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Research Article

Effects of Vermicompost Applications on Some Yield and Yield Properties of Wheat

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Abstract

In this study, it was aimed to determine the effect of different vermicompost applications on some yield components in bread wheat under Mardin conditions. The trial was established in 2017-18 in dry conditions, using two bread wheat varieties and four different vermicompost treatments in three repetitions according to the factorial experimental design in randomized blocks. According to the data obtained at the end of the experiment, the observed parameters were determined as respectively, the number of days of spiking (111.0 - 114.3 days), plant height (82.6 - 100.6 cm), plant spike length (7.2 - 10.3 cm), grain number per spike (29.8 - 55.9 pieces/spike), chlorophylls number (46.2 - 50.5 cci), vegetation temperature (21.8 - 22.6 °C), leaf area index (0.70 - 0.78 LAI), grain yield (4355.3 - 5360.7 kg ha^{-1}) and crude protein (11.4 - 12.9%). As a result of the research, it has been determined that vermicompost applied in increasing amounts in all the properties studied except for vegetation temperature caused a significant increase. As a conclusion, vermicompost can be said to be a good organic fertilizer in cereal cultivation due to its environmentally friendly, soil-improving effect and sufficient and balanced plant nutrients in its structure.

Keywords: Bread wheat, variety, vermicompost, yield

INTRODUCTION

Environmental pollution can cause deterioration of soil, air, and water quality. The wrong methods used in the disposal of agricultural waste and food processing factory waste often cause very serious environmental pollution and health problems. (Khedr et al. 2019). Therefore, it is necessary to reduce these sources of pollution during both domestic and industrial processing. In order to reduce the amount of food waste in regular waste storage areas and greenhouse gas emissions to the environment, food waste can be converted into organic fertilizer in many different methods and ways (Khedr et al. 2019; Stoknes et al. 2016). In recent years, one of the most important methods has greatly increased the use of worms in the breakdown of a wide variety of organic residues, including animal waste, crop residues, and industrial garbage (Atiyeh et al. 2002). Earthworms break down organic wastes to greatly stimulate microbial activity and increase their mineralization rates and turn them into humus-like substances with high microbial activity, making them a great benefit as organic fertilizer in agricultural production. The effects of these organic materials on the growth of various crops, including cereals and legumes, vegetables, ornamental and flowering plants, are enormous. High grain yields have been an important focus of most wheat-growing programs in the world. As an important component of agricultural profitability, genetic yield gain has helped maintain the sustainability of agricultural systems in both developed and developing countries. However, it is known that genetically high-yielding varieties can only show their performance under optimum conditions (climate, soil, and nutrients, etc.) (Aycicek and Yildirim 2006). Many organic sources are used to improve the physical, chemical properties, and nutrient content of the soil. One of these organic sources, vermicompost is a high-quality organic fertilizer produced by passing various organic residues or wastes, especially red worms, through the digestive system (Atiyeh et al. 2002; Kizilkaya et al. 2012). Although there is no weed seed in vermicompost fertilizer, it is a rich food source with nutrients and organic matter content that can be easily taken by high plants (Atiyeh et al. 2002). In addition, it has become a favorite organic fertilizer of recent times due to its slow release, physical, chemical, and biological improvements in the soil used (Atiyeh et al. 2002; Roberts et al. 2007; Sarwar et al. 2007). Therefore, this research was conducted to examine the effect of vermicompost on the growth, yield, and yield components of bread wheat.

MATERIAL and METHODS

The study was conducted in 2017-18 in dry conditions, using two bread wheat varieties and four different vermicompost treatments according to the factorial experimental design in randomized blocks with three replications in Mardin Artuklu University Kiziltepe Vocational School Agricultural Research and Training Center, Mardin, Turkey. In the study, the most preferred high yielding Sagittario variety registered in Italy and Adana 99 bread wheat varieties (*Triticum aestivum* L.) registered in Turkey were used as material. The materials were obtained from GAP Agricultural Research Institute were used as materials

Climate and soil properties of the trial location

The climate data for 2017-18 and long terms' averages (LTA) of the location where the experiment was carried out are given in Figure 1, and soil properties are given in Table 1. In the production season of 2017-18, the values of the average temperature and relative humidity were found to be above the average for many years during the trial. A significant decrease was observed in the average values of precipitation.

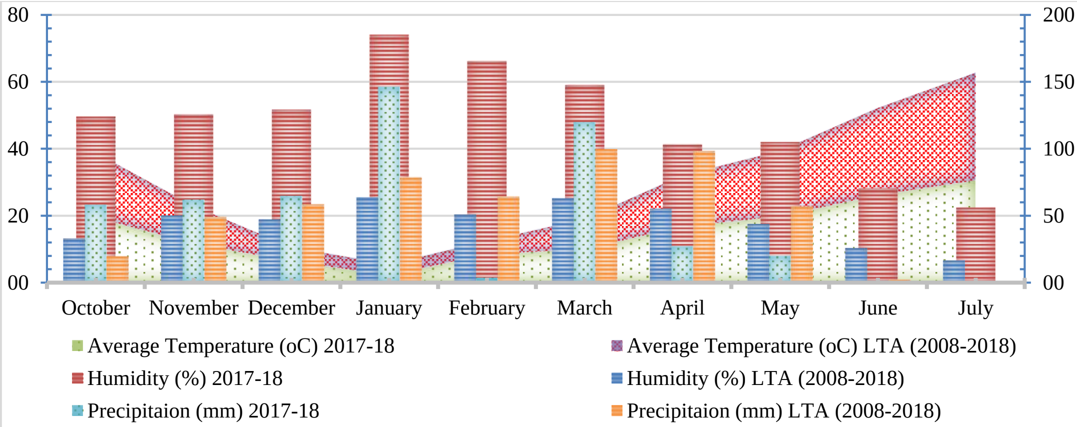


Figure 1. Climate data of the research period

According to the results of the analysis of soil samples taken from the field where the experiment was established, it was determined that the soil structure had no salinity and alkalinity problems. Trial soils were found to be weak in terms of lime and organic matter (Table 1).

Table 1. Soil data of the trial area (0-30cm) *

Soil texture (%)			**pH**	**P** (ppm)	**K** (ppm)	**Lime** (%)	**Organic matter** (%)
Sand	Loam	Clay					
50.20	23.50	10.90	7.10	27.20	273.00	17.58	1.70

*Martest Analysis Laboratory/Mardin

Method

The experiment was set up with three repetitions according to the factorial experimental design in random blocks. In the study, two types of bread wheat (Sagitario and Adana 99) and four doses of worm fertilizer (0, 800, 1600, and 2400 kg ha^{-1}) were applied as two main factors. The experiment was conducted in three homogeneous blocks. The plots in each block were set to consist of 6 rows of 6 m length and 20 cm row-spacing. 500 plants were calculated for each plot, and sowing was performed at a depth of 3-5 cm. A gap of 2 m between the blocks and 0.5 m between the plots were being left. The study was irrigated with sprinkling irrigation after sowing in order to have germination and outflows regular and sufficient. In the study, 50 cm from the head parts of each plot and the edge rows were excluded as an edge effect. The plants in the remaining 5 x 0.8 m = 4 m^2 area were mowed with a sickle and blended in bundles after a few days of drying. In the study, properties such as the days of spiking (days), plant height (cm), plant spike length (cm), grain number per spike (pieces), chlorophyll number (cci), vegetation temperatures (°C), index (LAI), grain yield (kg ha^{-1}) and crude protein ratio (%) were examined.

Evaluation of the data obtained in the study

The data obtained at the end of the study were subjected to LSD multiple comparison tests with CoStat (version 6.4) program in order to determine the significance levels of variance analysis and differences between applications. SPSS (Version 23) statistics program was used for the determination and analysis of the correlation matrix among the studied characteristics of yield.

RESULTS

The average data of the features examined in the study are given in Table 2, the comparisons of the important interactions are shown in Figure 2-4, the correlation matrix for the examined properties is presented in Table 3, and the correlation graphs of the parameters related to the seed yield in Figure 5A-D.

Days of spiking

According to the data obtained in the study, the effect of varieties and vermicompost doses on the number of spiking days of bread wheat was found significant. The average number of spiking days was found to be earlier in Sagitario variety (111.5 days) than Adana 99 variety (113.5 days) (Table 2). Aycicek and Yildirim (2006), in their study with 20 wheat genotypes in Erzurum, stated that there are important differences between genotypes in terms of the number of spiking days. It is considered that this difference arises from the genetic structure of the varieties. It was determined that there were significant differences between vermicompost applications applied in the experiment, and the lowest number of spiking days was taken from 0 and 800 kg ha^{-1} vermicompost applications (111.2 and 112.2 days), while the highest (113.2days) was counted from 2400 kg ha^{-1} vermicompost applications (Table 2).

Plant height

As observed in Table 2, the effect of variety and variety x vermicompost doses on the plant height were not statistically significant, while significant differences were found between vermicompost applications. The plant height average value was 95cm in Sagitario wheat cultivar and 93cm in Adana 99 cultivar. In terms of vermicompost applications, the highest plant height average values were obtained from 98.5 and 99.3 cm with 1800 and 2400 kg ha^{-1} applications, while the lowest plant length value (86.1cm) was obtained from 0 kg ha^{-1} vermicompost application (Table 2).

Plant spike length

According to the data obtained in the experiment, the effect of varieties and vermicompost doses on the spike length of bread wheat was found significant. The average spike length Sagitario cultivar (7.7cm) was found to have shorter spikes than Adana 99 cultivar (8.8cm). This difference is thought to be due to the genetic structure of the cultivars because the responses of the cultivars to vermicompost applications were the same. While vermicompost applications showed significant differences in terms of their effects on plant spike length, the longest average spike length value (9.6cm) was taken from 2400 kg ha^{-1} vermicompost application, but there was no statistical difference between the other three applications (Table 2).

Grain number per spike

As can be seen in Table 2, the effect of varieties on grain number was not statistically significant, while there were significant differences between vermicompost applications and interactions of varieties x vermicompost. The average value of grain number per spike was 39.4 in Sagitario wheat cultivar and 44.7 in Adana 99 cultivar. In terms of vermicompost applications, the average number of grains in the highest spike was obtained in the application of 50.3 to 2400 kg ha^{-1}, while the lowest values were counted in the other three applications that had no statistical difference between them (Table 2). As a result of multiple comparisons made to determine the common effect of cultivar and vermicompost applications, it was determined that the highest grain number value (55.9 pieces) was taken from the fourth vermicompost application in Sagitario variety, and the lowest value (29.8 pieces) was obtained from the control application of the same variety (Table 2 and Figure 2).

Table 2. Averages values of the properties examined in the experiment and groups formed as a result of LSD comparison test

Treatments		Levels	DS (day)	PH (cm)	PSH (cm)	GNS (number/spike)	CN (cci)	VT (ºC)	LAI	Y (kg ha^{-1})	CPR (%)
Cultivars' (C) Means *		Sagitario	111.5 **B**	95.0	7.7 **B**	39.4	49.9 **A**	21.9	0.7	4949.8 **A**	12.3
		Adana 99	113.5 **A**	93.0	8.8 **A**	45.4	48.0 **B**	22.1	0.8	4850.4 **B**	12.0
Vermicompost (V) Treatment Means **		V 1	112.0 b	86.1 c	7.6 b	38.3 b	48.3 b	22.2	0.7 b	4557.0 d	11.9 b
		V 2	112.2 b	92.1 b	8.1 b	38.0 b	49.4 ab	22.1	0.7 a	4810.0 c	12.3 ab
		V 3	112.7 ab	98.5 a	7.9 b	41.5 b	50.0 a	21.8	0.8 a	4943.7 b	12.6 a
		V 4	113.2 a	99.3 a	9.6 a	51.7 a	48.3 b	22.0	0.7 ab	5289.8 a	11.8 b
C x V Interaction Means ***	Sagitario	V1	111.0	89.6	7.5	29.8 *c*	50.4 *a*	21.8	0.7	4758.7 *d*	12.0
		V2	111.3	94.3	7.5	32.2 *b*	49.3 *ab*	22.3	0.7	4808.0 *d*	12.2
		V3	111.7	96.3	7.2	39.4 *b*	50.5 *a*	21.8	0.7	4872.0 *d*	12.7
		V4	112.0	99.9	8.8	55.9 *a*	49.5 *a*	22.0	0.7	5360.7 *a*	12.1
	Adana 99	V1	113.0	82.6	7.7	46.8 *ab*	46.2 *b*	22.6	0.7	4355.3 *e*	11.8
		V2	113.0	89.9	8.8	43.8 *ab*	49.4 *ab*	21.9	0.8	4812.0 *d*	12.4
		V3	113.7	100.6	8.5	43.5 *ab*	49.4 *ab*	21.9	0.8	5015.3 *c*	12.6
		V4	114.3	98.8	10.3	47.5 *ab*	47.1 *b*	22.0	0.8	5219.0 *b*	11.4
LSD %5 (C)			0.422	ns	0.909	ns	1.087	ns	ns	6.565	ns
LSD %5 (V)			0.597	4.646	1.285	9.453	1.537	ns	0.039	9.284	0.639
LSD %5 (C x V)			ns	ns	ns	23.156	2.756	ns	ns	22.741	ns

ns: Non-significant (at 5% level)
*: There is no difference between the means indicated by capital bold letters in the same column.
**: There is no difference between the means shown in small letters in the same column.
***: There is no difference between the means shown in small italic letters in the same column.

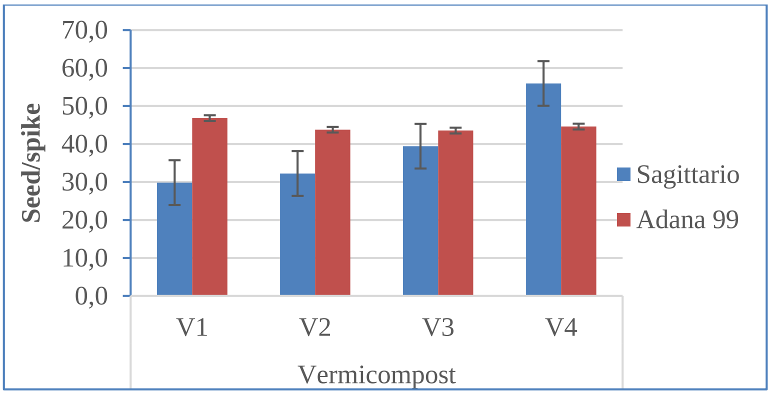


Figure 2. The effect of different vermicompost applications on grain number per spike

Chlorophylls number

When Table 2 was analyzed, it was found that the effect of factors and interaction between factors on chlorophyll number was statistically significant. It has been observed that the Sagitario wheat cultivar with chlorophyll count 49.9cci is higher than the chlorophyll count (48.0 cci) of the Adana 99 cultivar. In terms of vermicompost applications, the highest chlorophyll average number (50.0 cci) was obtained from 1600 kg ha^{-1} application, while the lowest values were obtained from the control and fourth vermicompost applications that did not have any statistical difference between them (Table 2). As a result of the common interaction of varieties and vermicompost applications, it was determined that the highest chlorophyll numbers (550.4, 50.5, and 49.5 cci) were taken from the control, third and fourth vermicompost applications of Sagitario variety, and the lowest values (46.2 and 47.1 cci) were obtained from the control and fourth vermicompost applications of Adana 99 variety (Table 2 and Figure 3). These differences may be due to the presence and useful amount of essential nutrients, including micronutrients such as magnesium and iron in vermicompost fertilizer, which can play an important role in chlorophyll synthesis.

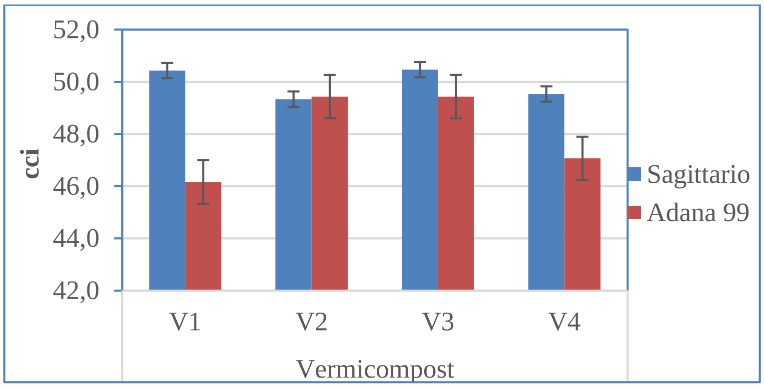


Figure 3. Effect of different vermicompost applications on the number of chlorophylls

Vegetation temperatures

High temperature during ripening and ripening creates great stress in many wheat production areas (Gibson and Paulsen 1999). When the trial results were examined from Table 2, it was observed that the effects of cultivar, vermicompost, and cultivar x vermicompost interaction on vegetation temperature values were not statistically significant (Table 2). Vegetation temperature values of Sagitario and Adana 99 varieties were measured as 21.9 and 22.1 °C respectively and it was observed that the response of the varieties to the temperature was the same. No significant difference was observed between vermicompost applications in terms of vegetation and it was

Leaf area index (LAI)

The genotypic effect of cultivars and the effect of cultivar x vermicompost interaction were not statistically significant on the leaf area index. The average leaf values of the varieties were determined as 0.73 in Sagitario wheat cultivar and 0.75 in Adana 99 cultivar. It was determined the effect of vermicompost applications on the leaf area index in wheat was found to be significant compared to the control, and the highest leaf area index average values (0.75 and 0.76) were obtained from 1200 and 1800 kg ha^{-1} application, whereas the lowest value (0.71) was obtained from 0 kg ha^{-1} vermicompost application (Table 2). Nitrogen is an indispensable element for chlorophyll synthesis and leaf elongation, and is often an essential element in the vegetative growth stage, vermicompost, which increases the absorbability of nitrogen in the soil, is therefore thought to have a positive effect on the leaf area index.

Grain yield

When the averages of grain yield from Table 2 are examined, it was determined that the effect of cultivars, vermicompost applications, and interaction between these two factors on seed yield was statistically significant. The seed yield of Adana 99 cultivar with 4850.4 kg ha^{-1} was found to be lower than that of the Sagitario cultivar (4949.8 kg ha^{-1}). In terms of vermicompost applications, the highest seed yield average value (5289.8 kg ha^{-1}) was obtained from the 2400 kg ha^{-1} application, while the lowest value (4557.0 kg ha^{-1}) was obtained from the control application of vermicompost (Figure 4). The slow release of vermicompost (Roberts et al. 2007), a rich food source with nutrients and organic matter content that can be easily taken by plants, and the physical, chemical, and biological improvements (Sarwar et al. 2007) it provides in the soil contribute significantly to yield.

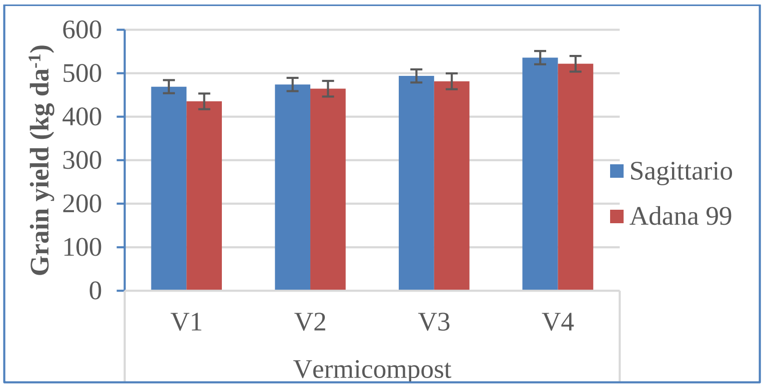


Figure 4. Effect of different vermicompost applications on grain yield in wheat varieties

Crude protein ratio

As seen in Table 2, the genotypic effect of cultivars on crude protein ratio was not found to be statistically significant. Crude protein mean value was determined as 12.3% in Sagitario wheat variety and 12.0% in Adana 99 variety. The effect of vermicompost applications on crude protein ratio of bread wheat was found to be significant compared to the control, and the highest crude protein average value (12.6%) was obtained from 1800 kg ha^{-1} application, while the lowest values (11.9% and 11.8%) were obtained from 0 kg ha^{-1} and 2400 kg ha^{-1} vermicompost applications (Table 2).

Correlation Matrices of Observed Parameters

The correlation matrices for the features examined as a result of this study were presented in Table 3, and the correlation curves between the yield and the other features examined were presented in Figure 5. As can be seen from Table 3, the correlation matrix showed that grain yield in wheat has a significant and strong positive correlation with plant height (r = 0.776 **). The yield was found to have a positive linear relationship (r^2 = 0.602) with a 60% plant height (Figure 5A).

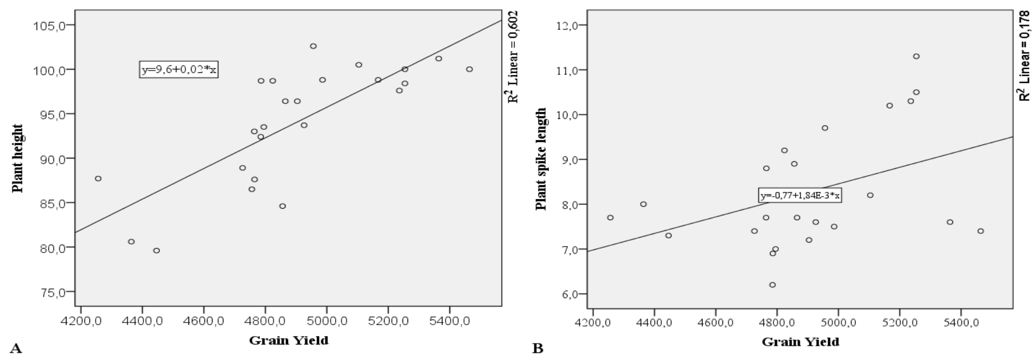
Table 3. Correlation matrices between seed yield and other studied properties

Properties	DS	PH	PSL	GNS	CC	VT	LAI	GY	CPR
Days of spiking (DS)	1	0.159	0.575 **	0.372 *	-0.446 *	-0.016	0.439 *	0.193	-0.314
Plant height (PH)		1	0.284	0.119	0.222	-0.243	0.317	0.776 **	-0.441 *
Plant spike length (PSL)			1	0.559 **	-0.236	-0.117	0.369 *	0.421 *	-0.367 *
Grain number per spike (SS)				1	-0.426 *	0.295	-0.069	0.324	0.055
Chlorophylls number (CN)					1	-0.710 **	0.167	0.268	0.107
Vegetation temperature (VT)						1	-0.360 *	-0.392 *	0.118
Leaf area index (LAI)							1	0.361 *	-0.301
Grain yield (GY)								1	-0.480 **
Crude protein ratio (CPR)									1

**. Pearson Correlation is significant at the 0.01 level.

*. Pearson Correlation is significant at the 0.05 level.

When Table 3 is examined, it is observed that seed yield has a significant, weak positive correlation with plant spike length (r = 0.421*) and a positive 18% linear relationship (r^2 = 0.178) (Figure 5B). However, it was determined that seed yield has a significant and weak negative correlation with vegetation temperature (r = -0.392 *) and revealed a negative linear relationship (r^2 = 0.154) with 15% vegetation temperature (Figure 5C). Also, it was determined that the seed yield had a significant, weak positive correlation with the leaf area index (r = 0.361 *), and showed a positive linear relationship (r^2 = 0.130) with the feature of leaf area index of 13% (Figure 5D).



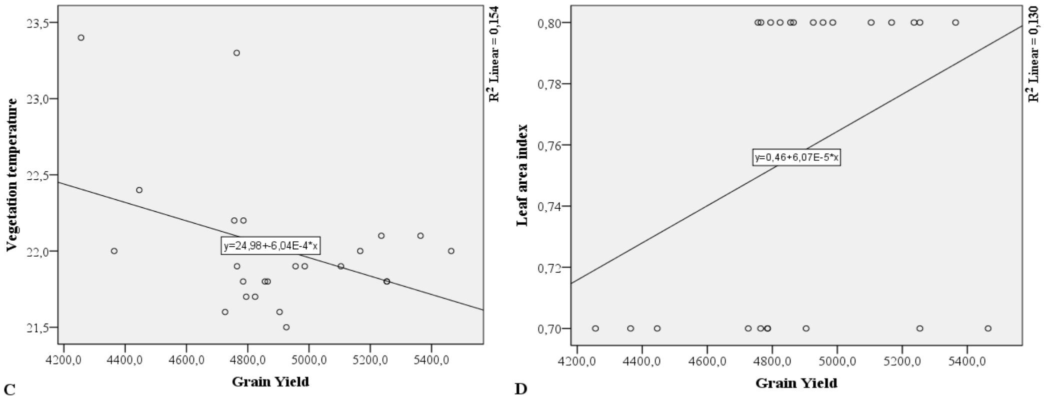


Figure 5. Simple scatter plot matrices between seed yield and other studied properties

DISCUSSION

Various necessary plant nutrients like nitrates, P, K, calcium, and magnesium (Nauman et al. 2020) and various plant growth materials like auxins, gibberellins, and cytokinins, and humic acids (Singh et al. 2008) are naturally found as the plant-available form in vermicompost and therefore, enhance the yield and quality-related properties of crops (Sharma and Garg 2018). Vermicompost positively enhances the growth of roots to efficiently absorb water and necessary nutrients from the considered soil due to the presence of hormone substances in the vermicompost (Joshi et al. 2013; Pezeshkpour et al. 2014; Theunissen et al. 2010). The results of this study supported the hypothesis that the application of vermicompost organic manures can improve the productivity and quality of *T. aestivum* (Tables 2 and Figure 2 - 4). The organic manures-based vermicompost treatments improved the days of spiking, plant height, plant spike length, grain number per spike, chlorophyll number, leaf area index, grain yield, and crude protein ratio, except vegetation temperatures, in this study. These observed properties are some important yield contributing factors. This study showed that V4 (2400 kg ha^{-1}) application of vermicompost gave higher values of these properties as compared to control plots, except chlorophyll number, vegetation temperature, and crude protein ratio. Similar results were reported by Joshi et al. (2013) who also stated that vermicompost has a positive effect on some yield and quality properties of bread wheat in his field study by applying vermicompost to enrich the soil with organic matter in order to increase the growth, yield, and quality characteristics. However, in the study, it was found that V3 (1600 kg ha^{-1}) vermicompost application gave the highest chlorophyll count and protein ratio. The trial results are in line with the results of Agrawal et al. (2003), which states that vermicompost increases the leaf area, which is directly proportional to the leaf area index. Statistically, significant increases determined in observed properties with vermicompost applications in comparison with control are due to the high nitrogen presence of micro and macro-nutrients of vermicompost (Atiyeh et al. 2002; Atiyeh et al. 2000). These increases have been confirmed by studies with different plants (Alam et al. 2007; Joshi et al. 2013). Additionally, the result of the study is partially in line with the results of Devi et al. (2011), Mohan et al. (2018), and Singh and Sukul (2019) and also are partially compatible with the findings of Joshi et al. (2013), who stated that the use of vermicompost alone and with other fertilizers promotes vegetative development in bread wheat. Similar judgment and conclusions for corn plants were reported by Dey et al. (2019). Also, the study results are in line with the results reported by Sanjeet and Singh (2010).

CONCLUSION

Compared to the control group, the applications performed in the study showed that vermicompost applications had a significant positive effect on all studied properties, except the vegetation temperature. In addition to being a fertilizer that does not pollute the environment, vermicompost improves soil quality and productivity in sustainable agriculture by contributing positively to the increase of organic matter of the soil, reduction of soil problems, availability of existing nutrients, and many more. It is thought that the use of vermicompost may also be useful for other product types. This study is thought to shed light on future field studies to obtain more detailed information about vermicompost use in plant growth.

REFERENCES

Agrawal S., A. Singh, G. Dwivedi. 2003. Effect of Vermicompost, Farm Yard Manure and Chemical Fertilizers on Growth and Yield of Wheat (*Triticum aestivum)*. Plant archives 3(1): 9-14.

Alam M., M. Jahan, M. Ali, M. Ashraf, M. Islam. 2007. Effect of vermicompost and chemical fertilizers on growth, yield and yield components of potato in barind soils of Bangladesh. Journal of Applied Sciences Research 3 (12): 1879-1888.

Atiyeh R., S. Lee, C. Edwards, N. Arancon, J. Metzger. 2002. The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresource technology 84 (1): 7-14.

Atiyeh R. M., J. Domínguez, S. Subler, C. A. Edwards. 2000. Changes in biochemical properties of cow manure during processing by earthworms (*Eisenia andrei*, Bouché) and the effects on seedling growth. Pedobiologia 44 (6): 709-724.

Aycicek M., T. Yildirim. 2006. Adaptability performances of some bread wheat (*Triticum aestivum* L.) genotypes in the Eastern Region of Turkey. International Journal of Science Technology 1(2): 83-89.

Devi K., M. Singh, N. Singh, H. Athokpam. 2011. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). Journal of Crop Weed 7(2): 23-27.

Dey S. R., R. Barman, G. Kandpal. 2019. Effect of combined application of organic and inorganic fertilizer on growth attributes of wheat (*Triticum aestivum* L.). Journal of Pharmacognosy Phytochemistry 8(3): 576-578.

Gibson L., G. Paulsen. 1999. Yield components of wheat grown under high temperature stress during reproductive growth. Crop science 39(6): 1841-1846.

Joshi R., A. P. Vig, J. Singh. 2013. Vermicompost as soil supplement to enhance growth, yield and quality of *Triticum aestivum* L.: a field study. International journal of Recycling of organic waste in Agriculture 2 (1): 16.

Khedr M. E., M. G. Nasseem, W. H. Ali, M. A. Rashad. 2019. Compost and Vermicompost as Soil Amendments to Immobilize Cu and Cd Under Wheat Growth Conditions. Alexandria Science Exchange Journal 40 (1): 705-716.

Kizilkaya R., Ş. Hepşen, C. Turkmen, M. Durmuş. 2012. Vermicompost effects on wheat yield and nutrient contents in soil and plant. Archives of Agronomy and Soil Science 58: 175-179.

Mohan B., P. Kumar, R. A. Yadav. 2018. Effect of integrated nutrient management on yield attributes and yield of wheat (*Triticum aestivum* L.). Journal of Pharmacognosy and Phytochemistry 7(1): 1545-1547.

Nauman A., M. N. Khan, M. S. Ashraf, S. Ijaz, H. Saeed-ur-Rehman, M. Abdullah, N. Ahmad, H. M. Akram, M. Farooq. 2020. Influence of Different Organic Manures and Their Combinations on Productivity and Quality of Bread Wheat. Journal of Soil Science and Plant Nutrition.

Pezeshkpour P., M. R. Ardakani, F. Paknejad, S. Vazan. 2014. Effects of vermicompost, mycorrhizal symbiosis and biophosphate soulbilizing bacteria on some characteristics related to chickpea root growth under Autumn in the dry land condition. Bulletin of Environment, Pharmacology and Life Sciences 3 (2): 19-25.

Roberts P., G. Edwards-Jones, D. L. Jones. (2007). Yield Responses of Wheat (*Triticum aestivum*) To Vermicompost Applications. Compost Science & Utilization 15(1): 6-15.

Sanjeet K., O. Singh. 2010. Response of wheat to different combination of integrated nutrient management under irrigated conditions. Green Farming 1(1): 27-29.

Sarwar, G., N. Hussain, H. Schmeisky, S. Muhammad, M. Ibrahim, E. Safdar. 2007. Use of compost an environment friendly technology for enhancing rice-wheat production in Pakistan. Pakistan Journal of Botany 39 (5): 1553-1558.

Sharma K., V. Garg. 2018. Comparative analysis of vermicompost quality produced from rice straw and paper waste employing earthworm *Eisenia fetida* (Sav.). Bioresource technology 250: 708-715.

Singh L., P. Sukul. 2019. Impact of vermicompost, farm yard manure, fly ash and inorganic fertilizers on growth and yield attributing characters of maize (*Zea mays* L.). Plant Archives 19(2): 2193-2200.

Singh R., R. Sharma, S. Kumar, R. Gupta, R. Patil. 2008. Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (*Fragaria x ananassa* Duch.). Bioresource Technology 99(17): 8507-8511.

Stoknes K., F. Scholwin, W. Krzesiński, E. Wojciechowska, A. Jasińska. 2016. Efficiency of a novel “Food to waste to food” system including anaerobic digestion of food waste and cultivation of vegetables on digestate in a bubble-insulated greenhouse. Waste management 56: 466-476.

Theunissen J., P. Ndakidemi, C. Laubscher. 2010. Potential of vermicompost produced from plant waste on the growth and nutrient status in vegetable production. International Journal of Physical Sciences 5(13): 1964-1973.