EFFECTS OF VERMICOMPOST APPLICATION ON GROWTH AND YIELD OF HOT PEPPER (*CAPSICUM FRUTESCENS*)

Atilgan Atilgan[1], Firat Arslan[1], Burak Saltuk[1], Joanna Kociecka[2], Egle Jotautiene[3], Antanas Juostas[3]
[1]Alanya Alaaddin Keykubat University, Turkey; [2]Poznan University of Life Sciences, Poland;
[3]Vytautas Magnus University, Lithuania
atilgan.atilgan@alanya.edu.tr, firat.arslan@alanya.edu.tr, bsaltuk@siirt.edu.tr,
joanna.kociecka@up.poznan.pl, egle.jotautiene@vdu.lt, antanas.juostas@vdu.lt

Abstract. In parallel with the increase in the world population, healthy nutrition becomes more important for people every day. However, Good Agricultural Practices (GAP) are also gaining importance. The main goal of our study is to reduce the level of inorganic fertilizer use. The experimental area where the study was conducted is located at 36º 31' 21" north latitude and 32º 05' 07" east longitude. In this study, 2 m high, 12 m long and 3 m wide plastic greenhouses with arc roofs were used. The greenhouses are naturally ventilated, unheated tunnel type greenhouses. UV-added plastic cover material was used as the cover material in the greenhouse. Hot pepper was chosen as the material. In the research, the development parameters of the hot pepper plant were examined by using different doses of one organic and one inorganic fertilizer type. Vermicompost (VC) was applied at a rate of 2,500 and 5,000 kg per hectare and inorganic fertilizer was used at a rate of 60-100-160 and 30-50-80 kg per hectare. Nine applications were carried out, including different doses of these two fertilizers, their combined use, and a control group. Plant heights, SPAD (Spectrum Authorized Dealer) values, plant diameters and yield values were measured weekly from the date the seedlings were planted in the experimental greenhouses until the end of harvest. The parameters found to be important in the variance analysis results of the data obtained from the trial subjects were compared with the Student's t test, and the application groups were determined and interpreted statistically. As a result, the effects of VC and inorganic fertilizer values on the development parameters and yield values of the pepper plant were determined. It has been determined that the plant growth parameters and productivity are higher, especially when 5000 kg of organic fertilizer and 5000+60-100-160 mixed fertilizer are used per hectare. Therefore, good agricultural practices include reducing the use of inorganic fertilizers.

Keywords: pepper, fertilizer, vermicompost, GAP.

Introduction

With sustainable agriculture, agricultural activities are carried out by using environmentally friendly agricultural technologies, without destroying natural resources and without harming the environment [1]. Organic agriculture is a production system that does not include the use of inorganic fertilizers, pesticides, hormones and animal feed additives [2]. In order to prevent the deterioration of the soil structure, unused and biodegradable organic waste should be turned into compost and used instead of inorganic fertilizers [3]. Worm fertilizers, also known as VC, are one of the best ways to turn all organic matter into compost.

VC is used in ornamental plants, fruit and vegetable cultivation as it positively affects the development of plants even when used in small amounts. VC not only ensures that plants are healthy, high-quality and productive with the nutrients it provides to the soil, but also regulates their development with humic acid and growth hormones. It also prevents the destruction of soil-borne diseases and pests [4]. It is reported that vermicompost makes plants more resistant to diseases and pests, in addition to its many positive properties such as rich nutrient content and soil regulator. For this reason, it is stated that the effect of VC on plants and especially the coelomic fluid of worms is due to its antibacterial and antifungal effects [5].

There are many wastes that can be used to obtain VC. These are human-generated wastes, industrial wastes, municipal and sewage wastes, garden wastes, restaurant wastes, sugar and paper wastes [6]. VC is odorless. In fact, compost worms transform smelly cattle manure into odorless worm manure within two weeks. Interactions between worms and microorganisms produce significant amounts of humic acid and plant growth hormones, which act as plant regulators [7]. Pepper is in the Capsicum L. genus of the Solanaceae family. The Capsicum genus has approximately 30 species with very different colours, shapes, sizes and heights in terms of plant, flower and fruit characteristics [8]. Pepper production in our country is increasing day by day [9]. When we look around the world, we see that the largest pepper producer is China. Turkey is the second largest pepper producer in the world after China, with a production of approximately 2.9 million tons [10].

Several previous studies point to the need to understand the application of organic and chemical fertilizers in particular. After the pandemic, we better understand the value of staple foods such as pepper. Especially sustainable food security is much more important for humankind. Therefore, achieving higher pepper yields in each unit should be one of the agricultural goals in agricultural policies. The aim of the study is to determine the yield of pepper in greenhouses in terms of fertilization in Alanya region. Organic and chemical fertilization was applied in pepper cultivation. The experiment was established in the sub-tropic region of Turkey which is located in the Mediterranean region.

Materials and methods

Study site. This work started on April 6, 2022 and was completed with the last harvest on August 8, 2022. The trial area where the study was conducted is located at 36º 31' 21" north latitude and 32º 05' 07" east longitude. In Alanya region, summers are hot, humid, dry and clear, and winters are long, cold, rainy and partly cloudy. The average annual temperature is 16 ºC and the average annual precipitation is 955 mm. In addition, the relative humidity value in the study area varies between 59-72%. The greenhouses used in the study are naturally ventilated and unheated tunnel type greenhouses. It is 12 m long, 3 m wide and has a planting area of 36 m^2. UV-added plastic cover material was used as the cover material in the greenhouse. The greenhouse was equipped without an air conditioner, natural ventilation, sunlight filter, benches for the placement of the samples, a drip water irrigation system, water tanks, power supply, and a controller.

Crop Management. *Capsicum Frutescens* pepper variety found in the region was used as biological material in the study. There are 3 plots in each greenhouse. In order to ensure an even irrigation distribution in the greenhouse, the drip irrigation method (4 $L \cdot h^{-1}$) was used, and it was planted at 30 cm intervals, with one seedling per dripper. The greenhouse soil properties are given in Table 1.

Table 1

Properties of the soil used in the experiment

Property	Value
pH (1/2.5 Soil/Water)	7.8
EC (1/2.5 Soil/Water)	0.28 $ds \cdot m^{-1}$
Organic Mater (%)	0.8
CaCO3 (%)	5
Texture	Sandy Clayey Loamy
CEC (me/100 g)	66

Irrigation of pepper seedlings planted in the greenhouse was carried out by giving equal amounts of water to all seedlings. Irrigation was continued until the soil reached a sufficient moisture level (field capacity) in each irrigation. From the date the seedlings were planted in the trial greenhouses until the end of harvest, the plant green parts were measured and recorded weekly.

Experimental Design. In the study, 9 different treatments including different doses of organic and inorganic fertilizers were applied. Vermicompost (VC; Berdoka Soil VC fertilizer, provided by a private company) was used as organic fertilizer and doses of 2500 and 5000 kg per hectare were applied. In addition, 30-50-80 and 60-100-160 $kg \cdot ha^{-1}$ of N-P_2O_5-K_2O were applied from chemical fertilizers. VC was placed 5 cm below the soil and mixed with the soil before planting. Inorganic fertilizers were applied by irrigation. Fertilizer application rates are provided in Table 2.

Table 2

Organic and inorganic fertilizer use levels applied in the research

Application topics	Fertilizer amounts, $kg \cdot ha^{-1}$	Application topics	Fertilizer amounts, $kg \cdot ha^{-1}$
T_1	0	T_6	30-50-80 + 2500
T_2	2500 VC	T_7	30-50-80 + 5000
T_3	5000 VC	T_8	60-100-160 + 2500
T_4	30-50-80	T_9	60-100-160 + 5000
T_5	60-100-160	-	-

Plant Analysis Procedures. The seedlings were planted in thegreenhouses on 06.04.2022. Harvests were done 11 times until the end of the growing period and post-harvest weights were measured and recorded with a precision scale. The first harvest was carried out on 03.06.2022 and the last harvest was carried out on 08.08.2022. Plant diameter and height values measured at the end of harvest were taken into consideration in the study. Pepper rows with a total of 9 application subjects were created in our greenhouses and 30 pepper seedlings were planted in each row. Due to the edge effect, 3 plants at the beginning and end of each row were not taken into consideration. From the remaining 24 plants, 8 pepper plants were selected and replicates were created, and statistical analyzes were performed. Application groups were determined by comparing the important parameters in the variance analysis results of the data obtained from the trial subjects with the Student's t test. A Minolta SPAD 502 instrument (Spectrum Authorized Dealer, chlorophyll meter) was used to determine the colour intensity of the leaves. A total of 5 plants from each row, 5 leaf samples from each plant, were selected from the same parts of each row. SPAD measurements were carried out at the end of June.

Results and discussion

In our study, each application was tried to be evaluated by taking into account the control group values obtained after harvest. When we examined our findings regarding the pepper plant stem diameter, it was determined that the highest value was in T_3 and the lowest value was in T_8 (Figure 1). In addition to T_3 application where the highest level was achieved, our second highest value was realized in the VC+ inorganic (T_9) fertilizer mixture. Diameter values of T_3 application were statistically significant (p<0.01), except T_9 and T_7 applications. Ulug [11] in his study on onion plants stated that the highest plant height value was obtained in VC. Researchers state that VC applications accelerate the development of plants and positively affect the yield [12-16]. Therefore, we can say that the values we obtained regarding the yield, plant height and stem diameter of the pepper plant are supported by these studies.

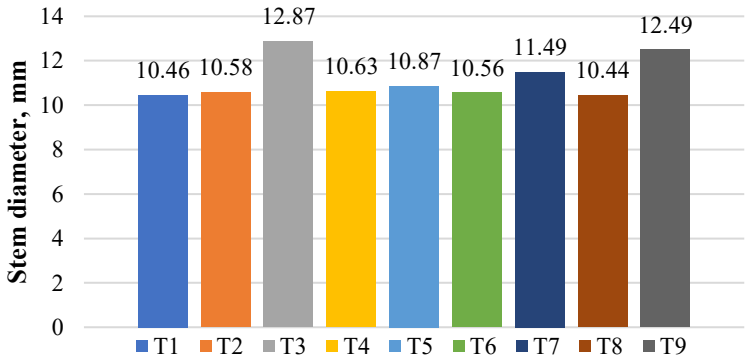

Fig. 1. **Stem diameter of pepper plants according to subjects**

When the height values of pepper plants were examined, it was determined that the highest value was in T_3 and the lowest plant height value was in T_5 (Figure 2). In addition to T_3, where the highest level was achieved, it was also determined that T_6, which is the VC + inorganic application, had the second highest value. The results of the height values of the T_3 subject were found to be statistically significant (p<0.01) from other applications except for the T_6, T_7 and T_9 subjects, and were found to be statistically insignificant (p>0.01) from the T_6, T_7 and T_9 values. In their study, Alaboz et al. [17] determined that the plant heights of different VC level applications in pepper plants were higher than the control group. In his study, Akça [14] determined that the application of VC and humic acid to the soil caused significant increases in the plant height, and the highest increase was determined in the V3 application. In our study, it was determined that applications with T_3 and T_6 subjects had the highest plant heights.

SPAD values of pepper plants were also examined in the study (Figure 3). It was determined that the highest value was in T_9. Again, it was determined that T_2 and T_3 subjects, where only VC was applied, were higher than the SPAD values of the control group. Applications in which the SPAD values were lower than the control group were determined only in T_4 and T_5 applications. The results of the

SPAD values of the T_9 application were found to be statistically significant in all applications ($p<0.01$). Mujdeci et al. [18] stated in their different soil water matrix studies that the SPAD values vary depending on the applications. In their study, they stated that plants increased their chlorophyll content to protect themselves from photodamage under water stress. They also stated that the SPAD values decreased in all applications as a result of the aging of the plants. Alaboz et al. [17] stated that the SPAD values of various VC applications in pepper plants changed but were not statistically significant.

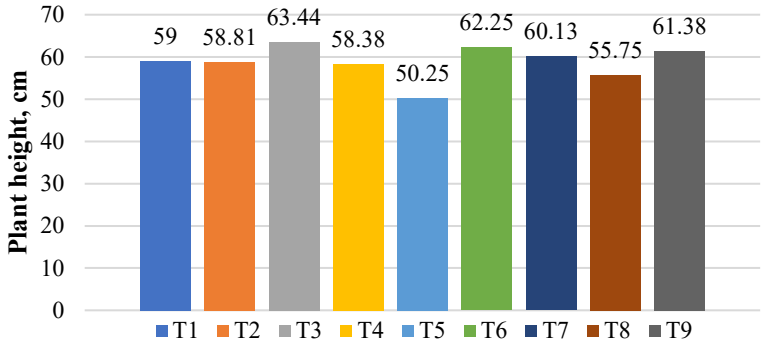

Fig. 2. **Height of pepper plants by subject**

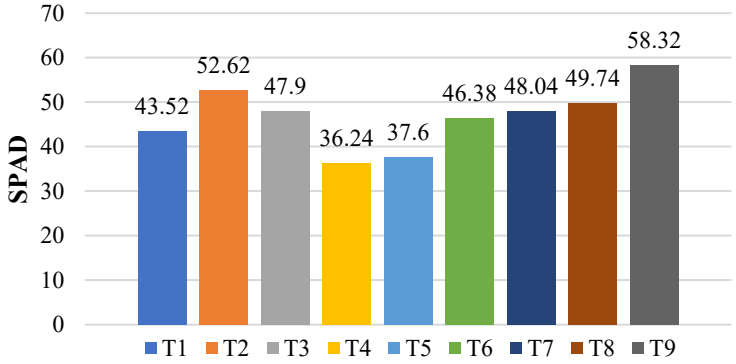

Fig. 3. **SPAD values of pepper plants according to subjects**

As seen in Figure 4, the control group and other applications were evaluated. Accordingly, we can say that VC application and VC + inorganic fertilizer ration increase the yield at right rate. We can say that T_3 application has a yield increase of more than 53% compared to the control group that received no fertilizer.

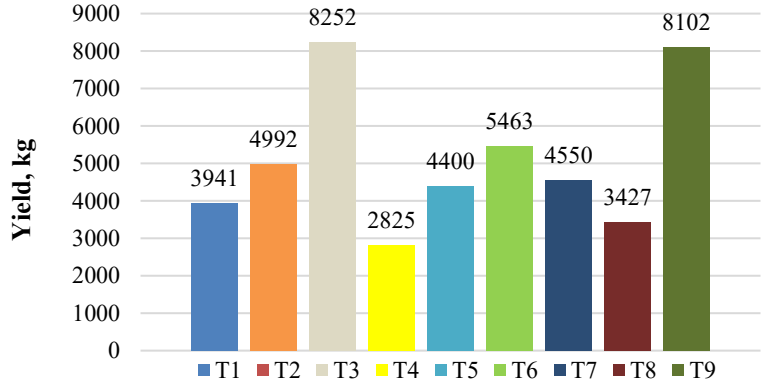

Fig. 4. **Yield values of pepper plants according to subjects (kg·ha^{-1})**

The highest yield was obtained from T_3 application, followed by T_9 application. In terms of the yield values, T_6 and T_2, T_7 and T_5, and T_1 and T_8 applications were in the same group among themselves. The lowest yield value was obtained from T_4 application ($p<0.01$). Küçükyumuk et al. [12] stated that VC application increased the pepper yield and plant growth rate. Kızılkaya et al. [19] stated that VC

application positively affected the yield of wheat. Aminifard and Bayat [20] in their study on VC for pepper, determined that the highest yield was by application of 5000 kg per hectare. We can say that these results coincide with the values we found. It was determined that similar results were found in other studies conducted with VC application [13; 14; 21].

Conclusions

1. In the study, it was determined that the mixtures containing only VC and VC + inorganic fertilizer levels positively affected the development parameters of the pepper plant.
2. In particular, it was determined that the plant growth parameters and efficiency of 5000 kg VC (T3) and 5000+60-100-160 (T9) mixed fertilizer application per hectare were higher than other applications.
3. The increased use of organic material vermicompost in crop production like hot pepper can decrease inorganic fertilizer application. Reducing inorganic fertilizer application is important for human and environmental health and safety.
4. Therefore, good agricultural practices can be increased by focusing on the use of organic fertilizers.

Acknowledgements

We would like to thank Berdoka Company and company officials for providing us with the vermicompost we used as material in our study.

Author contributions

Conceptualization, A.A.; methodology, A.A. E.J and A.J; software, B.S.; validation, A.A. and F.A; formal analysis, A.A and F.A.; investigation, A.A., B.S, and J.K..; data curation, A.A., J.K. an B.S; writing-original draft preparation, A.A., J.K, and F.A .; writing-review and editing, A.A. visualization, E.J. J.K. and A.J.; project administration, F.A.; All authors have read and agreed to the published version of the manuscript.

References

[1] Turhan Ş., Sustainability in Agriculture and Organic Farming. Journal of Agricultural Economics vol. 11(1), 2005, pp. 13-24.
[2] Demiryürek K. The Concept of Organic Agriculture and Current Status of in the World and Turkey. GOÜ Journal of Agriculture Faculty, vol. 28(1), 2011, pp. 27-36.
[3] Chanda G.K., Bhunia G., Chakraborty S.K., Journal of Horticulture and Forestry vol. 3(2), February 2011, pp. 42-45.
[4] Arancon N. Edwards C.A., Effects of vermicomposts on plant growth. Paper presented during the International Symposium Workshop on Vermi Technologies for Developing Countries (ISWVT 2005), Los Banos, Philippines, 2005, November pp. 16-18.
[5] Wang C., Zheng D.M. Sun Z.J., A review for antibacterial immunity of the earthworm, Chinese Journal of Applied Ecology, vol. 17(03), 2006, pp. 525-529.
[6] Edwards C.A., Historical overview of vermicomposting. Biocycle vol. 36(6), 1995, pp. 56-58.
[7] Arancon, N.Q., Edwards, C.A., Lee, S. and Byrne, R., Effects of humic acids from vermicomposts on plant growth. European Journal of Soil Biology, vol. 42, 2006, pp. 65-69.
[8] Mavi K., Mavi F., Maternal plant characteristics and emergence performance of some ornamental pepper genotypes, DUFED 4(1), 2015, pp. 31-35.
[9] Güvenç İ. The Production, Foreign Trade and Comparative Advantages of Peppers in Turkey. KSU J. Agric Nat vol. 23 (2), 2019, pp.441-445. DOI: 10.18016/ ksutarimdoga.vi.595512.
[10] Hortiturkey "Dünya Biber Üretimi 36 Milyon Tonu Aştı". [online] [16.04.2024]. Available at: https://www.hortiturkey.com/yazilar/dunya-biber-uretimi-36-milyon-tonu-asti
[11] Ulug Z., The Effects of The Use of Vermicompost and Mycorrhiza on Plant Development and Yield of Beans and Onion, Inönü University Graduate School of Natural and Applied Sciences Department of Horticulture, Master Thesis, 2018.
[12] Kücükyumuk Z. Gultekin M., Erdal I., Effects of Vermicompost and Mycorrhiza on Plant Growth and Mineral Nutrition in Pepper, SDU Journal of Agriculture Faculty, vol. 9(1) 2014, pp. 51-58.

[13] Şahin S., Geboloğlu N., Kartal H., Effects of Adding Vermicompost to the Tort-Perlite Mixture on The Development of Pepper Seedlings, TURJAF, vol. 8(sp1), 2020, pp. 192-196
[14] Akça S., Effect of Vermicompost and Humic Acid Applications on Soil Biological Properties and Wheat Yield, Ondokuz Mayis University, Institute of Graduate Studies, Department of Soil Science and Plant Nutrition Master's thesis, 2021.
[15] Nagavallemma K. P., Wani S. P., Lacroix S., Padmaja V. V., Vineela C., Rao M. B., Sahrawat K. L., Vermicomposting: Recycling wastes into valuable organic fertilizer. Global Theme on Agroecosystems Report no. 8, 2004. International Crop Research Institute for semi-arid tropics, Patancheru 502324, Andhra Pradesh, India.
[16] Yaviç Ş., Demir S., Boyno G., Determination of Effects of Worm Manure (Vermicompost) Application to Root Rot Disease Caused by Sclerotinia sclerotiorum (Lib.) de Bary on Tomato (Lycopersicon esculentum) YYU Journal of the Institute of Natural and Applied Sciences, volume 25(1) (April), 2020, pp. 13-20.
[17] Alaboz P., Işildar A.A., Müjdeci M., Şenol H., Effects of Different Vermicompost and Soil Moisture Levels on Pepper (Capsicum annuum) Grown and Some Soil Properties, YYU J AGR SCI vol. 27(1), 2017, pp. 30-36.
[18] Mujdeci M., Senol H., Cakmakci T., Celikok P., The Effect of Different Soil Water Matric Suctions on Stomatal Resistance. Journal of food, Agriculture & Environment Volume 9 (3&4) 2011, pp. 1027-1029.
[19] Kızılkaya R., Hepsen Turkay F.S., Turkmen C. Durmus M. Vermicompost effects on wheat yield and nutrient contents in soil and plant. Archives of Agronomy and Soil Science vol. 58(S1), 2012, pp. 175-179.
[20] Aminifard M.H., Bayat H., International Journal of Horticultural Science and Technology Vol. 3, No. 2, December 2016, pp 221-229.
[21] Huerta E., Vidal O., Jarquin A., Geissen V., Gomez R., Effect of Vermicompost on the Growth and Production of Amashito Pepper, Interactions with Earthworms and Rhizobacteria, Compost Science & Utilization, vol. 18(4), 2010, pp. 282-288.