important indicator of soil quality and productivity (Larson, Pierce 1994). Therefore, in recent years, the application of organic fertilizers has gained more attention among researchers investigating the sustainability and productivity of agricultural soils. Manure from cattle and other livestock is an essential nutrient source in intensive livestock regions. Manure has been regarded as a desirable soil amendment, and its effects on soil properties were often reported (Diacono, Montemorro 2010, Smith, Williams 2016, Tripolskaja et al. 2016).

Similarly, vermicompost was reported as a source of organic matter, increasing water holding capacity and nutrient uptake and showing activities like plant hormones (Galli et al. 1990). Adding vermicompost to soils can help to replenish soil organic carbon, which can ameliorate soil health and promote further primary productivity (Iwai et al. 2010, 2011).

Triticale is a hybrid of wheat (*Triticum spp.*) and rye (*Secale spp*). Triticale is used in both human and animal diets, and produces higher yield than other cereals, such as wheat and barley, on marginal lands. In addition, triticale is more drought resistant than other cereal species and performs better under low precipitation rates and in arid conditions without irrigation (Oettler 2005).

This study aimed to determine the effects of vermicompost and farmyard manure applications on the growth of field grown triticale and some soil properties of its growth media, which is Vertic Xerochrept soil.

MATERIAL AND METHODS

Experimental site

This study was carried out on an experimental field of the Agricultural Faculty in Van Yüzüncü Yıl University, which is located at 38°33′ N and 43°17′ E, 1725 m above sea level, in SE Turkey. The average of total annual precipitation and temperature values were 409 mm and 8.9°C in the 2017-2018 cropping season, respectively. The highest recorded average temp. was 21.2°C in July, and the lowest recorded average temp. was -3.7°C in January (Anonymous, 2019). Thetriticale cultivar Ümran Hanım (X *Triticosecale* Wittmack) was used as plant material, as it had higher environmental tolerance compared to other cultivars and better yields in poor soil conditions. Farmyard manure and vermicompost were used in this study as organic soil conditioners. The soil was classified as Vertic Xerochrept suborder according to Soil Taxonomy (Soil Taxonomy, 2014).

Laboratory analysis

Some properties of these organic soil conditioners are given in Table 1. Some physical and chemical properties of soil samples taken from

Table 1

Some properties of farmyard manure and vermicompost used in this study

Measured parameters	Vermicompost	Farmyard manure
pH	7.14	8.65
EC (mS cm^{-1})	2.39	8.55
Organic matter (%)	62.16	14.58
Moisture	80.41	6.78
Organic C (%)	36.06	8.46
Nitrogen (%)	1.02	0.63

the 0-20 cm depth were determined as follows; particle size distribution with the Bouyocous hydrometer method (Gee, Bauder 1986), soil reaction in 1:2.5 (W:V) soil:water suspension with a pH meter, and soil salinity with an EC meter, in the same suspension (Black 1965), lime content with a Scheibler calcimeter (Goh et al. 1993), organic matter with the Walkley-Black method (Tiessen, Moir 1993), available phosphorus with Olsen's method (Olsen, Sommers 1982). The moisture content at field capacity (FC) and permanent wilting point (PWP) were determined, equilibrating the soil moisture of saturated samples on ceramic pressured plates at 33 kPa for 24 h and 1500 kPa for 96 h, respectively (Tüzüner 1990). Soil aggregate stability (AS) was determined in soil samples by using the wet sieving method (Kemper, Rosenau 1986). In undisturbed soil samples, taken into 5 cm high cylinders of the diameters of 5 cm, bulk density was determined by using the method reported by Blake and Hartge (1986).

Plant samples were washed, dried and crushed for plant nutrient analysis. After plant samples were digested in a mixture of nitric and perchloric acid (3:1 ratio), Ca, Mg, Na, K, Fe, Mn, Zn and Cu content was analyzed with a atomic adsorption spectrophotometer, Thermo ICE 3000 series (Kacar, İnal, 2008).

Experimental design and field study

After autumn ploughing and root tiling (5 cm deep) in soil, plots (1x3 m^2) were sown in rows 20 cm apart, and the seeding density was 450 seed m^{-2}. A field trial was conducted in a randomized block design as three replications of eighteen plots. A three-meter space was left unplanted between the blocks. Each block was sown 3 m away from each other to prevent the mixing of treatments. Plots were sown on 23 November 2017. All plots were fertilized at the seeding time with 15 kg DAP (Di-Ammonium Phosphate) da^{-1} (N %18-P 46%) and 25 kg AS (Ammonium Sulphate) da^{-1} (N %21) as a top dressing application before the heading phase. Farmyard manure (FYM) and vermicompost (VC) were applied at three doses as 0%, 2% and 4%. All plots were weeded twice by hand during the growing season. No insects, pests or disease symptoms were observed. Triticale plots were harvested in 3 July 3 2018. Plant height was measured as the height of the tallest culm of 20 plants from the soil surface to the tip of the spike without awns. A sample composed of 20 plants was harvested from the two middle rows of each plot at grain maturity. Grain yield (kg da^{-1}) was determined by harvesting grain and weighing using a digital scale accurate to 0.1 g. Thousand grain weight was calculated by taking a random sample from the harvested grain, which was then counted and weighed on a digital scale accurate to 0.1 g.

Statistical analysis

The field trial was conducted according to a randomized block design as three replication in eighteen plots. SAS package program was used for statistical analysis (SAS, 1998).

RESULTS AND DISCUSSION

The experimental soil had a clay loam texture, non-saline, slightly alkaline, moderate lime, insufficient in organic matter, phosphorus (P), iron (Fe) and zinc (Zn) contents and sufficient in potassium (K), calcium (Ca), magnesium (Mg), copper (Cu) and manganese (Mn) contents (Table 2).

While significant differences among farmyard manure and vermicompost applications were determined for plant number per square (PNS), grain number per spike (GNS) and grain yield (GY) at $P<0.01$, the effects of doses were also statistically significant $P<0.05$ for spike length (SL) and GNS, and

Table 2

Some physical and chemical properties of experimental area soil

Texture class	Clay - loamy	K (mg kg^{-1})	290
pH	8.22	Ca (mg kg^{-1})	3034
EC (dS m^{-1})	0.15	Mg (mg kg^{-1})	405
Organic matter (%)	0.92	Fe (mg kg^{-1})	3.58
Lime (%)	13.50	Cu (mg kg^{-1})	0.81
N (%)	0.048	Mn (mg kg^{-1})	29.84
P (mg kg^{-1})	7.20	Zn (mg kg^{-1})	0.58

Table 3

The variance analysis results of effects of organic soil conditioners applications on plant growth criteria

SV	Df	PNS		PL		SNS		SL	
		MS	F	MS	F	MS	F	MS	F
Block	2	190.17	0.73 ns	4.612	0.51 ns	0.167	0.02 ns	0.242	0.62 ns
M	2	30422	116.81 **	2.840	0.31 ns	10.889	1.82 ns	1.274	3.29 ns
D	1	107314	412.06**	296.6	32.95 **	104.67	17.54**	2.382	6.16 *
MxD	2	34503	132.48**	33.67	3.74 ns	2.889	0.48 ns	0.351	0.91 ns
Error	12	260.4		9.001		5.967		0.386	
SV	Df	GNS		TGW		GY			
		MS	F	MS	F	MS	F		
Block	2	4.667	0.30 ns	1.399	1.47 ns	1366	0.71 ns		
M	2	600.9	39.02**	0.220	0.23 ns	21318	11.15 **		
D	1	113.2	7.34*	78.41	82.87 **	206103	107.77**		
MxD	2	143.7	9.33**	10.14	10.72 **	5863	3.06 ns		
Error	12	15.40		0.946		1912			

* %5, ** %1, ns – non significantly, M – manures, D – doses, SL – spike length, PL – plant length, SNS – spike, number per spike, GNS – grain number per spike, TGW – thousand grain weigth, PNS – plant number per square, GY – grain yield

for PNS, plant length (PL), spike, number per spike (SNS), thousand grain weigth (TGW) and GY at $P<0.01$. Some significant interactions among organic soil conditioners and doses were found for PNS, GNS and TGW at $P<0.01$ (Table 3).

As shown in Table 4, the plant growth and yield criteria obtained in VC applications were higher than those in FYM applications. The differences between the soil conditioners were significant at level of 1% for PNS, GNS and GY. The highest PNS, GNS and GY means were found as 232.78, 36.78 and 346,89 kg da^{-1} in VC applications, while the lowest means of these parameters were in FYM applications as 150.56, 25.22 and 296,07 kg da^{-1}, respectively.

Table 4

Effects of organic soil conditioners applications on plant growth criteria and Duncan differentiation groups among means

Treatments	PNS	PL	SNS	SL	GNS	TGW	GY
	number	cm	number	cm	number	(g)	(kg da^{-1})
Manures							
FYM	150.56*b*	71.58	18.56	10.60	25.22*b*	29.38	296.07*b*
VC	232.78*b*	72.38	20.11	11.13	36.78*a*	29.60	364.89*a*
LSD (p<0.05)	16.95	3.15	2.57	0.65	4.12	1.02	45.93
Doses (%)							
0	87.00*c*	64.51*c*	15.00*c*	10.29*b*	26.50*b*	25.70*c*	170.20*c*
1	145.67*b*	72.97*b*	19.67*b*	10.77*ab*	31.33*ab*	29.87*b*	287.81*b*
2	342.33*a*	78.47*a*	23.33*a*	11.54*a*	35.17*a*	32.90*a*	533.43*a*
LSD (p<0.05)	70.76	3.89	3.14	0.80	5.05	1.25	56.26

a, *b*, *c* – means followed by different small letters differ statistically at 0.05 level, FYM – farm yard manure, VC – vermi compost, SL – spike length, PL – plant length, SNS – spike, number per spike, GNS – grain number per spike, TGW – thousand grain weigth, PNS – plant number per square

Generally, yield criteria increased statistically by increasing manure doses. The lowest mean values of PNS, PL, SNS, SL, GNS, TGW and GY were 87.00, 64.51 cm, 15.00, 10.29 cm, 26.50, 25.70 g and 170.20 kg da^{-1} were obtained from unfertilized plots, while the highest means were obtained from the 2% doses of organic conditioners applications as 342.33, 78.47 cm, 23.33, 11.54 cm, 35.17, 32.90 g and 533.43 kg da^{-1}, respectively. These increases were found to be statistically significant for all investigated yield criteria. Significant interactions among organic soil conditioners and doses are shown in Figures 1,2,3.

The increases obtained by VC applications in plant growth characters were declared by Bachmna and Metzger (2008) in bedding plants, Mahmoud and İbrahim (2012) in barley, Srivastava et al. (2012) in Allium cepa, Konsotia et al. (2015) in barley and Rahimabad et al. (2018) in rice. Plant growth characters and yield increased by FYM applications as reported by Mugwe et al. (2009) in corn, Saha et al. (2010) in mango, Munir et al. (2012) in mungbean – wheat cropping system, Jarvan et al. (2017) in potato, oat and barley, Singh et al. (2018) and Abdel Nabi et al. (2020) in cauliflower, Alwaneen (2020) in corn.

The humic substances of vermicompost made auxin-like effects on plants (Muscolo et al. 1999). The humic materials of vermicompost were responsible for the increased chlorophyll contents observed in vermicompost treated plants. Ultimately these might increase plant photosynthesis and support better plant growth and yield criteria (Arancon et al. 2008, Tejeda et al. 2008). In addition, increases in plant growth with vermicompost applications can be related to sizeable particulate surface areas of vermicompost that

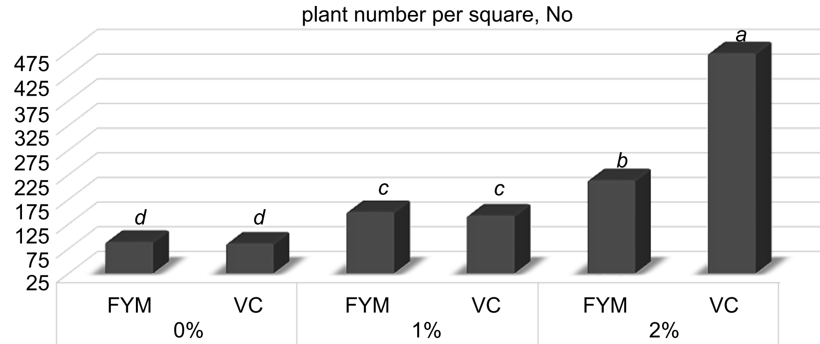

Fig. 1. Effects of manure x dose interactions on plant number per spike (*P*<0.01)

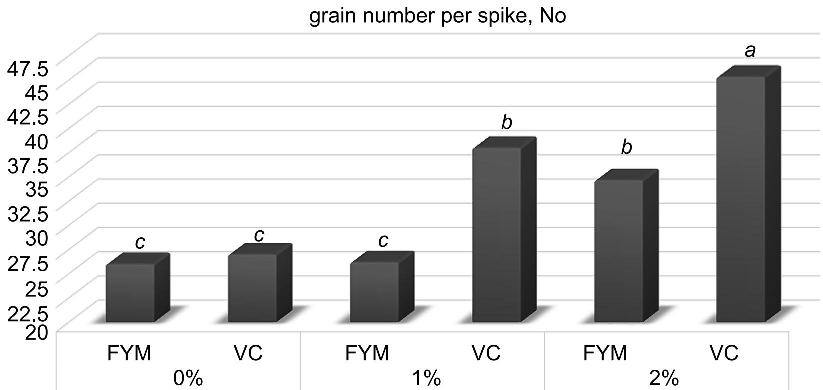

Fig. 2. Effects of manure x dose interactions on grain number per spike (*P*<0.01)

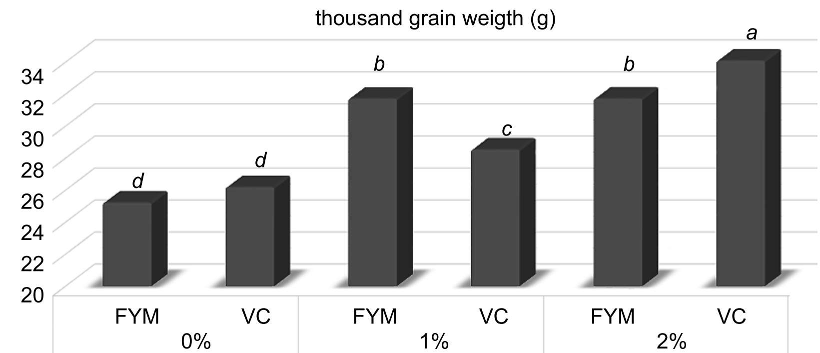

Fig. 3. Effects of manure x dose interactions on thousand grain weight (*P*<0.01)

provide many micro sites for microbial activity, strong retention of nutrients, and high nutrient contents (Atiyeh et al. 2000). Farmyard manure, a source of plant nutrition, has been used as a soil conditioner (Makinde et al. 2007). FYM release nutrients slowly and steadily over extended periods and improve soil fertility by activating the soil microbial biomass and chemical and physical properties (Belay et al. 2001, Vanilarasu 2014, Gülser et al. 2015). Our results on plant growth were in accordance with the literature knowledge above. When considering variance analysis results for soil properties of growth media, it was determined that organic soil conditioners, doses and their interactions significantly affected soil organic matter content (P<0.01) – Table 5.

Table 5

The variance analysis results belong effects of organic soil conditioners applications on soil chemical properties

SV	Df	SOM		pH		EC	
		MS	F	MS	F	MS	F
Block	2	0.0089	0.34 ns	0.0099	5.69*	0.0002	0.21ns
M	2	1.5022	56.91 **	0.0008	0.45ns	0.0011	0.77 ns
D	1	1.9552	74.08 **	0.0004	0.25ns	0.0048	3.44 ns
MxD	2	0.4733	17.93**	0.0021	1.21ns	0.0006	0.46 ns
Error	12	0.0263		0.0017		0.0014	

* %5, ** %1, ns – non significantly, M – manures, D – doses, EC – electirical conductivity, SOM – soil organic matter

Organic material type results show that soil organic matter contents obtained in vermicompost applications were higher than those in farmyard manure applications. The lowest and highest SOM means were determined as 0.86% and 1.44% in FYM and VC applications, respectively. Increasing organic material doses increased SOM contents according to control. SOM means were obtained as 0.63%, 1.06 % and 1.76% in control and 2nd doses of organic soil conditioners (Table 6, Figure 4).

The other soil properties investigated in this research were not significantly affected by organic soil conditioner types (Table 5, 7). The means of pH, EC, lime, field capacity (FC), permanent wilting point (PWP), available water (AW) and agregat stability (AS) were slightly higher in VC applications than in FYM applications. However, EC and PWP means were significantly affected by doses of organic soil conditioners at a level of 5%. The lowest and highest EC means were determined as 0.144 dS m^{-1} and 0.199 dS m^{-1} in the control treatment and 2nd doses of organic soil conditioners, respectively (Table 6). PWP means were obtained as 15.29%, 16.34% and 16.14% in control treatment 1st and 2nd doses of organic soil conditioners, respectively. The means of FC, AW and AS slightly increased by increasing organic soil conditioners doses. The lowest FC, AW and AS means were obtained as 25.77%, 10.48% and 51.79% in control, while the highest FC, AW and AS means were obtained in the 2nd dose of organic soil conditioners as 26.94%, 10.79% and 57.79% respectively. In contrast, BD decreased from 1.447 g cm^{-3} to 1.338 g cm^{-3} and 1.352 g cm^{-3} by increasing organic material doses (Table 8).

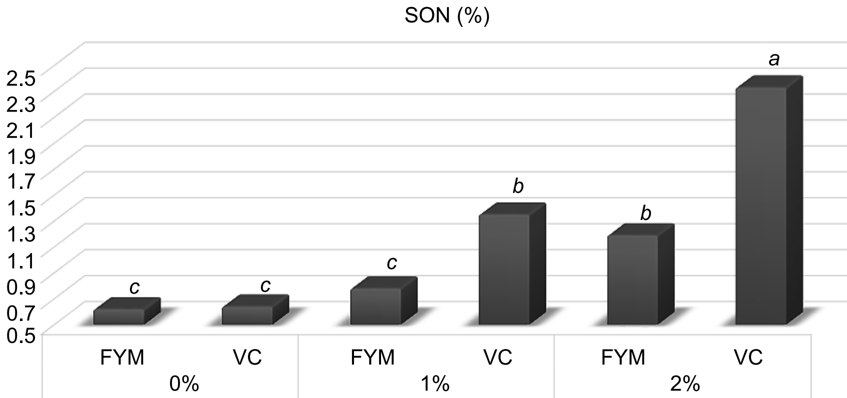

Fig. 4. Effects of manure x dose interactions on soil organic matter contents ($P<0.01$)

Table 6

The effects of organic soil conditioners applications on on some soil chemical properties and Duncan differentiation groups among means

Treatments	pH	EC (dS m^{-1})	Soil organic matter (%)
Manures			
FYM	8.21	0.166	0.86 b
VC	8.22	0.181	1.44 a
LSD ($p<0.05$)	0.04	0.039	0.17
Doses (%)			
0	8.22	0.144 b	0.63 c
1	8.22	0.178 ab	1.06 b
2	8.21	0.199 a	1.76 a
LSD ($p<0.05$)	0.05	0.048	0.21

a, b, c – means followed by different capital letters differ statistically at 0.05 level, FYM – farm yard manure, VC – vermi compost, EC – electirical conductivity

In this study, pH and EC values did not show significant changes induced by the application of organic soil conditioners. Konsotia et al. (2015) found that vermicompost applications led to nonsignificant changes in pH and EC values. However, contrasting results were found for organic soil conditioner treatments, with some researchers recording increases or decreases in pH and EC values (Horák et al. 2020). Demir and Gülser (2008) mentioned that tobacco waste applications generally increased EC values along soil profiles. Azarmi et al. (2008) reported that soil pH values decreased while the soil EC values increased under the influence of increasing vermicompost doses. The second doses of VC and FYM insignificantly increased soil EC values in the ratio of 42% and 31%, respectively. The EC values observed were in accordance with the results of Azarmi et al. (2008). Mugwe et al.

Table 7

The variance analysis results belong effects of organic soil conditioners applications on soil physical properties

SV	Df	FC		PWP		AW		AS		BD	
		MS	F	MS	F	MS	F	MS	F	MS	F
Block	2	4.3600	5.57*	1.217	2.17 ns	1.392	3.60 ns	81.919	0.63 ns	0.0040	0.60 ns
M	2	3.108	3.97ns	2.486	4.43 ns	0.033	0.08 ns	46.948	0.36 ns	0.0001	0.01 ns
D	1	2.733	3.49 ns	1.876	3.34 ns	0.151	0.39 ns	59.043	0.45 ns	0.0209	3.17 ns
MxD	2	1.087	1.39 ns	0.516	0.92 ns	0.108	0.28 ns	48.996	0.37 ns	0.0093	1.41 ns
Error	12	0.781		0.561		0.367		129.111		0.0066	

* %5, ns – non significantly, M – manures, D – doses, FC – field capacity, PWP – permanent wilting point, AW – available water, AS – agregat stability, BD – bulk density

Table 8

The effects of organic soil conditioners applications on on soil physical properties and Duncan differentiation groups among means

Treatments	FC	PWP	AW	AS	DB
	(%)				(g cm^{-3})
Manures					
FYM	26.13	15.55	10.58	52.66	1.379
VC	26.96	16.29	10.67	55.89	1.379
LSD (p<0.05)	0.93	0.79	0.65	11.93	0.085
Doses (%)					
0	25.77	15.29 *b*	10.48	51.79	1.447
1	26.93	16.34 *a*	10.60	53.23	1.338
2	26.94	16.14 *ab*	10.79	57.79	1.352
LSD (p<0.05)	1.14	0.96	0.80	14.62	0.105

a, *b*, *c* – means followed by different small letters differ statistically at 0.05 level, FYM – farm yard manure, VC – vermi compost, FC – field capacity, PWP – permanent wilting point, AW – available water, AS – agregat stability, BD – bulk density

(2009) declared that FYM treatments increased soil pH values. There are records in the literature of long-term compost and manure treatments, both decreasing (Bastida et al. 2008, Bi et al. 2008) and increasing (Garcia-Gill et al. 2004, Buttler, Muir 2006).

Maeder et al. (2002) observed similar results for the soil pH in cow manure compost treated plots, which aligned with our findings. Alwaneen (2020) reported that soil pH values did not change by FYM treatments. Our results were in accordance with the findings presented above. It was thought that the differences among our results and the referred literature findings concerning pH and EC values may be due to differences in terms and quantities of applied organic materials and the initial pH and EC values.

Organic soil conditioner treatments significantly increased the soil organic matter content. Increases in the soil organic matter content by VC applications were reported by Azarmi et al. (2008), Zhang et al. (2009), Mahmoud et al. (2012) and Oo et al. (2015). Similarly, Mugwe et al. (2009), Saha et al. (2010), Gülser and Candemir (2012), Kansotia et al. (2015), Francioli et al. (2016), Jarvan et al. (2017) and Alwaneen (2020) suggested that FYM treatments increased soil organic matter content. Our findings were in line with the referred research results. These increases were attributed to the high organic matter content of the applied organic soil conditioners. The soil organic matter content obtained in VC treatments was higher than in in FYM treatments. It was thought that this might have been due to the higher organic matter content of VC compared to FYM (Tables 2, 6). Many studies have investigated the effect of organic soil conditioners on soil aggregation, water holding capacity, aeration and bulk density. Positive effects of organic soil conditioners on soil properties were reported by Zeytin and Baran

(2003), Gülser (2006), Mahdavidamghani (2007), Mirzaei et al. (2009), and Ahmadabadi (2011), who determined that vermicompost treatments improved soil structure, water penetration, aeration and decreased bulk density, and increased aggregate stability. Hossain et al. (2007), Zhang et al. (2009), and Rahimabadi et al. (2018) reported that cow manure supplies additional nutrients to soil with the increased microbial activity. Furthermore, the treatments enhance soil fertility, and ameliorate soil structure and aeration regulated by the soil type and manure. Gülser et al. (2016) determined that adding organic residues to soils improved soil structure by the increasing aggregate stability. In this study, increasing doses of the organic soil conditioners slightly increased aggregate stability by 11.5% and decreased bulk density by 7% compared to the control. Gülser et al. (2017) reported that addition of hazelnut husk to soil with sandy clay loam increased aggregate stability and decreased bulk density. Additionally, PWP significantly increased in response to increasing organic soil conditioner doses (Table 8). Bronic et al. (2005) reported that AS is an important soil property in the maintenance of porous soil structure and, ultimately, water movement. It was reported that vermicompost addition led to decrease in bulk density due to higher porosity material added to the soil. Similarly, other studies declared that adding organic wastes to soil improved soil hydraulic properties and increased water use efficiency (Baran et al. 1996, Gülser, Candemir 2015, Demir, Gülser 2021, Temiz et al. 2021). Our results were in accordance with the referred research results.

The variance analysis of the results concenirng the effects of the application of organic soil conditioners on macro- and microelements were given in Tables 9 and 10.

According to the variance analysis results, significant differences among farmyard manure and vermicompost applications were determined for Ca, Mg, Na, Fe and Mn contents of triticale at the level of statistical significance equal 1%. There were also significant differences among doses for Ca, Mg, Na, and Fe at level of 1% and for Cu at the 5% statistical significance. Effects of interactions between organic soil conditioners and doses were found statistically significant for Ca, Mg, Na, Fe, and Mn at the level of 1% and for Cu level of 5% (Tables 9, 10).

Ca, K, Fe, Zn, and Cu contents obtained in FYM applications were higher than those obtained in VC applications (Table 11). Means of Ca, K, Fe, Zn and Cu contents were 4167 mg kg^{-1}, 5277 mg kg^{-1}, 396 mg kg^{-1}, 6.52 mg kg^{-1} and 3.71 mg kg^{-1} obtained from FYM applications while these means were 3662 mg kg^{-1}, 5213 mg kg^{-1}, 317 mg kg^{-1}, 6.08 mg kg^{-1} and 3.56 mg kg^{-1} in VC applications, respectively. It was concluded that increasing organic material doses generally increased the nutrient content, except for Na and Cu. The lowest nutrient means were found in the control treatment for Ca (2649 mg kg^{-1}), Mg (1466 mg kg^{-1}), K (4921 mg kg^{-1}) and Fe (184 mg kg^{-1}), while the lowest Zn means were obtained as 6.42 mg kg^{-1} and 5.61 mg kg^{-1} in the control and the 2nd dose of organic soil conditioners, and

Table 9

The variance analysis results concerning effects of organic soil conditioners on macroelements

SV	Df	Ca		Mg		Na		K	
		MS	F	MS	F	MS	F	MS	F
Block	2	60 022	1.98 ns	30 255	1.86 ns	65 093	0.67 ns	208 661	0.67 ns
M	2	1144080	37.79**	262 088	16.15**	35 780 160	370.78**	18 496	0.05 ns
D	1	10 440 435	344.91**	134 755	8.30**	2 308 843	23.92**	479 393	1.53 ns
MxD	2	3 932 907	129.92**	548 130	33.78**	4 726 407	48.97**	851 968	2.73 ns
Error	12	30 269		16 225		96 498		311 736	

Table 10

The variance analysis results concerning effects of organic soil conditioners on microelement

SV	Df	Fe		Mn		Zn		Cu	
		MS	F	MS	F	MS	F	MS	F
Block	2	1 290	1.20 ns	1.415	0.19 ns	0.057	0.07 ns	0.715	3.25*
M	2	28 084	26.21**	353.336	47.91**	0.875	1.06 ns	0.110	0.50 ns
D	1	136 970	127.82**	1.148	0.15 ns	2.471	3.00 *	1.957	8.90 **
MxD	2	9 255	8.63**	63.921	8.66**	0.754	0.91 ns	0.976	4.44*
Error	12	1 071		7.375		0.822		0.220	

Table 11

The effects of organic soil conditioners on macro- and microelements and groups among means distinguished with the Duncan's test

Treatments	Ca	Mg	Na	K	Fe	Mn	Zn	Cu
	(mg kg^{-1})							
Manures								
FYM	4167*a*	1517*b*	2175*b*	5277	396*a*	16.12*b*	6.52	3.71
VC	3662*b*	1759*a*	4994*a*	5213	317*b*	24.99*a*	6.08	3.56
LSD (p<0.05)	183	134	326	568	34	2.85	0.95	0.49
Doses (%)								
0	2649*c*	1466*b*	3982*a*	4921	184*b*	20.50	6.42*ab*	4.16*a*
1	3814*b*	1712*a*	3901*a*	5376	425*a*	21.02	6.88*a*	3.02*b*
2	5281*a*	1736*a*	2870*b*	5438	461*a*	20.15	5.61*b*	3.73*a*
LSD (p<0.05)	223	164	399	718	42	3.49	1.17	0.60

they were in the same group according to the Duncan's multiple comparison test.

According to the results of our plant nutrient analysis, the organic soil conditioners positively affected the nutrient content of triticale compared to the control, except Na and Cu. The highest Ca (5281 mg kg^{-1}), Mg (1736 mg kg^{-1}), K (5438 mg kg^{-1}) and Fe (461 mg kg^{-1}) means were obtained in treatments with the 2nd doses of organic soil conditioners while the highest Zn mean was in treatments with the 1st doses of organic soil conditioners as 6.88 mg kg^{-1}.

Regarding interactions, the highest Ca and Fe contents were found in the treatments with the 2nd and 1st doses of FYM, respectively (Figures 5, 6).

The highest Na and Mn contents were obtained in treatments with the 2nd doses of VC applications, while the highest Mg content was in the applications of the 1st dose of VC (Figures 7, 8, 9).

The results obtained in this study on plant nutrient content agree with results of similar research. Theunissen et al. (2010) reported that vermicompost contains nutrients such as N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B,

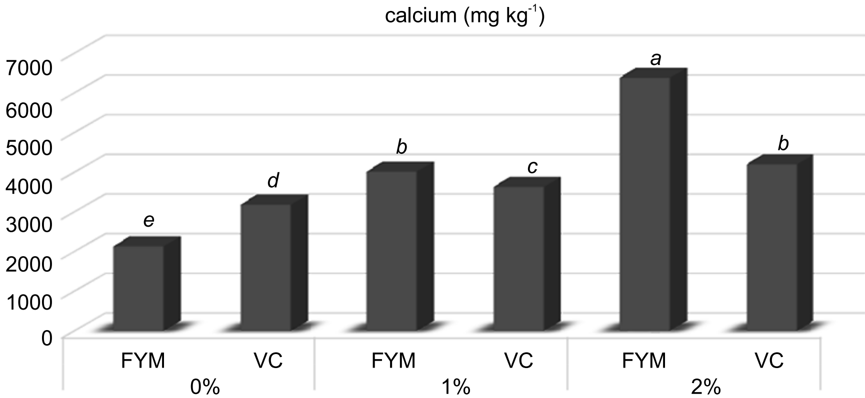

Fig. 5. Effects of organic soil conditioner x dose interactions on plant Ca content (P<0.01)

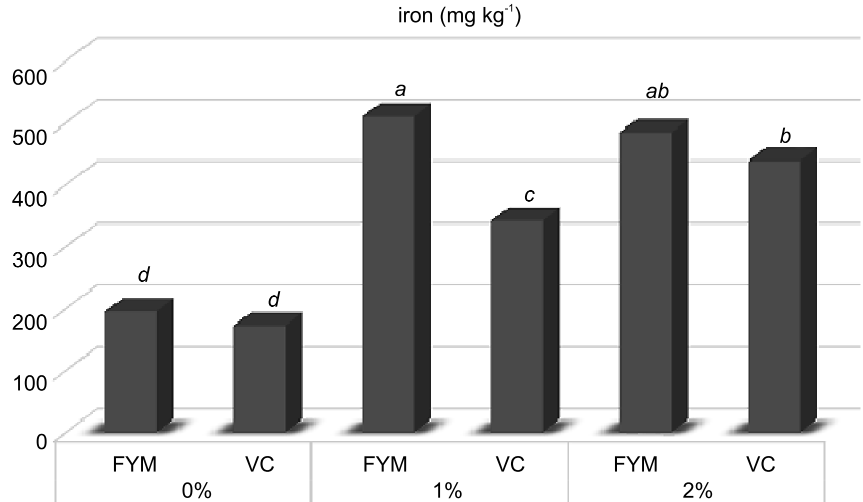

Fig. 6. Effects of organic soil conditioner x dose interactions on plant Fe content (P<0.01)

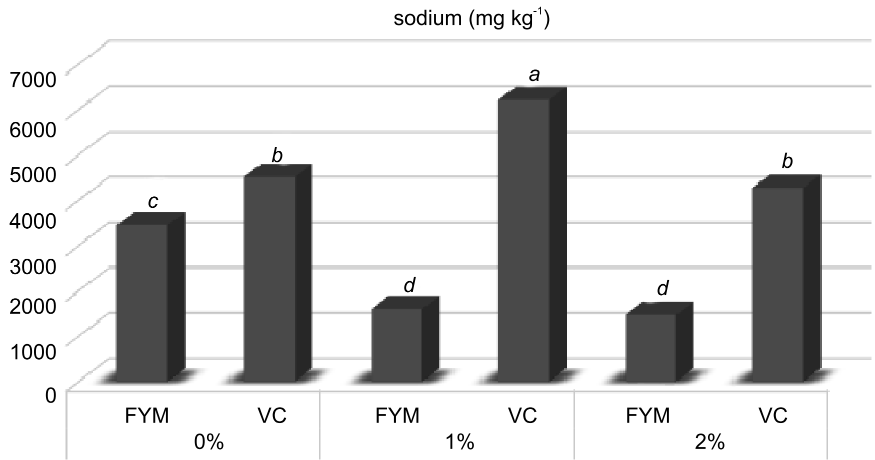

Fig. 7. Effects of organic soil conditioner x dose interactions on plant Na content (*P*<0.01)

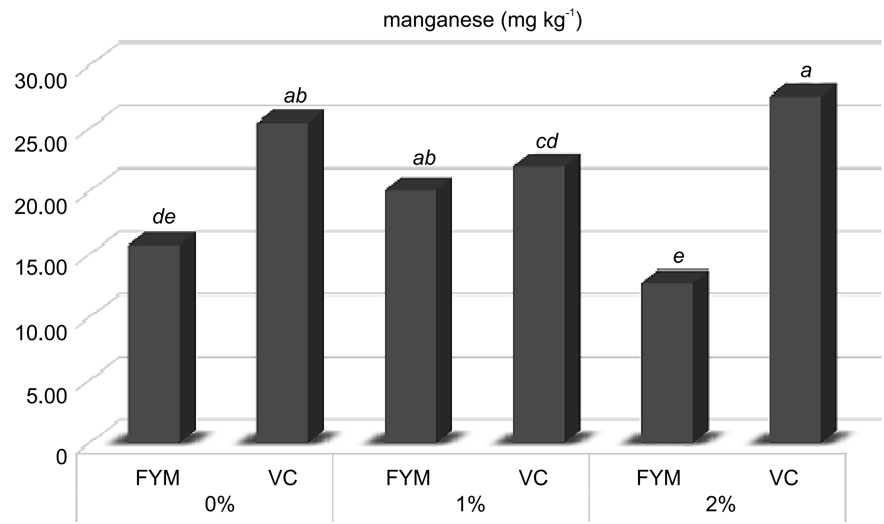

Fig. 8. Effects of organic soil conditioner x dose interactions on plant Mn content (*P*<0.01)

and has positive effects on plant nutrition. Similarly, it was reported that vermicompost could supply both macro- and micronutrients to soil for the optimum plant growth (Harris et al. 1990). These nutrients are adsorbed by humic acid molecules, released slowly into the soil solution, and made available for the plant growth (Arancon et al. 2005, Guiterrez-Miceli 2007). Tejeda and Gonzales (2006) declared that foliar application of vermicompost extracts increased macronutrients in the leaves of rice and maize owing to the high humic substance content of vermicompost.

Applications of different organic materials containing farmyard manure increased the macronutrient content (Aziz et al. 2010). Marschner (1995)

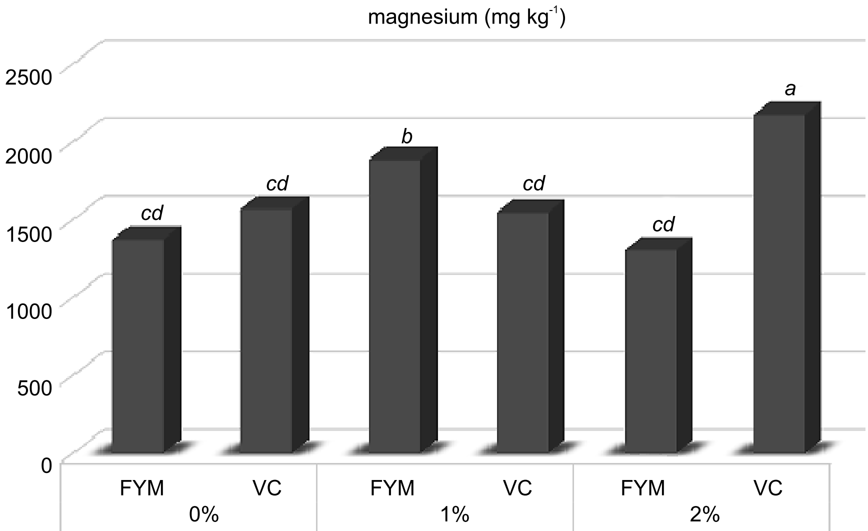

Fig. 9. Effects of organic soil conditioner x dose interactions on plant Mg content (P<0.01)

reported that adding organic matter ameliorates soil, nutrient availability and uptake by plants owing to the increasing CO_2 concentration, which occurs by decomposition of organic matter. An increasing CO_2 concentration leads to the formation of carbonic acid and improves the solubility of nutrients in soils (Marschner 1995, Mengel, Kirkby 2001).

CONCLUSION

In this study, organic soil conditioner treatments improved yield criteria, aggregate stability, permanent wilting point, and plant nutrient content while decreasing bulk density. This situation may be attributed to the positive effects of organic soil conditioners on biomass through ameliorating soil physical properties and enhancing nutrient availability under adequate conditions. Organic treatments can increase nutrient availability directly by adding total nutrients, by controlling the net mineralization immobilization processes as a source of C to continue the microbial activity. Decreasing soil organic matter due to intensive or inappropriate agricultural practices can lead to destruction of soil structure and decrease in soil nutrients, organic matter content and fertility. Overusing agrochemicals in agricultural production also leads to irreversible effects on soil and water sources, causing their pollution. Consequently, using vermicompost and farmyard manure may be good alternative to conventional fertilization regimes for sustainable agricultural production owing to their positive effects on plant production and soil quality in the current climate change scenerio. Additionally, it was determined that Vermicompost and Farmyard Manure could be used as soil conditioners to contribute significantly to better condition of the environment.

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