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Seed Quality of Organically Fertilized Plant: A *Solanum Melongena* Study

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Abstract: This research was carried out to investigate the effectiveness of the use of organic fertilizers in order to improve the organic seed production process and to increase the seed quality needed in organic agriculture production. The experiment was established with organic fertilizers (farmyard manure-FYM, leonardite-L, vermicompost-VC) and eggplant plant 'Pala-49' variety and conducted for two years. As a result of the study; plant height (52,65-68,06 cm), plant diameter (51,85-61,20 cm), fruit height (14,67-21,90 cm), fruit diameter (4,73-6,73 cm), number of seeds (1344-2508 pcs/fruit), seed weight (4,79-9,38 g/fruit) and germination percentage (14,67-21,90%) varied between FYM, L and VC organic fertilizer applications. In general, it was determined that the first year gave better results. In terms of parameters, the best result in all parameters was obtained from FYM organic fertilizer application. In addition, the nutrient element contents of the seed samples were found to be statistically significant. Organic applications significantly increased the nutrient element content of the seed samples according to the control. Nitrogen content varied between 0.242% and 0.271%, and phosphorus content varied between 0.274% and 0.456%. The highest K content was determined in FYM application in both years (0.272% and 0.309%), while Fe, Zn and Mn contents were 35.1 mg kg^{-1}, 63.7 mg kg^{-1} and 200.7 mg kg^{-1} in VC application in the second year, respectively. The effect of the treatments on soil available nutrient content was also found to be significant. The amount of the soil available plant nutrients were higher in the second year.

Keywords: eggplant; organic fertilizer; plant nutrient elements; seed; soil

1. Introduction

The negative impacts of agricultural chemicals used by farmers and the consequent consumption of chemically grown food on public health are becoming more and more apparent all over the world.

In order to reduce the harm to humans and the environment caused by chemicals used in agricultural production in recent years, ecological agriculture and the use of ecological agricultural products have regained importance. Provision of a sustainable environment in the soil by amending with organic inputs can improve the quality and acceptability of crop [1]. Organic agriculture is not only a source of food production, but also effective in conserving biodiversity and reducing the impact of factors that cause erosion, desertification and climate change. All of these reasons direct researchers, producers and consumers to ecological agricultural inputs and ecological agricultural products.

Seed, which is an important input in agricultural production, has become a technological product in recent years. Moreover, since organic agriculture is a form of agriculture that does not involve the use of chemical fertilizers and pesticides, plant growth regulators and genetically modified organisms, the demand for organic seeds has been increasing day by day in recent years. Increased market demand for organic products has stimulated research interest in evaluating the effect of organic farming on the quantity and quality of nutrients in fruits, vegetables, and grains [2,3].

One of the most important inputs in organic vegetative production is seed, and the use of organic seed in production has become compulsory since 2001 [4]. However, since organic seed production in our country, as in many countries, is far below producer demand, the implementation of this compulsion is postponed to a later date every year. Organic seed production is at very low levels in our country [5]. Especially in species with long vegetation periods, the longer the plant is exposed to natural conditions, the more difficult it becomes to fight against diseases and pests, to ensure balanced nutrition and to maintain the sustainability of the soil structure. Such problems indicate that organic vegetable seed production is developing very slowly in the world and the number of species for which seed is available is very low [6].

Organic fertilizer sources have effects such as maintaining the sustainable fertility of the soil, the availability of soil organic matter and plant nutrients, and also reducing the effects of some insect pests and diseases. Therefore, the application of plant nutrients through organic sources like compost, farmyard manure and biofertilizers remain the alternative choice of the growers for maintaining its sustainable production [7]. Utilization of organic fertilizer is an alternative to overcome the problem of degradation of soil fertility as a result of the use of synthetic inorganic fertilizers were excessive and intensive [8].

Organic fertilizer applications significantly affect crop yield and quality [9]. In addition to excessive use of mineral fertilizers, decreasing organic matter contents threaten the quality elements of agricultural soils. Organic fertilization plays an important role in increasing yields not only in terms of providing nutrients but also by regulating the physical, chemical and biological properties of the soil and improving sustainable productivity parameters [10].

In many studies, it has been stated that compost, fermented manure and vermicompost can be preferred instead of mineral fertilizers. It has been reported that organic-based fertilizer applications increase soil respiration and enzyme values and thus soil microbial activities, improve soil fertility characteristics and increase dry matter and mineral nutrient contents of plants [11–17].

As a result of organic practices, increasing soil fertility, healthy growth of plants and obtaining quality products are seen as the primary goal. In this regard, there are many materials that can be used as fertilizers of organic origin and to improve soil properties. Barnyard manure is known as the most commonly used fertilizer. In recent years, it is seen that leonardite and FYM have potential in terms of soil and plant development and studies on this field have increased. It is an organic mixture containing high amounts of humic acid (HA) and fulvic acid (FA) [18]. Vermicompost is sourced from the feces of earthworms. Worms can eat vegetables, fruits, kitchen and industrial wastes. The celoma body fluid in the digestive system of the worms passes into the fertilizer and provides the development of immunity against pathogens in the plant. The micronutrient elements in organic waste can be easily taken up by plants as they are naturally chelated and excreted through the digestive system of earthworms. It is known that microorganisms, enzymes, and plant nutrients enrich the soil with organic matter thanks to the celoma fluid and have positive effects on its pH and biological structure [19–22].

Eggplant, whose homeland is India, is in the Solanum genus of the Solanaceae family and is botanically named as *Solanum melongena* L. The heat-loving eggplant plant is grown in commercial productions at temperatures between 15-35°C for a vegetation period of 6 months. [23]. Eggplant is rich in minerals (K, Mn, Fe and Ca), vitamins beneficial to human health and low in calories and is not only used as an edible vegetable, but also has many medicinal values. Eggplant plant helps to reduce cholesterol levels in the blood and regulates high blood pressure, making it suitable for diet and diabetic patients [24]. Although eggplant production and consumption is quite high in Turkey (817,591 tons in 2023), organic eggplant production and organic seed production remain quite limited. The lack of scientific studies, especially in organic seed production, and the fact that farmers have problems in obtaining organic seeds show that there is a deficit in this field. Therefore, the aim of this study was to determine the effects of FYM, L and VC organic fertilizers on seed yield and quality of 'Pala-49' type, which has a high production and consumption.

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2. Material and Method

'Pala-49' eggplant type was used as plant material in the study and it was carried out with organic methods by carrying out all necessary procedures on time. The organic parcel (Nilufer Municipality Urban Bostans, Urunlu village, Bursa) where the cultivation was carried out has organic certification and the climatic data of Bursa province are given in Table 1. The research was established according to the randomized plots experimental design. FYM, L and VC were applied as organic materials in the study. Generally recommended economical amounts for production were applied. The doses used were as FYM 2 kg m^{-2}, 0.5 kg m^{-2} L and 0.5 kg m^{-2} VC. The data were obtained by measuring fruit morphology and seed characteristics.

Table 1. Temperature, precipitation and proportional humidity values for 2020 and 2021 in Bursa/Nilüfer during the long years average and the study period.

Months	Old-Field Average			Year 2020			Year 2021		
	Temperature (°C)	Precipitation (mm)	Proportional Humidity (%)	Temperature (°C)	Precipitation (mm)	Proportional Humidity (%)	Temperature (°C)	Precipitation (mm)	Proportional Humidity (%)
May	17.43	44.30	62.17	17.50	93.70	68.80	18.60	14.50	67.10
June	22.57	36.30	57.74	21.70	40.50	67.90	20.90	61.70	73.00
July	24.85	17.28	56.12	24.80	1.30	64.10	25.50	32.80	66.10
August	24.56	13.70	57.37	24.70	1.50	62.00	25.90	0.10	60.60
Total	-	111.58	-	-	148.70	-	-	109.10	-
Average	22.35	-	58.35	22.18	-	65.70	22.73		66.70

2.1. Fruit Analysis

The characteristics and methods examined in the fruits harvested at the end of the development period were as follows. After harvesting, 50 fruits were randomly selected and 10 fruits of different sizes were randomly selected and weighed and expressed as fruit weight (g/fruit). All seeded fruits were measured with a ruler and the values were determined as fruit length (cm). After harvesting, the fruits with seeds were cut in the middle and measured with a ruler and the values were determined as fruit diameter (cm). Seeds from 10 randomly selected fruits were manually removed, weighed, and seed weight (g/fruit) was determined. After the seeds obtained from each fruit were weighed, they were counted manually and the average number of seeds per fruit was expressed as the number of seeds (piece). From the seeds of different treatments, 1000 seeds were counted in four replicates and weights were determinated.

2.2. Seed Analysis

The seeds taken right after the harvest were rinsed twice with tap water, rinsed thoroughly with pure water, dried at 65 ºC and ground to determine the content of some plant nutrient elements. Total nitrogen in seed samples was determined by the modified Kjeldahl method. The samples digested in a Buchi K-437 digestion block were distilled in a Buchi K-350 steam distillation device. Within the scope of the study, nutrient element concentrations determined in the solution obtained as a result of wet digestion were evaluated [25]. (Kacar & İnal, 2010). Samples were wet digested in a Berghof MWS 2 model microwave oven using HNO_3 and H_2O_2. Some macronutrient elements (P, K, Ca, Mg, Na) and micronutrient elements (Cu, Fe, Mn and Zn) in the extract were determined by Perkin Elmer OPTIMA 2100DV model ICP OES.

2.3. Soil Analysis

Samples were taken 0-30 cm from the parcels where the study was carried out before planting and after harvesting according to the principle of soil fertility, and some physical and chemical analyzes were performed and evaluated in the study. The sand, silt and clay fractions of the

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experimental area soil were determined by hydrometer method. Soil pH value was diluted 1:1 with pure water and determined with a pH meter model WTW 3110 [26]. EC value was diluted 1:1 with pure water and determined with a using a WTW LF 92 model EC meter also [27]. Lime content was determined by Scheibler calcimeter and organic matter content was determined by Walkley-Black method [28,29]. Total nitrogen content of the soils taken from the parcels was determined by Kjeldahl method. The samples incinerated in a Buchi K-437 incineration block were distilled in a Buchi K-350 steam distillation device [29]. Available phosphorus content was determined by the ascorbic acid method in the filtrate obtained by extraction with 0.5 M sodium bicarbonate (pH 8.5), available cations (Na, K, Ca, Mg) were determined with 1 N ammonium acetate (pH 7, 0) solution, sodium, potassium and calcium were determined by Eppendorf Elex 6361 fleymphotometer and magnesium was determined by Perkin Elmer Optima 2100 DV model ICP OES device. Available microelements (Fe, Cu, Zn, and Mn) were determined in the filtrate obtained by extracting the soil with DTPA and the available metals were determined with a Perkin Elmer Optima 2100 DV model ICP OES [30]. (Jones, 2001). The results obtained are given in Table 2 and compared with the limit values.

Table 2. Soil characteristics of the experimental area.

Characteristics	Values	Limit Values
% Sand	27.2	
% Silt	21.9	Clay
% Clay	50.8	
pH	8.1	Slightly alkaline
EC, µS cm^{-1}	315	No Salt
Lime, %	5.8	Medium calcareous
Organic matter, %	3.1	High
Total N, %	0.298	High
Available P, mg kg^{-1}	25.0	Very high
Available Na, mg kg^{-1}	130.0	Low
Available K, mg kg^{-1}	54.6	Very low
Available Ca, mg kg^{-1}	4900	Very high
Available e Mg, mg kg^{-1}	23.6	Very low
DTPA-Cu, mg kg^{-1}	27.4	Very high
DTPA-Zn, mg kg^{-1}	2.0	Low
DTPA-Mn, mg kg^{-1}	12.9	Low
DTPA-Fe, mg kg^{-1}	14.7	Middle

2.4. Organic Fertilizer Analysis

The properties and methods examined in the organic materials (FYM, L and VC) used in the study are as follows. The pH values of the organic samples were determined with a pH meter model WTW 3110 in a 1:10 dilution of pure water [31]. Electrical conductivity value was determined by measuring with a WTW LF 92 model condactivitometer in 1:10 diluted medium. The amount of organic matter was determined by taking into account the weight loss of the sample as a result of incineration of the materials in a ash furnace at 550 °C [32]. Total nitrogen content was determined by Kjeldahl method. The samples incinerated in a Buchi K-437 incineration block were distilled in a Buchi K-350 steam distillation device. Total P and K were determined by Perkin Elmer Optima 2100 DV model ICP OES in the solution obtained by wet incineration with HNO_3+HCI in Berghof MWS2 microwave incineration unit [33]. The results obtained are given in Table 3.

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Table 3. Some properties of the organic materials used in the experiment.

	FYM	L	VC
pH	7.70	4,18	9.18
EC, mS cm^{-1}	3.2	3,75	6.97
Organic matter, %	75.03	55,14	47.3
Total N,%	2.1	1,45	0.95
C:N ratio	20.72	22.05	28.8
Total P,%	1.05	0.03	0.38
Total K, %	0.81	0.60	0.88
Total Fe,%	0.08	1.27	0.96
Total Cu, mg kg^{-1}	55.4	25.1	41.0
Total Zn, mg kg^{-1}	397.0	15.2	95.0
Total Mn, mg kg^{-1}	332.0	26.3	283.0

2.5. Statistical Analysis

The statistical analysis of the physical and chemical data obtained from the fruit and seed and the data obtained as a result of chemical analysis in the soil where the study was conducted was carried out with the JUMP package program. Minimum significant difference (LSD) test ($p<0.05$) was used to compare the differences between the means.

3. Result and Discussion

The experiment was established with FYM, L and VC organic fertilizers and eggplant 'Pala-49' type according to the regulation on the principles and implementation of organic agriculture and repeated for two years. According to the results obtained; the difference of L, VC and FYM treatments between years was found statistically significant ($p\leq 0.05$) in terms of all parameters. While I. year gave better results in plant height, plant diameter and fruit length parameters, II. year gave better results in fruit diameter parameter. In general, the fact that the results of the first year were better than the results of the second year can be attributed to the fact that the amount of precipitation falling in June and July in the second year was above the long-term average of precipitation.

When the results were examined; the best effect was obtained from FYM in plant height parameter with values of 68.06 cm and 65.12 cm in the first and second years, respectively (Table 4). This was followed by VC with 61.13 cm and 61.47 cm, and then control with 57.26 cm and 55.81 cm, respectively. The lowest effect on plant height was determined in the L treatment with 55.93 cm and 52.65 cm in the first and second years, respectively. The most effective treatment on plant diameter was FYM with values of 61.20 cm and 60.50 cm in the first and second years, respectively. This was followed by VC with 59.00 cm and 58.70 cm, and then control with 54.00 cm and 53.02 cm, respectively. The lowest effect on plant height was determined in the L treatment with 52.13 cm and 51.85 cm in the first and second years, respectively (Table 4). Likewise, organic fertilizer doses given compared to the control treatment were effective in increasing plant size [34]. In previous studies, it was reported that plant height always increased in parallel with increasing nitrogen doses and increasing organic fertilizer doses [35,36]. Plant height was found 46.50 cm and 66.80 cm in the first measurement on the 30th day in organic and conventional plots, respectively, was 73.90 cm and 83.33 cm in the last period [37]. It has been shown that the performance of organic fertilizers is much better and has a significant advantage over chemical fertilizers. [38]. Organic fertilizers, which are mixtures of manure, improved the growth characteristics of plants [39]. Fertilization using natural pigeon manure up to a dose equivalent to 18 kg plot^{-1} or 15 tons ha^{-1} (G3) increased plant height, leaf number and tiller increased its number [8].

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Table 4. Plant height, plant diameter, fruit height and fruit diameter measurements of eggplant 'Pala-49' type at the end of FYM, L and VC organic fertilizer application.

Years	Application	Plant height (cm)	Plant diameter (cm)	Fruit height (cm)	Fruit Diameter (cm)
1st Year	Control	57.26 b *	54.00 ab	15.85 b	5.02 b
	FYM	68.06 a	61.20 a	21.90 a	6.73 a
	L	55.93 b	52.13 b	14.68 b	5.06 b
	VC	61.13 ab	59.00 ab	16.61 b	4.89 b
	Means	**60.59 A**	**56.58 A**	**17.26 A**	**5.42 B**
2nd Year	Control	55.81 b	53.02 ab	16.76 b	4.73 c
	FYM	65.12 a	60.50 a	20.73 a	6.70 a
	L	52.65 b	51.85 b	14.67 b	5.06 bc
	VC	61.47 ab	58.70 ab	15.57 b	5.54 b
	Means	**58.76 B**	**56.01 B**	**16.93 B**	**5.50 A**

* Letters indicate different groups at $p \leq 0.05$ level. [a] Lower case letters are used to compare the mean of treatments and upper case letters are used to compare the mean of years.

FYM showed the highest performance in the 1st and 2nd year measurements of fruit length. The 1st and 2nd year measurements year FYM showed the highest performance in the measurements of fruit diameter followed by VC (Table 4). It was reported that plant height, grain yield and 1000 grain weight increased with organic and chemical fertilizer applications and that this was due to the increase in the uptake of useful nutrients, and the difference in plant height was due to the diversity of main nutrients in fertilizer sources, which is in parallel with our study result [40]. Similarly, The combined application of biofertilizer and vermicompost and spraying seaweed extract on leaves have a significant effect on yield per plant and total yield per hectare [7]. This may be because the organic matter contained in vermicompost improves the physical, chemical and biological properties of the soil and when combined with biofertilizer leads to the dissolution of the nutrient fixed in the soil, mineralizing it and making it available to the plant for better growth. While year I gave better results than year II in seed number and germination percentage parameters, year II gave better results than year I in seed weight parameter.

When the obtained results were analyzed in terms of parameters; FYM showed the highest performance in seed number, seed weight and germination percentage parameters, while there were numerical differences between the other organic fertilizers, but statistically they were in the same group with $p \leq 0.05$ level. While seed number was found to be statistically insignificant in year II, FYM showed the highest performance in seed weight parameter in year II measurements, which was followed by the control (Table 5). It can be explained by the high organic matter content of FYM and its significant effect on the physical, chemical and biological properties of the soil. Quality criteria are one of the most important issues in seed studies. The relationship between parameters such as seed weight, seed weight per fruit and 1000 grain weight are among the noteworthy issues. Seed size is an important parameter of seed quality because larger seeds promote better seedling establishment in the field [41].

Table 5. Number of seeds, seed weight, germination percentage measurements eggplant 'Pala-49' type at the end of FYM, L and VC organic fertilizer application.

Years	Application	Number of seeds (pcs/fruit)	Seed weight (g/fruit)	Germination Percentage (%)
1st Year	Control	1519 b *	5,58 b	15,85 b
	FYM	2508 a	9,38 a	21,90 a
	L	1383 b	5,05 b	14,68 b
	VC	1344 b	4,79 b	16,61 b
	Means	**1688 A**	**6,20 B**	**17,18 A**

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2nd Year	Control	1502	6,05 ab	16,76 b
	FYM	2177	8,60 a	20,73 a
	L	1493	5,16 c	14,67 b
	VC	1424	5,69 b	15,57 b
	Means	**1649 B**	**6,37 A**	**16,93 B**

* Letters indicate different groups at p ≤ 0.05 level. Lower case letters are used to compare the mean of treatments and upper case letters are used to compare the mean of years.

Başay (2020) with eggplant seed study; she stated that as eggplant fruit weight, length and width increased, the seed 1000 grain weight increased. Cebeci & Padem (2014) conducted a study on the relationship between fruit number and seed quantity and quality in F1 cucumber (*Cucumis sativus* L.) seed production and reported that fruit weight values were positively correlated with fruit diameter, fruit length and 1000 grain weight values.

In the eggplant seed study; it was determined that as eggplant fruit weight, length and width increased, seed 1000 grain weight increased [42]. In a study examining the relationship between fruit number and seed quantity and quality in F1 cucumber (Cucumis sativus L.) seed production, fruit weight values showed a positive correlation with fruit diameter, fruit length and 1000 grain weight values [43].

Nutrient Element Content

The effects of organic applications on the nutrient content of plants were evaluated and statistically significant results were found. N, P, K, Ca, Mg, Na, Fe, Cu, Mn and Zn contents of seed samples are given in Table 6.

Table 6. Effects on the nutrient element content of eggplant 'Pala-49' cultivar at the end of the first and second year FYM, L and VC organic fertilizer application.

Years	**Application**	**Plant Nutrient Element**								
		N, %	**P, %**	**K, %**	**Ca, %**	**Na, mg kg⁻¹**	**Fe, mg kg⁻¹**	**Cu, mg kg⁻¹**	**Mn, mg kg⁻¹**	**Zn, mg kg⁻¹**
1st Year	Control	0,242	0,286	0,210 b *	0,026	0,091	11,9 c y	37,6	77,6 d*	29,3 c*
	FYM	0,254	0,279	0,272 a	0,038	0,103	17,6 c	45,3	85,4 cd	32,5 c
	L	0,251	0,274	0,236 ab	0,028	0,099	16,1 c	43,8	93,7 cd	28,8 c
	VC	0,258	0,292	0,237 ab	0,036	0,103	15,8 c	47,3	110,3 c	39,3 bc
	Means	**0,251**	**0,283 B****	**0,239**	**0,032**	**0,099**	**15,3 B****	**43,5 B ****	**91,7 B ****	**32,5 B****
2nd Year	Control	0,247	0,417	0,248 ab y	0,034	0,084	22,6 bc y	72,0	146,6 b y	41,7 bc y
	FYM	0,271	0,431	0,309	0,049	0,092	31,7 ab	85,4	152,5 b	52,5 ab
	L	0,266	0,433	0,277 ab	0,025	0,090	30,0 ab	83,2	172,4 ab	45,1 abc
	VC	0,270	0,456	0,274 ab	0,047	0,094	35,1	89,8	200,7 a	63,7 a
	Means	**0,264**	**0,434 A**	**0,277**	**0,039**	**0,090**	**29,9 A**	**82,6 A**	**168,0 A**	**50,7 A**

* Letters indicate different groups at p ≤ 0.05 level. ** Letters indicate different groups at p ≤ 0.01 level. Lower case letters are used to compare the mean of treatments and upper case letters are used to compare the mean of years.

Nitrogen content of the seeds varied between 0.242 and 0.271%. The difference between treatments in both the first and second year was not significant. Relatively high values were determined in VC and FYM treatments compared to the control. This is related to the high total nitrogen content of the experimental soil (Table 2). The differences in total P content of eggplant seed samples depending on the treatments were not found statistically significant, while the differences between years were found significant. P content of seed samples varied between 0.274% and 0.456%.

Relatively high values depending on the treatments were determined in VC treatments. The second year P content average (0.434%) was higher than the first year average (0.283%). The results obtained are related to the high available P content of the second year experimental soil.

The differences in K content of seed samples due to treatments were not significant in both years. Potassium content in the second year (0.277%) was higher than the first year (0.239%). Depending on the applications, K content varied between 0.210 and 0.309%. In both years, the highest K value was obtained from barnyard manure (FYM) applications compared to the control application. These results can be explained by the higher K content of FYM. The differences in Na and Ca contents of the seed samples due to the applications were not found to be statistically significant in both years. Na and Ca contents of the samples varied between 0.026%-0.049% and 0.084%-0.103%.

Total Fe, Cu, Zn and Mn contents of seed samples were found to be statistically significant in both years. Fe, Cu, Zn and Mn contents of seed samples varied between 11.9-17.6 mg kg^{-1}, 37.6-47.3 mg kg^{-1}, 77.6-110.3 mg kg^{-1}, 28.8-39.3 mg kg^{-1} in the first year. In the second year of application, the values varied between 22.6-35.1 mg kg^{-1}, 72.0-89.8 mg kg^{-1}, 146.6-200.7 mg kg^{-1} and 41.7-63.7 mg kg^{-1}. While the lowest amounts were determined in control applications in both years, the highest Fe, Cu, Zn and Mn contents were obtained from VC applications in the second year. These values were followed by FYM in terms of Fe, Cu and Zn content and L treatments in terms of Mn content. The values obtained in the second year were higher than the first year application results.

It has been reported that organic origin materials and organic fertilizer applications have positive and significant effects on plant growth and plant nutrient content. Some researchers reported that L application increased mineral nutrient absorption and yield in plants [44–46]. Leonardit applied plants grew better than the control treatment, but the changes in N, K, Ca, Fe, Mn, Cu and Zn contents except for P were not statistically significant. They also stated that the effectiveness of Leonatdit application increased with mycorrhizal fungus application [47]. L and VC application increased the protein content of the plant compared to the control [48].

VC applications increase the macro and micro element content of the soil and enable the nutrients to be taken more easily by the plants [49]. Similarly, there are significant increases in the soil and plant K, Ca, Mg and some other element contents in VC applications [50]. VC application increases the nutrient content of the plant more than FYM. It has been reported that the effect on nutrient uptake is related to the properties of organic substances [51]. It has been determined that the effect of FYM applications on the dry matter, yield, total N, K, Fe, Cu and Zn content of the plant is statistically significant, but the effect on total P, Ca, Mg, Na and Mn content is insignificant [16]. The highest nutrient contents were obtained in the increasing FYM applications This result is attributed to the calcareous and alkaline structure of the soil in which the study was conducted [52].

In general, it has been stated that the changes in soil properties and increases in plant growth with the application of organic fertilizers and organic source materials to the soil may be due to the physical and chemical properties of the applied materials, the increase in enzyme activity of the soils The high microbial diversity in the content, and the increase in microbial activity [53–57].

In this study, it is thought that the treatments increased dry weight and yield, but the reason why the change in nutrient content was not significant is due to the accumulation effect. The fact that the effect seen in the seed samples, especially in micro-element contents, is important is that micro-element deficiencies are common in our country's soils in general and in order to prevent this, solutions are sought with organic origin applications. This effect was also observed in this study.

In the study, in order to determine the changes in soil properties as a result of the treatments, soil samples were taken from the treatment plots according to the productivity principle and analyzed. The effects of the treatments on soil properties were found to be statistically ($p<0.05$, $p<0.01$) significant. The results obtained are given in Table 7.

Table 7. Changes in soil characteristics depending on applications.

Years	**Treatment**	Soil Properties								
		N, %	P, mg kg^{-1}	K, g kg^{-1}	Ca, g kg^{-1}	Na, mg kg^{-1}	Fe, mg kg^{-1}	Cu, mg kg^{-1}	Mn, mg kg^{-1}	Zn, mg kg^{-1}

1st Year	Control	0.145	92.5	0.078	4.083	0.079	46.61	6.51	33.3	6.51b*
	FYM	0.164	114.5	0.122	4.224	0.083	59.32	6.90	32.0	6.90b
	L	0.145	124.8	0.065	4.396	0.083	53.70	6.62	29.2	6.90b
	VC	0.154	149.0	0.082	4.316	0.084	51.15	8.29	38.8	8.29a
	Means	**0.152B ***	**120.2 B***	**0.089 B**	**4.255A**	**0.082B**	**52.697**	**7.08**	**32.2 B**	**17.72**
2nd Year	Control	0.164	136.5*	0.086	4.105	0.110	50.07	7.10	41.81	18.92
	FYM	0.181	196.2a	0.196	4.081	0.109	51.14	7.09	55.13	22.17
	L	0.190	202.4a	0.154	4.164	0.104	49.86	7.29	44.21	18.73
	VC	0.164	198.7a	0.176	4.084	0.104	60.40	8.04	59.90	25.66
	Means	**0.190 A**	**183.4 A**	**0.167 A**	**4.109 B**	**0.107 A**	**52.863**	**7.38**	**48.3 A**	**21.37**

* Letters indicate different groups at $p \leq 0.05$ level.
Lower case letters are used to compare the mean of treatments and upper case letters are used to compare the mean of years.

When Table 7 is examined, it is seen that the differences in soil available P content in the second year and available Zn content in the first year depending on the applications were not found to be statistically significant. In general, the second year soil nutrient content was higher than the first year soil sample results in terms of total N, available P, available K, Na and available microelements. Organic C-rich materials improve the physical, chemical and biological properties of soils and increase plant growth [18]. VC and FYM increase soil nutrient availability [58]. It has been reported that FYM application increases plant P uptake and soil P availability [59]. This effect is associated with the release of both P and low molecular weight organic acids during the decomposition of organic components [60]. Organic acids/anions can solubilize insoluble P and compete with phosphate for adsorption sites on the surfaces of soil particles, thereby increasing P availability [61]. In addition, organic compounds have been reported to increase soil biological and enzyme activities, thereby increasing P availability through dissolved organic carbon in the soil [62].

It is thought that the reason why the change between the applications was not significant in the study was due to the fact that the nutrient contents in the soil were above the sufficiency limit value. Humic substances provided by the application of materials of organic origin to the soil play an important direct and indirect role in the development of plants. The direct effect on plants occurs by affecting root development and the metabolism of nutrients absorbed by plants. Humic acid indirectly increases the availability of nutrients by improving water retention, drainage, aeration and by forming water-soluble forms by forming chelate compounds or metallic-hydroxides with metallic ions.

4. Conclusions

In terms of the plant parameters evaluated in the study, the efficiency of FYM organic fertilizer was found to be higher in all parameters. Considering the soil characteristics of our country, it can be said that L and VC organic fertilizers, especially FYM, will increase success in organic seed production. According to the results of the analysis of the seed samples, it was observed that the organic materials applied in the organic farming process increased the nutrient element contents of the seeds at different levels. When the nutrient element content was evaluated in terms of seed quality, it was observed that the effect of FYM and VC applications was more apparent.

In the conducted study, the differences in seed nutrient content between years varied depeding on the change in the available nutrient content of the soil and climatic conditions.

Materials of organic origin are known to be beneficial in terms of ecological balance, sustainable continuation of soil fertility, increase in plant health and quality, and proper use of natural resources. In the organic production process, fertilizer application levels should be determined by considering soil properties and plant needs in the application of organic origin materials to soils as organic carbon sources. Therefore, economic applications and fertilization programs can be put forward depending on the conditions. Since the type and application level of organic fertilizers to be used in the studies to be carried out are also of great importance in terms of mineralization, these factors should be taken into consideration in the studies to be planned.

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