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The Effect of Vermicompost Enriched with *Ulva Lactuca* on Germination of Cucumber Seeds

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Abstract

Vermicompost was obtained from farmyard manure compost enriched with sea lettuce (*Ulva lactuca*), which grows naturally on the Ordu coast, and its effects on the germination of cucumber seeds were investigated. The seaweeds collected from the sea and dried and composted in the natural environment together in 5 different groups with cattle manure after grinding. *Eisenia fetida*, known as Red California Worm, was used as worm species.The composts obtained were fed to earthworms according to different dose ratios. These dose ratios were determined as G1 group 9000 gr 100 % Ç.G (farm manure), G2 group 8100 gr Ç.G + 900 gr U.L (*Ulva lactuca*), G3 group 7200 gr Ç.G + 1800 gr U.L, G4 group 6300 gr Ç.G + 2700 gr U.L. and G5 group 5400 gr Ç.G + 3600 gr. U.L. The vermicompost was applied directly to the soil. The experiment was designed according to the randomised plots experimental design with one control and three replicates. The experiment was carried out with local *Cucumis sativus* (cucumber) seeds in plastic containers in open field. Including the control group, 15 saddles were used. Sowing was done by hand at a depth of 5-6 cm with 7 seeds/saddle. The 6-day development process of the seeds was observed and germination rates were analysed. At the end of the study, significant differences were found between the groups.

Keywords: Vermicompost, *Ulva lactuca*, *Cucumis sativus*, *Eisenia fetida*, Germination.

Salatalık Tohumunun Çimlenmesinde *Ulva Lactuca* İle Zenginleştirilmiş Solucan Gübresinin Etkisi

Öz

Ordu sahillerinde doğal olarak yetişen ve deniz marulu (*Ulva lactuca*) ile zenginleştirilmiş çiftlik gübresi kompostundan solucan gübresi (vermikompost) elde edilmiştir ve salatalık tohumlarının çimlenmesi üzerindeki etkileri araştırılmıştır. Denizden toplanıp kurutulan yosunlar kıyılma işleminden sonra sığır gübresi ile birlikte 5 farklı grup olacak şekilde doğal ortamda kompostlaştırılmıştır. Solucan türü olarak Kırmızı Kaliforniya Solucanı olarak bilinen *Eisenia fetida* kullanılmıştır. Elde edilen kompostlar belirlenen farklı doz oranlarına göre solucanlara mama olarak verilmiştir. Bu doz oranları G1 grubu 9000 gr % 100 Ç.G (çiftlik gübresi), G2 grubu 8100 gr Ç.G + 900 gr U.L (*Ulva lactuca*), G3 grubu 7200 gr Ç.G + 1800 gr U.L, G4 grubu 6300 gr Ç.G + 2700 gr U.L. ve G5 grubu 5400 gr Ç.G + 3600 gr. U.L. olarak belirlenmiştir. Oluşan vermikompost doğrudan toprağa uygulanmıştır. Tesadüf parselleri deneme düzenine göre tek kontrollü ve üçer tekerrürlü olarak tasarlanmıştır. Deneme, yerli salatalık tohumu ile açık alanda plastik deneme selelerinde yürütülmüştür. Kontrol grubu dahil 15 adet sele kullanılmıştır. Ekim elle 5-6 cm derinliğe 7 tohum/sele gelecek şekilde yapılmıştır. Tohumların 6 günlük gelişim süreci gözlemlenmiş ve çimlenme oranları incelenmiştir. Çalışma sonunda gruplar arasında önemli farklılıklar bulunmuştur.

Anahtar Kelimeler: Vermikompost, *Ulva lactuca*, *Cucumis sativus*, *Eisenia fetida*, Çimlenme.

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1. Introduction

The intense use of pesticides and chemical fertilisers in the agricultural area has globally destroyed soil fertility, killed beneficial microorganisms and also decreased natural resistance in crops, thereby making them more vulnerable to pathogens besides affecting human health and the environment. To overcome these problems, it is crucial to turn to environmentally friendly alternatives such as vermicompost, which can not only increase crop growth and yields, but also protect human health and the environment (Yatoo et al., 2021).

Vermicompost is a rich humus-like substance obtained by using earthworms for composting organic waste. The earthworms are popularly known as "the farmer's friend" or "nature's plowman". Earthworm microbial flora impresses the physical and chemical properties of the soil. Earthworms contribute to microbial decomposition by breaking down large soil particles and leaf litter to increase the availability of organic matter. However, its convert organic waste into usable vermicompost by grinding and digesting it with the help of aerobic and anaerobic organisms (Maboeta and Van Rensburg 2003). Vermicompost is generally physically, biochemically and nutritionally better than conventional compost. Therefore vermicompost can obtain a higher degree of humification and enhance the mineralization rate of organic matter (Lim et al., 2015).

Vermicomposting has emerged as a sustainable option with the two benefits of converting plant available nutrients into much more soluble forms and simultaneously reducing the bioavailable heavy metal content (Bhunia et al., 2021). However, vermicompost provides many benefits to agricultural soil, including increased moisture retention, better nutrient holding capacity, better soil structure and higher levels of microbial activity (Sallaku et al., 2009).

Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, which have a positive effect on plant nutrition, photosynthesis, chlorophyll content of the leaf and improve the nutrient content of different plant components (Theunissen et al., 2010). Vermicompost increases soil biodiversity by promoting beneficial microbes that enhance plant growth directly by producing plant growth-regulating hormones and enzymes and indirectly by controlling plant pathogens, nematodes and other pests, thereby improving plant health and minimising yield loss (Pathma and Sakthivel 2012).

This study focuses on the effects of vermicompost formed by feeding different combinations of *Ulva lactuca* and cattle manure to earthworms on the germination of cucumber seeds.

2. Materials and Methods

In the summer of 2020 (May-August), *Ulva lactuca* was collected by hand from the Perşembe coast of Ordu province in the middle of Black Sea. They were first washed with sea water and then completely cleaned from sea water, epiphytes, sediment and other organic residues with tap water (Sivasankari et al., 2006). The cleaned sea lettuce was kept in a shaded area for a week for drying. The dried *Ulva lactuca* were shredded using a 0.5 cm to 1 cm grinding tool. Dried and ground *Ulva lactuca* were fermented with farm manure at different dose rates under natural conditions. Manure obtained from a barn where a cattle breeding was carried out in a village in Giresun province was used as farm manure. After these steps, food mixtures were prepared for earthworms at the ratios given in the Table 1.

Table 1. Combination rates of earthworm food groups

G1	9000 gr % 100 F.M.
G2	8100 gr F.M. + 900 gr U.L
G3	7200 gr F.M. + 1800 gr U.L.
G4	6300 gr F.M. + 2700 gr U.L.
G5	5400 gr F.M. + 3600 gr. U.L.

F.M.: Farm manure (cattle)
U.L.: *Ulva lactuca*

Foods with different combination ratios and the same total weights were placed in plastic containers for composting. In order to shorten the composting process of the food, the plastic containers were covered with stretch films to allow air to enter. The food was checked for temperature and humidity by opening the cling films once a week. When the food was uncovered, water droplets were observed on the stretch films and it was understood that the food warmed up as a result of the activation of the bacteria in the food and the fermentation activities progressed positively. However, every week, sufficient amount of water was added to the groups with low moisture and mixed. Thus, the optimum moisture content of the foods was balanced (Tchobanoglous et al., 1993). The composting process started in June 2021 and ended in December 2021. After the groups were prepared, 200 g samples were taken from each group and some analyses of the food were made. Some physical and chemical analyzes of the food used in the experiment are given in the Table 2.

Table 2. Some physical and chemical analyzes of the food used in the trial

Parameters	G1	G2	G3	G4	G5
Organic matter (%)	**69±5.19[b]**	63.33 ±4.33 [ab]	52±2.89 [a]	55±2.31 [ab]	**51±1.73 [a]**
Total humic+fulvic acid (%)	**40.57±2.87[b]**	35.96±0.96[b]	25.69±0.75[a]	24.67±0.74[a]	**22.1±0.89[a]**
Water soluble K2O (%)	2.18±0.07[a]	**1.88±0.1[a]**	2.18±0.11 [a]	**2.33±0.25 [a]**	2.16±0.11 [a]
Total Nitrogen (%)	1.85±0.16 [a]	**3.25±0.15 [a]**	1.51±0.04 [a]	2.88±0.14 [a]	**1.4±0.06 [a]**
Moisture (%)	11.19±0.61[a]	**9.28±0.48[a]**	10.35±0.48[a]	**11.57±0.56[a]**	10.27±0.68[a]
Mg (ppm)	**33.36±0.12[a]**	79.59±0.66 [a]	86.26±0.47 [a]	78.47±0.41[a]	**88.59±0.59 [a]**
Ca (ppm)	**295.73±1.07 [a]**	388.5±1.61 [c]	**479.1±2.97[e]**	318.93±1.09 [b]	403.53±0.32 [d]
Na (ppm)	**58.0±0.22[a]**	84.06±0.45 [b]	**116.5±1.23[d]**	83.32±0.5[b]	107.2±0.2 [c]
P (ppm)	167.03±27.61 [ab]	253.97±33.33 [bc]	**114.53±10.07 [a]**	**310.9±17.74 [c]**	286.87±30.92 [c]
K (ppm)	138.93±0.75 [a]	159.57±4.71[b]	**185.33±4.45[c]**	**131.1±0.23 [a]**	164.1±0.1 [b]
Mn (ppm)	**1.14±0.01[a]**	1.59±0.01[a]	**2.11±0.01[a]**	1.64±0[b]	2.03±0.01[a]
Fe (ppm)	**46.28±0.14[a]**	82.2±0.33 [a]	**110.7±0.68 [a]**	82.66±0.29 [a]	108.9±0.36 [a]
Cu (ppb)	**342.33±1.99[a]**	276.1±5.45 [a]	320.83±4.18 [a]	**220.83±5.86 [a]**	341.30±5.11 [a]
Zn (ppb)	**1102.67±9.53[e]**	750.93±8.56 [d]	687.53±17.65 [c]	**313.40±8.46 [a]**	571.07±11.46 [b]
Pb (ppb)	**10.17±0.17 [a]**	14.02±0.12 [a]	21.64±0.42 [a]	14.77±0.33[a]	**30.43±0.24 [a]**

*There is no statistical difference between the groups indicated with the same letter.

Red California earthworm, *Eisenia fetida* species, was used in the vermicomposting process. 1500 g of food was allocated for each group and 15 experimental groups were formed as three replicates of 500 g each. The temperature of the compost for earthworms was balanced between 15-25°C (Rostami et al., 2009). Before introducing earthworms into the system, the prepared medium was allowed to stand for a few days to establish the appropriate temperature and humidity. Then, 100 earthworms with an average weight of 31.84±1.54 g were separated one by one and each group was transferred to a food container. As a result of calculating the average weight and number of worms (100 worms=30.8 g, 100 worms=34.1 g, 100 worms=30.6 g, 100 worms=32.8 g, 100 worms=30.9 g), the average weight of one worm was found to be 0.31 g. Temperature, pH and humidity were checked every two days until the worms consumed the food. To prevent the worms from escaping, the test containers were covered with a fine-mesh gauze. It was observed that the worms consumed the food in 10-12 days. After this stage, the worms were separated from the vermicompost obtained and the vermicompost to be used in the biodetection was dried and sieved. Samples were taken from the obtained vermicompost groups and some physical and chemical analyzes were performed.

Soil material was obtained from a garden in Kayabaşı neighborhood of Altınordu district of Ordu province. Some physical and chemical analyzes of the soil used in the experiment are given in Table 3.

Table 3. Some physical and chemical analysis results of the soil used in the experiment

Analyzes	Soil
Organic Matter (%)	6.67
Total Nitrogen (%)	0.22
Total Humic+Fulvic Acid (%)	7.19
Water Soluble Potassium Oxide (%)	0.01
Moisture (%)	7.6
Na (ppm)	109.1
Mg (ppm)	4.35
P (ppm)	202.53
K (ppm)	129.53
Ca (ppm)	335.5
Mn (ppm)	3,46
Fe (ppm)	266
Cu (ppb)	563.2
Zn (ppb)	151.7
Pb (ppb)	2344

Local cucumber (*Cumumis sativus*) seeds were used as bioassay material. The experiment was carried out in open field in plastic saddles with a single control group in three replications according to the coincidence plots experimental design (Yurtsever, 1984). Including the control group, 15 saddles were used. Different doses obtained for each experimental group. The vermicomposts were transferred to the saddles filled with soil. After the vermicomposts were mixed with the experimental soil, sowing was done manually at a depth of 5-6 cm with 7 seeds/saddle. No other vermicompost application was applied to the groups during the study. The first germinations started on the fifth day after sowing. 13 days after sowing, the arrangement was made so that 3 seedlings remained in each saddles and other conditions except fertilization were equalised. The first germination time of cucumber was analysed during the research.

The parameters and analysis methods analyzed from the food, vermicompost and soil materials used in the experiment are given in the Table 4.

Table 4. Soil, food and vermicompost analysis and applied methods

Analyses	Method Applied
Total Nitrogen (%)	1965 Bremner
Water Soluble Potassium Oxide (%)	GPGDY Annex -3 Article 4.1 EN 15477, ICP/AAS
Organic Matter (%)	70 ^{0}C Until Constant Weight -550 ^{0}C Dry Incineration
Moisture (%)	70 ^{0}C Until Constant Weight
Total Humic+Fulvic Acid (%)	TSE 5869 ISO 5073
Na (ppm), Mg (ppm), P (ppm), K (ppm), Ca (ppm), Mn (ppm), Fe (ppm), Cu (ppb), Zn (ppb), Pb (ppb)	ICP/MS

In this study, food, soil, vermicompost and germination data were used. Firstly, descriptive statistics and distribution of the data were examined. Afterwards, it was examined whether there was a significant difference in the averages between the groups. The hypotheses were tested using parametric tests (ANOVA) for normally distributed data and non-parametric (KRUSKAL-WALLIS) test for non-normally distributed data. After it was found that there was a significant difference between the groups, PostHoc and Mann Whitney tests were used to analyze which groups these differences were between. All statistical analyses were performed with the help of SPSS 23 package program.

3. Findings and Discussion

In our study, sea lettuce (*Ulva lactuca*) and farmyard manure were used as the source of vermicompost at different dose ratios and five experimental groups with different food contents were formed from them. The effect of the obtained vermicomposts on the germination and development of cucumber seeds was investigated. According to the results, germination started on the fifth day after sowing. When Table 5 is examined, it is seen that on the first day of germination, the highest germination rate was in the G5 (5400 g farm manure + 3600 g *Ulva lactuca*) group with 95.2% and the lowest was in the G1 (9000 g 100% farm manure) group with 33.3%. From the first day of germination to the fourth day, the lowest rate was 80.9 % in G1 and G3 groups and the highest rate was 100 % in G5 group. On the sixth and last day, it was observed that all of the seeds germinated in all groups. Higher germination rates were obtained from vermicompost applications obtained from *Ulva lactuca* and farm manure compost compared to the control, and it was determined that vermicompost had a positive effect on germination. When Table 5 is analysed as a result of the research, it is seen that germination occurs faster as *Ulva lactuca* content increases. It is thought that the microorganisms in *Ulva lactuca* content increase the usefulness of plant nutrients or break down the organic matter and make it ready for the use of the plant. However, the slow germination rate observed in the G3 group compared to G2 is thought to be a developmental retardation due to environmental conditions. In addition, while germination in G2 group was 95.2% on the second day, it was observed that germination stopped until the sixth day. Seed germination characteristics are affected by many factors such as nutritional status of the seed mother plant, pathogens during and after harvesting period, mechanical damages during harvesting as well as other factors such as fertilisation, irrigation, pesticide application, determination of seed harvest maturity (Kaya, 2008). Due to their different characteristics, marine algae have become the centre of interest of many researches (Türkmen and Kütük, 2017; Dyo et al., 2018; Türkmen and Su, 2019; Lauritano et al., 2020; Riccio and Lauritano 2020; Rosales-Mendoza et al., 2020; Silva et al., 2020; Türkmen and Akyurt, 2021; Türkmen and Duran, 2021; Türkmen and Aydın, 2021).

Table 5. Germination rates according to groups five days after sowing (%)

Groups	5th day	6th day	7th day	8th day	9th day	10th day
G1	33.3±12.6	47.6±12.6	61.9±12.6	80.9±9.52	95.2±4.76	100±0
G2	61.9±12.7	95.2±4.76	95.2±4.76	95.2±4.76	95.2±4.76	100±0
G3	33.3±4.76	52.3±12.6	71.4±8.25	80.9±9.52	90.5±9.52	100±0
G4	38.1±25.2	61.9±20.6	90.5±9.52	90.5±9.52	95.2±4.76	100±0
G5	95.2±4.76	95.2±4.76	95.2±9.52	95.2±4.76	100±0	100±0

Similar to the results of this study, previous studies used vermicompost on germination. Among these, stimulated seed germination in various plant species such as mung beans (Karmegam et al. 1999), tomato plants (Atiyeh et al. 2000b; Zaller 2007), petunia (Arancon et al. 2008) and pine trees (Lazcano et al., 2010a) are among the positive effects of vermicompost. In their study, Dizikısa et al. (2022) observed that vermicompost application was very effective in germination of maize seed. Ananthalli et al. (2019) reported that combinations of seaweed and cow dung are very suitable for converting into nutrient-rich vermicompost. Göksu and Kuzucu (2017) investigated the effect of control group, 300 and 600 kg/da applications on the germination rate and germination power of watermelon seeds in the research conducted with different dose rates of vermicompost, and found the lowest germination power in the control group with 85.0% and the highest germination power in 300 kg/da applications with 93.3%. In another study, lettuce, pea, wheat, tomato, cabbage and radish plants and ornamental plants were first germinated in small pots containing vermicompost obtained from animal wastes, and then they were surprised (Edwards et al. 1988). In both studies, it was reported that the germination rate and seedling growth were better in mixtures containing vermicompost. In another study, Mathivanan et al. (2012) found that the vermicompost used in planting peanut seeds in their experiment increased the germination rate compared to the control, and these results are in harmony with the findings obtained in this study.

Some physical and chemical analyzes result of the vermicompost used in the experiment are given in Table 6. When the vermicompost analysis was analyzed, the highest organic matter content was in the G4 group with 58%. When we look at the germination rates, the highest germination rate on the first day was in the G5 group. In the G4 group, germination increased rapidly after the second day. When this situation is analyzed, it is seen that there is a high amount of organic matter content in the environment for germination of cucumber seeds in G4 and G5 groups (Table 6). It was determined that the difference between the groups in terms of organic matter content was not statistically significant ($p>0.05$). According to another study, it was determined that the application of organic materials in the form of compost to the soil positively regulated the physical properties of the soil and increased the nutrient availability and values (Alagöz et al., 2006). The highest total humic+fulvic acid content was found in the G4 group with 31.33% and the lowest was found in the G5 group with 17.97%. The difference between the groups in terms of total humic+fulvic acid content was statistically significant ($p<0.05$). The highest water soluble K_2O content was found in the G4 group with 0.96% and the lowest was found in the G1 group with 0.78%. The difference between the groups in terms of water soluble K_2O content was not statistically significant ($p>0.05$). The highest amount of total nitrogen was found in G4 group with 2.32% and the lowest amount was found in G1 group with 1.62%. Vermicompost application added higher amount of N to the soils than the control (G1) group. As the amount of *Ulva lactuca* in different doses of vermicompost increased, the total nitrogen content increased significantly in general. Statistical analysis of the data obtained in terms of % total nitrogen (N) content showed that there was no statistically significant difference between the groups ($p>0.05$). In a study conducted by Cortez et al. (2000), radioactive N and decomposing organic matter were applied to the soil and in the experiment conducted, it was determined that the amount of nitrogen released in the environment with vermicompost application was higher than the application environment without vermicompost. The highest moisture content was found in the G2 group with 66.14% and the lowest was found in the G1 group with 61.63%. The difference between the groups in terms of moisture content was statistically significant ($p<0.05$). The highest amount of Mg was found in the G1 group with 13.87 ppm and the lowest amount was found in the G5 group with 11.87. The difference between the groups in terms of Mg content was not statistically significant ($p>0.05$). The highest amount of Ca was found in the G3 group with 121.73 ppm and the lowest amount was found in the G2 group with 95.82 ppm. The difference between the groups in terms of Ca content was not statistically significant ($p>0.05$). According to a study, it was determined that increasing doses of vermicompost application gave better results in the uptake of Ca, Cu and Zn elements into the structure of lettuce plants (Hınıslı, 2014). The lowest Na content was found in the

G3 group with 38.12 ppm and in the G1 group with 8.3 ppm. The difference between the groups in terms of Na content was not statistically significant ($p>0.05$). The highest amount of P was found in the G4 group with 464.83 ppm and the lowest amount was found in the G5 group with 379.80 ppm. The difference between the groups in terms of P content was not statistically significant ($p>0.05$). In a study, it was reported that 97% of the plant nutrients in vermicompost, especially phosphorus, are in a form that can be taken up directly by the plant during growth (Barley 1961). It was also determined from similar studies that vermicomposts increased the P contents of soils and the P contents of soils increased significantly compared to the control depending on the increase in fertilizer dose and the highest increase was obtained from 600 kg da-1 fertilizer application of vermicompost (Lazcano et al, 2008). The highest K content was in the G3 group with 73.15 ppm and the lowest K content was in the G1 group with 10.94 ppm. The difference between the groups in terms of K content was not statistically significant ($p>0.05$). In a study conducted by Werner (1997), he investigated the availability of some macronutrients in the soil with the application of increasing doses of organic fertilizer to the soil and found that the amounts of some macronutrients such as N, P and K increased in the plant. The highest Mn content was found in G3 group with 0.4 ppm and the lowest was found in G1 group with 0.26 ppm. The difference between the groups in terms of Mn content was statistically significant ($p<0.05$). The highest Fe content was found in G2 group with 21.16 ppm and the lowest was found in G4 group with 11.32 ppm. The difference between the groups in terms of Fe content was not statistically significant ($p>0.05$). Adiloğlu et al. (2015) investigated the effect of increasing doses of vermicompost on the yield of salad plants. As a result, it was determined that there were significant increases in some micronutrient contents of the plant such as Fe and Mn. The highest Cu content was in G3 group with 435.97 ppb and the lowest was in G1 group with 62.7. The difference between the groups in terms of Cu content was not statistically significant ($p>0.05$). The highest Zn content was in the G3 group with 1530 ppb and the lowest 133.7 ppb in the G2 group. The difference between the groups in terms of Zn content was not statistically significant ($p>0.05$). In a study conducted by Sönmez and Özen (2019), the change in plant nutrient contents of soils depending on different incubation periods (0, 30 and 60 days) and vermicompost applications (0, 50, 100 and 200 kg da-1) was investigated and it was reported that the available Zn content of soils generally increased depending on the increasing vermicompost application dose. The highest Pb content was in the G3 group with 19.96 ppb and the lowest 0.57 ppb in the G1 group. The difference between the groups in terms of Pb content was not statistically significant ($p>0.05$). When the Pb contents in the initial soil and the soil at the end of the experiment were compared, it is thought that the application of vermicompost to the soil decreased the amount of Pb in the soil. The applied organic fertilisers and vermicompost improve the fertility and physical properties of the soil and facilitate the phytoremediation process (Jadia and Fluker, 2008). Hoehne et al. (2016) reported that the absorption of Pb was at the highest level in 25% vermicompost application in their study on black oat plant.

Table 6. Some physical and chemical analysis results of vermicompost used in the experiment

Parameters	G1	G2	G3	G4	G5
Organic matter (%)	53±1.73 [a]	57.99±4.85 [a]	57±1.05 [a]	**58±1.73** [a]	56±1.15 [a]
Total humic+fulvic acid (%)	20.54±1.15[ab]	24.65±0.56[c]	22.6±0.55[bc]	**31.33±0.97[d]**	**17.97±0.59[a]**
Water soluble K_2O (%)	**0.78±0.12[a]**	0.88±0.08 [a]	0.86±0.04 [a]	**0.96±0.04** [a]	0.94±0.05 [a]
Total Nitrogen (%)	**1.62±0.08** [a]	1.99±0.19 [a]	2.04±0.17 [a]	**2.32±0.16** [a]	1.79±0,.07 [a]
Nem (%)	**61.63±0.77[a]**	**66.14±1.13[b]**	65.94±1.18[ab]	65.67±1.03[ab]	63.51±0.49[ab]
Mg (ppm)	**13.87±0.07** [a]	12.63±0.1 [a]	13.59±2.52 [a]	13.71±0.23 [a]	**11.87±0.11** [a]
Ca (ppm)	97.69±0.32 [a]	**95.82±0.59** [a]	**121.73±0.7** [a]	97.9±0.65 [a]	112.67±1.13 [a]
Na (ppm)	**8.3±0.06** [a]	11.03±0.23 [a]	**38.12±0.65** [a]	14.28±0.55 [a]	12.23±0.2 [a]
P (ppm)	418.73±38.71 [a]	416.97±82.93 [a]	452.53±25.2 [a]	**464.83±58.85** [a]	**379.80±44.25** [a]
K (ppm)	**10.94±0.72** [a]	19.81±6.01 [a]	**73.15±1.1** [a]	22.9±0.18 [a]	23.6±1.89 [a]
Mn (ppm)	**0.26±0[a]**	0.3±0[b]	**0.4±0[e]**	0.34±0.01[d]	0.32±0[c]
Fe (ppm)	19.12±0.11[a]	**21.16±0.19** [a]	17.72±3.49 [a]	**11.33±3.5** [a]	20.1±0.25 [a]
Cu (ppb)	**62.7±5.04** [a]	38.37±1.71 [a]	**435.97±2.82** [a]	141.23±2.96 [a]	104.57±2.63 [a]
Zn (ppb)	183.13±14.98 [a]	**133.7±9.20** [a]	**1530.7±14.5** [a]	598.6±8.24 [a]	1187.7±17.15 [a]
Pb (ppb)	**0.57±0.3** [a]	1.27±0.35 [a]	**19.96±0.6** [a]	5.31±0.2 [a]	2.7±2.29 [a]

*There is no statistical difference between the groups indicated with the same letter.

4. Conclusions and Recommendations

The effects of vermicomposts obtained from different food combination groups on germination are clearly seen. When the vermicompost analysis results were analyzed in Tables 6, it was found that the total humic+fulvic acid, Ca, Na, P, Mn, Fe, Cu, Zn and Pb amounts in the experimental groups increased significantly compared to the analysis results of the worm food groups. When the G5 (5400 gr. F.M. + 3600 gr. U.L.) group with the best germination was analyzed, it was observed that the increased presence of *Ulva lactuca* in the worm food combination significantly promoted germination.

As a result, it has been concluded that seaweeds that grow spontaneously in the seas can be used as raw material of a quality product by preventing environmental pollution with vermicompost method and the product obtained can be commercially marketed and recycled to the economy. Our developing world needs a sustainable alternative that is both economical, productive and protects soil health and fertility. For a healthier world and a healthier society, ecological agriculture such as vermicomposting has become inevitable. The vermicomposting process improves soil ventilation and thus promotes the survival and distribution of beneficial bacteria in such systems. However, vermicomposting techniques are easy-to-apply methods that require very low costs. Especially thanks to the algae that grows spontaneously on our coasts, there is a high nutrient content and a very economical vermicompost production. In this way, our beaches will be cleaned and our soils will be improved with the vermicompost obtained. This article opens new areas for further research.

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Authors' Contributions

Contribution of the authors to the article should be indicated. (For example: All authors contributed equally to the study.)

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

This study was conducted in accordance with the " It is based on his PhD thesis titled "The Effect of Vermicompost Enriched with Sea Lettuce (Ulva Lactuca) on Vegetable Yield". (Doctoral dissertation, Giresun University / Institute of Science and Technology, Giresun, Turkey).

The authors declare that all the rules required to be followed within the scope of "Higher Education Institutions Scientific Research and Publication Ethics Directive" have been complied with in all processes of the article, that The Black Sea Journal of Science and the editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than The Black Sea Journal of Science.

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