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RESEARCH ARTICLE

Effect of Liquid and Solid Vermicompost Applications on Growth and Yield of Sunflower (*Helianthus annuus* L.)

Volkan Gül[1*] • Furkan Çoban[2] • Erdoğan Öztürk[3]

[1*]*Bayburt University, Faculty of Applied Sciences, Organic Agriculture Management, Bayburt/Turkey.*

E-mail: volkangul@bayburt.edu.tr

[2]*Atatürk University, Faculty of Agriculture, Department of Field Crops, Erzurum/Turkey. E-mail: furkan.coban@atauni.edu.tr*

[3]*Atatürk University, Faculty of Agriculture, Department of Field Crops, Erzurum/Turkey. E-mail: erozturk@atauni.edu.tr*

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ABSTRACT

Vermicompost, which is not harmfull to the environment, and is increasing in agricultural production in terms of both gaining to the soil and benefiting the waste. This research was carried out in 2019 in Bayburt ecological conditions in order to determine the impacts of different doses of solid (250, 500 and 750 kg da^{-1}) and liquid (0, 250, 500 and 750 ml da^{-1}) vermicompost fertilizers on the flowering and maturation period (days), stem diameter (cm), table diameter (cm), plant height (cm), thousand weight (g) seed yield (kg da^{-1}), seed internal rate (%) oil ratio (%) and oil yield (kg da^{-1}) of sunflower (*Helianthus annuus*). In the experiment, it was determined that all parameters were statistically significant compared to $p<0.01$. The highest seed (218.7 kg da^{-1}) and oil yield (75.9 kg da^{-1}), which are the most important parameters in oil sunflower, were obtained in 750 kg da^{-1} solid and 750 ml da^{-1} Liquid vermicompost application (K_3S_3). As a result, the use of solid and liquid vermicompost application in oil sunflower together will be beneficial in obtaining the highest healthy, high quality seed and oil yield.

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Introduction

Chemical and synthetic inputs, which have been used extensively due to the development in agricultural areas from past to present, have increased the number of products obtained from the unit area. Nevertheless, it caused serious pollution of soils, environment, cultivated products, and groundwater resources. These problems led to serious health problems for livings (Schuman and Simpson, 1997). Following these developments, new studies, which target to grow healthier and qualified products by preventing the deterioration of the physical, chemical and biological structure of the soils, have accelerated. Within this scope, biological fertilizer, which they can produce by completely using natural inputs and not being harmful to nature, have been used.

The use of natural fertilizers obtained from agricultural and industrial wastes as in compost form has been widely used to improve the soil and enrich the amount of organic matter (İlay et al., 2013; Mondal et al., 2017).

Vermicomposting (worm manure), one of the most important natural compost fertilizers, is defined as the material obtained from the processing of natural wastes by worms and converting them into organic fertilizers. This fertilizer known as vermicomposting worm poop has surpassed other fertilizers in terms of its use of macro and micronutrients for the plant (Bellitürk, 2016; Yılmaz and Kurt, 2018). As another definition, vermicomposting is an important organic fertilizer that is widely used in solid and liquid form, which is formed by digesting various organic wastes (such as vegetable and animal waste) using Californian worms and containing several fungi in it, as well as symbiotic and asymbiotic microorganisms. As another definition, Vermicomposting is an important organic fertilizer that is widely used in solid and liquid form, which is formed by digesting various organic wastes (such as vegetable and animal waste) using Californian worms and

*Corresponding author: volkangul@bayburt.edu.tr
ORCID: 0000-0003-4899-2822

containing a number of fungi in it, as well as symbiotic, asymbiotic microorganisms (Tejada and González, 2009; Demir et al., 2010). In many studies with solid and liquid worm fertilizers, it is stated that these fertilizers transform the plant nutrients into needed form for plants. Furthermore, product quality in plant production increases yields and improves the physical, chemical and biological properties of the soil (Chaoui et al., 2003; Arancon et al., 2004; Alam et al., 2007; Singh et al., 2008; Çıtak et al., 2011).

In vermicomposting studies, worm manure applications were generally made as an input, mainly on some vegetables and fruits in greenhouse cultivation. Vermicomposting is not enough alone, because sunflower plant, which has an important place in the production of vegetable oil in our country, Since the meal of the sunflower, which is of great importance, is a valuable animal feed while supporting animal husbandry, which is an important source of livelihood in the region, the development of the vegetable oil industry will be one of the factors that can relatively prevent migration by providing employment (Sefaoğlu and Kaya, 2018). especially in field crops, demand excessive plant nutrients from the soil. In addition to the worm fertilizer used as the bottom fertilizer to supply the plant nutrient naturally that this plant needs, it is thought that yield can be increased by applying liquid worm fertilizer in certain periods until the development and flowering period of the sunflower plant. For this purpose, it is tried to determine the effects of different doses of solid and liquid worm manures on yield and quality of sunflower in Bayburt.

Materials and Methods

Bayburt University Organic Farming Land Management Test Area in which the study conducted is located 1550 meters above the sea in north-east of Turkey. Soil samples gathered from 0-20 cm depth of the test area were determined by analyzing in the Soil, Water and Plant Analysis Laboratory of the Black Sea Agricultural Research Institute. It was determined that the soil structure in the test area was clay loam and slightly alkaline (pH 7.67). When evaluated according to Kacar (2009), the soil analysis results for 2019 are determined respectively as lime ratio 7.85% (moderate limestone), total salt rate 0.023% (nonsaline), organic matter ratio 1.18% (low), phosphorus amount 4.31 (low) kg^{-1} and potassium amount 129.25 kg^{-1} (high). The region is dominated by the transition climate between the Eastern Black Sea and Eastern Anatolia that is hot, arid in summer; cold and rainy in winter. Climate data (precipitation, temperature and relative humidity) for tested and long years are given in Figure 1.

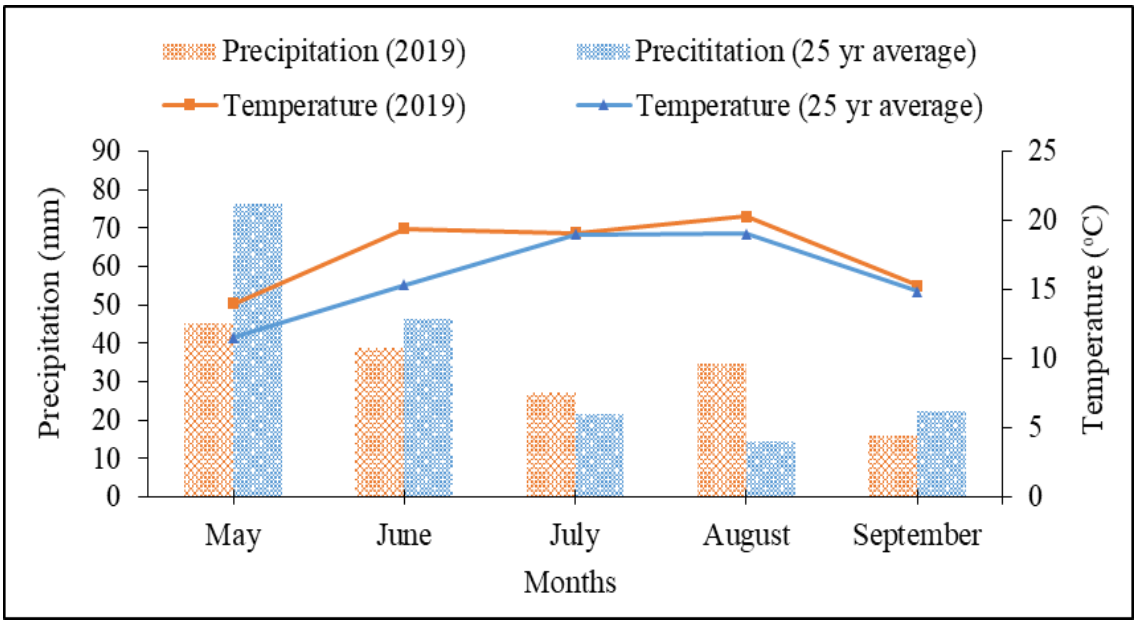

Figure 1. Average monthly temperature, precipitation values at the experimental site in 2019 and long term period (1982-2017)

This study was carried out in the test area of Bayburt University in the spring-summer period in 2019. The research was settled in three replications according to "Coincidence Blocks Split Parcels Test Pattern" and seeds are planted as the interrow was 70 cm and intrarow was 30 cm for each parcel. Each parcel is composed of 48 parcels, 4.8 m long, 2.8 m wide and 4 rows. In the experiment, Pıoneer 64LE119 oil sunflower was used as material. 15-20 days before planting 0 for each parcel, 250, 500, 750 kg^{-1} doses of solid worm manure and 0, 250, 500 and 750 ml^{-1} doses of liquid worm manure, after the plant has 4-5 leaves, were applied to plant leaves average 2 times every 20 days until the blossom stage (Table 1). The chemical properties of vermicompost fertilizer, which is supplied from a private enterprise in Şiran district of Gümüşhane and used in the test area, are given in Table 2.

Table 1. Vermicompost Application Doses

Application	(Sub-Parcel) Liquid Vermicompost (S), (ml da^{-1})				
		S_0	S_1	S_2	S_3
(Main Parcel) Solid Vermicompost (K), (kg da^{-1})	K0	0	250	500	750
	K_1 (250)	0	250	500	750
	K_2 (500)	0	250	500	750
	K_3 (750)	0	250	500	750

Table 2. Chemical properties of the vermicompost

Name of Analysis	Solid Vermicompost	Liquid Vermicompost
PH	9.46	8.5
Moisture (%)	25.70	---------
Conductivity (dS m^{-1})	5.50	4.0
Total (Humic + fulvic acid) (%)	30.60	6.0
Organic Matter (%)	50.20	11.0
Organic Nitrogen (%)	0.82	0.4
P_2O_5 (%)	1.78	0.11
K_2O (%)	0.62	0.12

Sowing was done manually on 08.05.2019, with 3 seeds for each seedbed. After 2-3 weeks of seeding out, a misfire was made on each seedbed with a seedling. During the growing season, hoeing was applied to prevent weeds and irrigation was carried out according to the plant's needs, especially during the flowering period. The harvesting process was evaluated as one row from the edges and 0.25 m of edges at the ends, and 2 rows in the center were harvested. In the study, flowering and ripening time, plant height, stalk diameter, table diameter, thousand kernel weight, grain yield, grain internal rate, oil ratio, and oil yield were investigated.

The results were analyzed using the SPSS and the differences between the averages were checked by Duncan multiple range test according to their significance levels.

Results and Discussion

In the study carried out with the application of different doses of solid and liquid worm fertilizer applied to oil sunflower under Bayburt ecological conditions, it was determined that all parameters were statistically significant compared to p<0.01. Flowering time varied between 81-85.7 days and ripening time between 109-113.7 days according to vermicomposting doses. The earliest flowering time (81 days) and ripening time (109 days) were obtained from K0S2 vermicomposting application, while the latest flowering time (85.7 days) and ripening time (113.7 days) were obtained from the K_2S_2 vermicomposting application (Table 3). As a result of the studies, the researchers found that vermicomposting applications improve the soil and increase the flowering and ripening period of the plants (Gajalakshmi and Abbasi, 2002; Paterson, 2003; Pritam et al., 2010).

According to the vermicomposting application, the stem diameter of the sunflower plant has been observed to vary between 10.3-15.2 cm, the table diameter between 12.6-15.6 cm and the plant height between 89.4-117.9 cm. Findings of the research revealed that the highest stem diameter and plant height obtained from K_0S_2 vermicomposting application, and the highest stem diameter obtained from K_3S_1, the highest diameter, and plant height were obtained from K_1S_0 vermicomposting application (Table 3).

Table 3. Effects of different doses of solid and liquid Vermicompost applied to sunflower on flowering and ripening time, stem diameter, table diameter and plant height

Application		F.T (day)	M.T (day)	S.D (cm)	H.D (cm)	P.H (cm)
Applications of solid (K) and liquid (S) Vermicompost	K_0S_0	81,7	109,7	14,4	13,3	107,7bcd
	K_0S_I	83,3	111,3	11,8	14,1	103,5de
	K_0S_2	81,0	109,0	15,2	14,8	117,9a
	K_0S_3	84,0	112,0	13,3	13,7	110,1b
	K_1S_0	84,7	112,7	10,3	12,6	89,4f
	K_1S_I	82,0	110,0	12,6	14,5	104,3cd
	K_1S_2	83,0	111,0	11,4	13,2	103,5de
	K_1S_3	84,0	112,0	11,5	13,5	108,2bcd
	K_2S_0	84,0	111,7	13,6	15,5	105,2bcd
	K_2S_I	82,7	109,7	13,4	13,4	109,1bce
	K_2S_2	85,7	113,7	11,9	13,3	99,1e
	K_2S_3	82,0	109,3	11,6	13,1	92,9f
	K_3S_0	84,7	112,7	13,2	14,1	108,9b
	K_3S_I	84,0	112,0	13,4	15,6	108,5bcb
	K_3S_2	83,0	110,7	13,3	14,7	99,2e
	K_3S_3	83,0	110,7	14,1	12,6	115,9a
Mean		**83,3**	**111,1**	**12,8**	**13,9**	**105,2**
Significance Value		**	**	**	**	**

** It İs Significant at the level of $P < 0.01$, **FT:** Flowering Time, **MT:** Maturation

Time, **SD:** Stem Diameter, **HD:** Head Diameter, **PH:** Plant Height

It is clearly stated in many studies that vermicomposting is more useful in plant growth and development compared to animal fertilizer. Although animal fertilizer is used in vermicomposting production, vermicomposting fertilizer has better quality compared to animal fertilizer in the life phase since it releases plant nutrients in a way that the plant can take (Atiyeh et al., 2000). It is observed that vermicomposting applied in soilless cultivated petunia increased the germination, flowering, and growth of the flower (Arancon et al., 2008). In addition, some researchers

have stated that Vermicompost fertilizer -they have tested on different plants- has a positive effect on yield parameters such as plant height and stem thickness (Alam et al., 2007; Yourtchi et al., 2013; Adiloğlu et al., 2018). Ramasamy and Umavathi (2011) observed that as the vermicomposting dose increased, the stem diameter, table diameter and plant height of the sunflower increased. Although the study results indicated that vermicomposting applications have a positive effect on yield parameters such as stem diameter, table diameter, and plant height, our results were low. The reasons for this are the plant nutrient content of the soil and dry conditions of the climate during the period of cultivation.

When the significant yield parameters of sunflower are evaluated, the highest grain yield (218.7 kg da^{-1}), grain internal rate (77.2%) and oil yield (75.9 kg da^{-1}) from K_3S_3, the highest thousand-grain weight (54.2 g) from K_1S_3 vermicomposting application. The highest oil rate (36.5%) was obtained from K_1S_2 vermicomposting application. The lowest grain yield (75.1 kg da^{-1}), oil ratio (31.6%) and oil yield (23.71 kg da^{-1}) are obtained from the control application, while the lowest thousand-grain weight (33.6 g) is from K_1S_0 vermicomposting application, and the lowest grain internal rate (64.6%) was obtained from K_0S_2, K_1S_2, and K_2S_1 vermicomposting applications. When evaluated in terms of grain yield and oil ratio, which are important parameters of oil plants; while the grain yield increased due to the increase in liquid worm fertilizer applied as a supplement to the solid worm fertilizer used as bottom fertilizer, the increase in the oil ratio was limited (31.6-36.5%) although there was a certain increase due to the application of vermicomposting (Table 4). Since vermicompost contains nitrate, phosphate, changeable calcium, soluble potassium, hormones that promote plant growth, it has a significant effect on plant growth and yield increase (Joshi and Vig, 2010). The studies of many researchers revealed that the solid and liquid vermicompost used in vegetable, fruit, landscaping and field crops cultivation increases the yield and quality of the product (Karmakar et al., 2012; Yan et al., 2013; Açıkbaş and Bellitürk, 2016). It is stated vermicompost application in sunflower increases photosynthesis with high plant nutrient intake, accordingly, increase in grain yield and grain internal rate (Anup et al., 2006). Researchers such as Kinama et al. (2018) and Yaser et al. (2011) have reported that vermicompost application provides a positive increase in oil content in sunflower. Vermicompost fertilizer application provided significant increases in parameters such as seed yield, table diameter, plant height, and oil ratio in the sunflower (Shehata and EL-Khawas, 2003; Tamer et al., 2016). Our results demonstrate that solid and liquid vermicompost applications are below the results of other researchers, although the applications increase the yield and oil ratio at a certain rate. It can be said that these results are affected depending on environmental and climatic factors.

Table 4. Effects of different doses of solid and liquid Vermicompost applied to sunflower on thousand weight, seed yield, seed internal ratio, oil ratio and oil yield

Applications		T.S.W (g)	S.Y (kg da^{-1})	SIR (%)	O.C (%)	O.Y (kg da^{-1})
Applications of solid (K) and liquid (S) Vermicompost	K_0S_0	45,3bc	75,1h	66,1ef	31,6e	23,7l
	K_0S_1	37,5de	109,4ef	65,4ef	32,8de	35,9ıjk
	K_0S_2	43,2bcd	116,5de	64,6f	34,8 abcd	40,5ghı
	K_0S_3	41,1bcd	146,6c	65,4ef	36,1ab	52,9c
	K_1S_0	33,6e	94,8g	65,8ef	32,8de	31,1k
	K_1S_1	39,1cde	112,8def	68,5d	33,3cde	37,5hıj
	K_1S_2	36,7de	123,4	64,6f	36,5a	45,1efg
	K_1S_3	54,2a	139,1c	70,5c	34,7abcd	48,3cde
	K_2S_0	51,9a	103,6fg	68,5d	33,4cde	34,6jk
	K_2S_1	37,4de	119,6de	64,6f	35,7 abc	42,7fgh
	K_2S_2	40,1cde	144,2c	73,9b	34,8 abcd	50,1cde
	K_2S_3	37,2de	148,4c	73,9b	34,7 abcd	51,6cd
	K_3S_0	42,4bcd	114,5de	66,9de	34,8cde	37,8hıj
	K_3S_1	48,0ab	138,8	68,5d	33,1bcde	46,7def
	K_3S_2	42,7bcd	190,9b	75,6ab	33,7 abcd	66,5b
	K_3S_3	37,9de	218,7a	77,2a	34,8 abcd	75,9a
Mean		**41,8**	**131,0**	**68,8**	**34,2**	**45,1**
Significance Value		**	**	**	**	**

** It İs Significant at the level of $P < 0.01$, **TSW:** 1000 Seed Weight, **SY:** Seed Yield,

SIR: Seed İnternal Ratio, **OC:** Oil Content, **OY**: Oil Yield

Conclusion

It is important to use organic input materials to improve the physical, chemical and biological properties of the soils and to obtain healthy and quality products. Vermicomposting is one of the organic inputs that can be used for this purpose, and which has become widespread in recent years. Since the sunflower, which is necessary for the production of natural vegetable oil in our country, is

excessively exploited the soil, it is clearly observed in many research results that the use of vermicompost is not enough alone. For this purpose, in addition to solid vermicompost in sunflower cultivation, the application of liquid vermicompost as a supplement in certain periods is considered to make an important contribution in increasing grain yield.

In the study, it is observed that both solid and liquid Vermicompost application increases the efficiency more than only solid vermicompost application. According to our results, the highest grain yield (218.7 kg da^{-1}) was obtained from K_3S_3 vermicompost application. However, it was seen that the oil content remained below the standards even though it increased at a certain rate in the application of solid and liquid vermicomposts. These results may depend on the genetic characteristics of the types, environmental and climate factors.

Consequently, although the liquid vermicompost supplement increases the efficiency of solid Vermicompost application, the results proved a decrease in the oil ratio. Regarding the previous studies, we consider that the reasons depend on environmental and climatic factors rather than vermicomposting. Therefore, similar studies can be conducted in oil crops, and the desired quality and yield can be increased.

Compliance with Ethical Standards

a) Authors' Contributions

Gül V. 1: Designed the study and interpreted data.

Çoban F. 2: Performed the laboratory work and drafted the paper.

Öztürk E. 3: Performed the laboratory work and drafted the paper.

b) Conflict of Interest

The authors declare that there is no conflict of interest.

c) Statement of Human Rights

This study does not involve human participants.

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