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Effect of Rhizobacteria (PGPR) and LiQuid Vermicompost Applications on Yield and Yield Coponents in Lettuce (*Lactuca sativa* L.) Culture

Yusuf ÇELİK[1*]

Highlights:

- PGPR increased efficiency
- Increased vermicompost yield
- Increased intake of nutrients

Keywords:

- Lettuce
- Rhizobacteri
- Organicfertilizers
- Yield

ABSTRACT:

Lettuce (*Lactuca sativa* L.) is a type of vegetable that can be produced in almost every region of Turkey and is consumed throughout the year. Product yield and quality decrease in soils with poor organic matter content. Rhizobacteria (PGPR) and Liquid vermicompost, which support plant growth, were used in the study carried out to increase crop yield and improve soil. In the study; plant head length, head diameter, root collar diameter, leaf fresh and dry weight, root length, leaf number, head weight, water-soluble dry matter content and plant nutrient content (N, P, K, Ca, Mg, Fe, Zn and Cu) was measured. As a result of different PGPR strains and vermicompost applications, when single PGPR applications and PGPR and vermicompost combination applications are compared; It has been observed that PGPR+VC applications are more effective in increasing the yield, development and nutrient content of lettuce plant. Among the applications in the study, the combination of YÖ41+VC (bacteria+vermicompost) came to the fore. As a result; the PGPR+VC combination used in the study made a significant contribution to the yield components with its effect on the head weight, number of leaves, stem length and diameter, N, P, K, Ca, Mg and Fe contents of the lettuce plant.

[1] Yusuf ÇELİK (**Orcid ID:**0000-0002-8590-6690), Mersin University, Silifke Vocational School, Department of Crop and Animal Production, Mersin, Türkiye

***Corresponding Author:**Yusuf ÇELİK, e-mail: ycelik33@mersin.edu.tr

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a cool climate vegetable group known as an annual belonging to the Lactuca genus of the Compositae (Asteraceae) family. Lettuce leaves are among the most consumed vegetables group (Eşiyok, 2012). It has been reported that lettuce, which has an important production potential among green leafy vegetables, has a history of more than 2500 years in Europe and Asia, and its use in the agricultural sector and medical fields has been used for many years. It has been determined that the homeland of lettuce is European, North African and Asian countries (Aybak, 2002). Lettuce, which is among the cool climate vegetables, can be cultivated both in the open and under cover. It is widely consumed because it contains important mineral substances for human health. 100 g of fresh lettuce; It is 96% water and contains 13 cal energy, 0.9 g protein, 0.1 g fat and 2.9 g carbohydrates, including 330 IU of vitamin A, 6 mg of vitamin C, 0.3 mg of niacin, 0.06 mg thiamin, 0.06 mg riboflavin, 175 mg K, 22 mg P, 20 mg Ca, 9 mg Na and 0.5 mg Fe. (Pierce 1987; Ryder, 1979). In addition, it has been reported that lettuce, which is widely used in salads, contains high amounts of antioxidant compounds, most of which are vitamin C and polyphenols, as well as fiber content (Nicolle et al., 2004). Lettuce, which is not very resistant to cold, develops well and quality in humid weather conditions. Lettuce shows good growth in the weather where the average temperature is 15-18°C, while the temperature being above 27-30°C at the maximum and below 2-4°C at the minimum negatively affects the plant growth (Eşiyok, 2012; Günay, 2005; Thompson, 1957). The optimum germination temperature for seeds is 15°C. Due to the short vegetation period, it can be grown in all regions of Turkey in cool seasons (Günay, 2005). Lettuce cultivation develops well when the soil pH is between 5.5 and 7 (Aybak, 2002).

Fertilization;It is the application of different nutrients to the soil for better nutrition of the plant in agricultural production.While fertilizing, it is important to give the fertilizers needed by the plant at the appropriate time and amount according to the results of soil analysis, both in terms of soil health and in terms of product yield and quality (Yıldız, 2008).Various chemical drugs, fertilizers, hormones and additives, etc. applications used to increase productivity cause some negative consequences such as environmental pollution (soil and air), food production that poses a risk to human health (Yolcu and Daşcı, 2008).

The structural content of vermicompost turns into a form that can be used very easily by the plant due to the slow release and slow dissolution of the nutrients covered with worm mucus.Vermicompost has an excellent soil conditioner feature due to its high air and water holding capacity and good heating.At the same time, this material has the property of reducing the growth of weeds and the risk of erosion, while protecting the roots of plants from extreme temperatures.Vermicompost contains more nutrients that are beneficial to the plant, since the nutrients taken by the worm in liquid form after aerobic digestion are further broken down in the digestive system (Buchanan et al., 1988).

In a study conducted to determine the effects of different doses of vermicompost manure and barn manure on the development of spinach plant and soil fertility, vermicompost applications provided significant increases in plant growth, yield, mineral substance content and soil fertility compared to control. According to the control, the pH, EC and organic matter values of the soil increased in all treatments; It has been reported that applications with barn manure are more effective on the N, P, K and Mg contents of the soil (Sönmez et al., 2011). In the study carried out under pot conditions; Vermicompost was applied to farm and sheep manure in amounts of 0% (control), 1% (25 g), 3% (75 g), 5% (125 g), 7% (175 g) and the lettuce development of the fertilizer materials was

compared. It has been determined that the effect of vermicompost applications on the earliness of curly lettuce is significant. In general, it has been determined that sheep manure applications give positive results in terms of the availability of plant nutrients. It was determined that farm manure played an important role in N uptake. It has been reported that vermicompost gives good results in the uptake of Ca, Cu and Zn elements into the plant body of curly lettuce (Hınıslı, 2014). In the study, the effects of various chemical fertilizers, biofertilizers and vermicompost combinations on the growth of mustard plant (Brassica campestris cv.) were investigated; They reported that the best results were obtained in vermicompost applied parcels and that the 25% reduced chemical fertilizer and vermicompost combination gave positive results in many parameters in agroclimatic conditions compared to the control group (Mondal et al., 2015).

The rhizosphere is an area around the root surfaces where the biological activity of a microorganism is highest (Choudhary et al.2018). PGPR are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plants'health (Parewa et al.2018). PGPR are involved in all beneficial activities within the soil like decomposition of crop residues, synthesis of soil organic matter, mineralization of soil organic matter, and immobilization of mineral nutrients which help in soil fertility improvement (Sharma et al.2017).PGPR has the ability to increase plant growth directly or indirectly in a variety of ways (Ahmed et al.2017).Direct mechanisms include various processes such as phosphate solubilization, nitrogen fixation, production of siderophores, HCN, ammonia, vitamins and phytohormones (e.g. auxin, cytokinin and gibberellins) while indirect mechanisms include ACC deaminase activity, antibiotic production, hydrolytic enzymes, ISR of phytopathogens.takes (Aloo et al 2019; Parewa et al.2018). Plants benefit from nutrients that are difficult to obtain from the soil, regulate soil pH, balance soil moisture content, increase soil air, increase soil temperature, as well as seed germination, root development, plant water consumption, production of growth hormones, and protection against various diseases and harmful effects.They show a wide variety of effects, such as providingWhile rhizobacteria (PGPR) enable plants to benefit from nutrients through N binding to soil, P and K mineralization;they support plant growth by activating plant growth regulators (Sinha et al., 2014).In thisstudy, it is aimed to develop applications that will contribute to high yield and quality lettuce production by using different bacterial strains and vermicompost materials within the scope of beneficial soil management practices.

MATERIALS AND METHODS

Materiels

Climatic features of silifke

Silifke District is geographically located between 36° 22' north latitude and 33° 56' east longitude.The average height above sea level is 15m.Silifke is located in the semi-arid climate zone and the Mediterranean climate is observed in the region.Summers are hot and dry, winters are mild and rainy.Considering the long-term average temperatures, the annual average temperature is 19.1°C.The coldest month is January (10.2°C) and the hottest month is August (28.1°C).The annual average precipitation is 532.50 mm.The highest precipitation falls in December with 120.1 mm.Considering the seasonal distribution of precipitation, the rainiest season is winter, while the least precipitation is summer.

Soil properties of the trial area

Soil characteristics of the field where the study was carried out; The soil pH was found to be 6.97, salinity 0.10%, lime 1.7%, organic matter 2.1% soil texture sandy/loamy. Vermicompost

Properties Used in the Study The pH of the vermicompost fertilizer used in the study was 6.9, the electrical conductivity (EC) was 3.7 dS/m, the organic matter rate was 20%, the nitrogen content was 1.2%, the phosphorus content was 1.09%, and the potassium amount was 6.51% detected.

Fertilizer Materials Used in the Research

In the study, $(NH_4)_2SO_4$ was used as nitrogen fertilizer, P_2O_5 as phosphorus source fertilizer, and K_2SO_4 as potassium fertilizer source.

Vermicompost properties used in the study

The pH of the vermicompost fertilizer used in the study was 6.9, the electrical conductivity (EC) was 3.7 dS/m, the organic matter rate was 20%, the nitrogen content was 1.2%, the phosphorus content was 1.09%, and the potassium amount was 6.51% , detected.

Analysis of plant nutrient element contents

Leaf samples taken from the plants were washed for chemical analysis and dried and ground at 65 °C until they reached a constant weight. The total N in the ground samples was determined according to the modified Kjeldahl method (Kacar and İnal, 2008);For the analysis of P, K, Ca, Mg, Fe, Mn, Zn and Cu, the plant samples were wet burned (4:1, HNO_3:$HClO_4$) and read in the ICP-OES device (Soltanpour and Workman, 1981).

Table 1. Different bacterial strains

Plant activators used in the experiment and their properties	
SA7	Erwinia chrysanthemi biotype II: MIS similarity index (%) is 86, Nitrogen fixation is strongly positive, phosphorus solubility is positive. Turgenia Latifolia was isolated from the soil surrounding the plant roots.
YÖ15	Pseudomonas fluorescens biotype F: MIS similarity index (%) is 63, Nitrogen fixation is positive, phosphorus solubility is weakly positive. Thymus vulgaris was isolated from plant roots
YÖ19	Virgibacillus pantothenticus: MIS similarity index (%) 56, Nitrogen fixing and phosphorus dissolving properties are strongly positive. Thymus vulgaris was isolated from plant roots.
YÖ41	Bacillus cereus GC subgroup A: MIS similarity index (%) is 78, Nitrogen fixing properties are strong, phosphorus dissolving properties are strongly positive. Thymus vulgaris was isolated from plant roots.

Method

This study was carried out in the application and research areas of Mersin University Silifke Vocational School in the fall semester of 2020. The PGPR strains used in the experiment were applied as seed coating in the laboratory. Seed sowing was started on 15.08.2020, and on 20.09.2020 the seedlings, which were duly grown, were planted in 3-5 leaf periods, when they reached a length of about 10-12 cm. The study was terminated after approximately 70 days. The subject of the experiment; According to the soil analysis results of PGPR strains (SA7, YÖ9, YÖ15, YÖ41 107cfu/ml), vermicompost (350ml/100 water) and chemical fertilizer applications, 22 kg/da N, 24 kg/da P and 24 kg/da K were determined. Experiment: It was composed of VC, SA7, YÖ9, YÖ15, YÖ41, SA7+VC, YÖ9+VC, YÖ15+VC and YÖ41+VC and the control group. In the experiment, which was planned with four replications according to the randomized blocks trial design, 10 applications and 10 plants in each application were planted in 10 rows, 25 cm on the row and 30 cm between the rows, a total of 10x10x10x4=4000 plants. The data obtained from the experiment were evaluated according to ANOVA analysis of variance using “IBM SPSS statiscids 23” statistical software programs. The Duncan Multiple Comparison Test was used to compare the differences between the means.

RESULTS AND DISCUSSION

The effects of different bacterial (PGPR) strains and vermicompost applications on plant growth and yield are shown in Table 2. Variance analysis results were found statistically in terms of the effect

of PGPR and vermicompost applications on yield and yield components. important. When the effect of applications on plant head length is examined; According to the data, the highest value was obtained from the YÖ4l+VC (35.9 cm) application, and the lowest value was obtained from the control (27 cm) application. YÖ41+VC application, which received the highest value in terms of plant head height, showed an increase of 32.9% compared to the control application. When the effect of applications on plant head diameter was examined, the highest value was obtained from YÖ41+VC (38 cm) application, and the lowest value was obtained from control (31.2 cm) application. YÖ41+VC application, which has the highest value in terms of plant head diameter, increased by 21% compared to the control application. YÖ41+VC application, which has the highest value in terms of plant head weight, increased by 386% compared to the control application. When the effect of the applications on the root length of the plant was examined, the highest value was obtained from YÖ41+VC (11.7 cm) application, and the lowest value was obtained from the control (7.6 cm) application.YÖ41+VC application, which has the highest value in terms of plant root length, has increased by 54% compared to the control application. When the effect of the applications on the number of leaves on the plant was examined, the highest value was obtained from the application of YÖ41+VC (45.9 units/plant) and the lowest value was obtained from the control (36.8 units/plant) application. In terms of plant leaf number, the highest value YÖ41+VC application was increased by 24.7% compared to the control application. When the effect of the applications on the amount of water-soluble dry matter was examined, there was no statistically significant difference between them, since all applications were at the same level of importance. When the effect of the applications on the plant leaf wet weight was examined, the highest value was obtained from the YÖ41+VC (147.8 g) application, and the lowest value was obtained from the control (127.9 g) application. YÖ41+VC application, which has the highest value in terms of plant leaf fresh weight, increased by 15.6% compared to the control application. While the highest value in the effect of applications on leaf dry weight was obtained from the application of YÖ41+VC (12.8 g), the lowest value was obtained from the application of YÖ9+VC (10.9 g). A difference of 17.4% was obtained between the applications.Vermicompost use has been shown to increase macro and micro element uptake from soil and remediation of soil of tomato, spinach, lettuce, pepper, and sun-flower (Zaller 2007; Cıtak et al.2011; Belliturk et al.2017; Erten Adak 2016, Adilogluet al.2018).The results of the reference studies are similar to the results of our study.

Table 2. Effects of different bacterial strains and vermicompost applications on yield components of lettuce plant

Aplications	Crown lenght (cm)	Crown diameter (cm)	Head weight (cm)	root length (cm)	leaf number (number/plant)	water-soluble dry matter (%)	Leaf fresh weight (g)	Leaf dry weight (gr)
Control	27±0.9^{d}	31.2±0.9^{e}	0.7±0.1^{f}	7.6±0.5^{b}	36.8±0.4^{e}	3.6±0.6^{b}	127.9±3.4^{c}	11.5±1.1^{a}
VK	29.3±0.6^{c}	33±0.5^{d}	1.2±0.7^{e}	9.5±0.4a	36.6±1.1^{e}	3.8±0.1^{a}	132.9±2.8^{abc}	12.7±1^{a}
SA7	34.7±0.7^{ab}	37±0.5^{abc}	2.4±0.2^{bc}	10.9±0.5^{a}	43.6±0.3^{bcd}	3.5±0.3^{b}	139.4±3.5^{abc}	11.9±0.5^{a}
YÖ9	34.1±0.7^{ab}	36.1±0.4^{bc}	2±0.1^{d}	10.2±0.5^{a}	41.7±0.5^{d}	3.5±0.3^{b}	137.4±1.7^{abc}	10.9±0.6^{a}
YÖ15	33.3±0.5^{b}	35.3±0.4^{c}	2.2±0.1^{cd}	10.2±0.9a	42.4±0.7^{cd}	3.5±0.3^{b}	131.3±4.6^{bc}	12.3±0.6^{a}
YÖ41	34.6±0.4^{ab}	37.2±0.7^{ab}	2.5±0.8^{ab}	11±0.9a	44.2±0.4^{abc}	3.5±0.2^{b}	136.3±5^{abc}	12.4±0.7^{a}
SA7+VC	35.3±0.3^{a}	37.8±0.4^{ab}	2.6±0.6^{ab}	11.1±0.6^{a}	45.4+0.5^{ab}	3.5±0.6^{b}	142.1±5^{ab}	12.4±0.5^{a}
YÖ9+VC	34.8±0.4^{ab}	36.6+0.4^{abc}	2.5±0.6^{ab}	10.6±1.1^{a}	44.3±0.7^{abc}	3.5±0.3^{b}	138.3±4.6^{abc}	12.2±0.5^{a}
YÖ15+VC	34.3±0.4^{ab}	36±0.7^{bc}	2.5±0.4^{abc}	11.4±0.9^{a}	44.8±0.9^{ab}	3.5±0.4^{b}	135.6±6.4^{abc}	12.1±0.6^{a}
YÖ41+VC	35.9±0.2^{a}	38±0.5^{a}	2.7±0.6^{a}	11.7±0.9^{a}	45.9±0.4^{a}	3.6±0.7^{b}	147.8±3.3^{a}	12.8±0.6^{a}
Average	**33.33**	**35.82**	**2.13**	**10.42**	**42.57**	**3.55**	**136.9**	**12.12**

VC;Vermicompost.When the columns are examined from top to bottom, the means containing the same letter are not statistically different according to the Duncan (p=0.05) test

In Table 3, the effects of different bacterial strains and vermicompost applications on plant nutrient content are examined. The effect of different PGPR and vermicompost applications on plant

nutrient content was found to be statistically significant as a result of analysis of variance. When the effects of applications on plant nitrogen contents are examined; According to the data, the highest value was obtained from SA7+VC (3.7%) and HS41+VC (3.7%) applications, while the lowest value was obtained from the control (2.8%) application. When the effects of applications on plant P contents are examined; While the highest value was obtained from YÖ41+VC (0.5%) application, the lowest value was obtained from control (0.3%). The highest value in the effect of applications on plant K contents was obtained from SA7+VC application (4.7%), and the lowest value was obtained from control application (2.7%). The highest value in the effect of applications on plant Ca content was obtained from SA7+VC application (2.2%), and the lowest value was obtained from control application (1.7%). The highest value in the effect of applications on plant Mg content was obtained from all applications (0.5%), while the lowest value was obtained from control (0.3%). The highest value in the effect of applications on plant Fe content was obtained from SA7+VC (170.5 kg/mg) application, and the lowest value was obtained from control application (131.4 kg/mg). The highest value in the effect of the applications on the plant Zn content was obtained from the application of SA7+VC (65. 8 kg/mg), and the lowest value was obtained from the application of the control (56. 9 kg/mg). The highest value in the effect of applications on plant Cu content was obtained from control (11.2 kg/mg) application, and the lowest value was obtained from YÖ41 (7.1 mg/kg) application. According to Pezeshkpour et al. (2014) accurate soil, bacteriaand vermicompost combinations as organic matter have potential to increase soil fertility anduptake of nutrient elements.

Table 3. Effects of different bacterial strains and vermicompost applications on nutrient content of lettuce plant

Aplications	N(%)	P(%)	K(%)	Ca(%)	Mg(%)	Fe (mg/kg)	Zn (mg/kg)	Cu(mg/kg)
Control	2.8±0.1^{c}	0.3±0^{c}	2.7±0.2^{d}	1.7±0	0.3±0^{b}	131.4±6^{b}	56.9±4^{a}	11.5±2^{ab}
VK	3.1±0.1^{b}	0.4±0^{bc}	4.2±0.1^{bc}	1.7±0.1	0.5±0^{a}	158.3±5^{a}	63.3±4^{a}	10.9±2^{a}
SA7	3.6±0.1^{a}	0.5±0^{ab}	4.3±0.1^{abc}	1.9±0.1	0.5±0^{a}	169.2±8^{a}	65.1±4^{a}	8.1±2^{ab}
YÖ9	3.3±0.1^{b}	0.5±0^{ab}	4.1±0.2^{bc}	1.7±0.2	0.4±0^{a}	161.1±5^{a}	63.9±4^{a}	8.3±1^{ab}
YÖ15	3.1±0.1^{b}	0.4±0^{ab}	4±0.1^{c}	1.7±0.1	0.5±0^{a}	160.3±6^{a}	59.9±5^{a}	8.6±1^{ab}
YÖ41	3.6±0^{a}	0.5±0^{a}	4.5±0.1^{abc}	1.9±0.1	0.5±0^{a}	164.3±10^{a}	62.2±5^{a}	7.1±1^{b}
SA7+VC	3.7±0^{a}	0.5±0^{a}	4.6±0.1^{ab}	2.1±0.2	0.5±0^{a}	166.5±7^{a}	63.2±4^{a}	7.9±1^{ab}
YÖ9+VC	3.6±0.1^{a}	0.5±0^{ab}	4.5±0.1^{ab}	1.9±0.1	0.5±0^{a}	165.7±5^{a}	61.1±2^{a}	8.9±1^{ab}
YÖ15+VC	3.6±0.1^{a}	0.5±0^{ab}	4.4±0.2^{abc}	1.9±0.2	0.5±0^{a}	162.9±7^{a}	61 ±5^{a}	8.6±1^{ab}
YÖ41+VC	3.7±0.1^{a}	0.5±0^{a}	4.7±0.2^{a}	2.2±0.2	0.5±0^{a}	170.5±6^{a}	65.8±3^{a}	8.9±1^{ab}
Average	**3.41**	**0.46**	**4.2**	**1.87**	**0.47**	**161.02**	**62.24**	**8.85**

VC; Vermicompost. When the columns are examined from top to bottom, the means containing the same letter are not statistically different according to the Duncan (p=0.05) test

CONCLUSION

In this study, which was carried out as an open field experiment, statistically significant differences were found when the effects of different PGPR additional vermicompost applications on the yield criteria of lettuce plant on the crown diameter, crown height, minimum and maximum crown weight. As a result of different bacterial strains and vermicompost applications, all applications increased the yield compared to the control application. When the results of PGPR and PGPR+VC applications are compared, it is seen that PGPR+VC applications are more effective in yield parameters. When the amount of water-soluble dry matter, which is an important quality criterion of lettuce, was examined, no statistically significant difference was found between the applications. Likewise, when the nutrient content of the applications was examined, it was observed that PGPR + VC applications were more effective in plant nutrient intake compared to single PGPR applications in general. It is seen that all applications except Cu have a positive effect on the uptake of N, P, K, Ca, Mg, Fe, Zn elements. As a result, it was determined that the combined (PGPR+VC) use of the

fertilizers used in our study contributed more to the yield. It has been concluded that testing our study under different conditions (soil, climate) in different plant species and the widespread use of PGPR and vermikopst combination in agricultural production will provide more benefits to the producers.

Conflict of Interest

The author declared that there is no conflict of interest.

REFERENCES

Ahmed, B., Zaidi, A., Khan, MS., Rizvi, A., Saif S, & Shahid, M. (2017). Perspectives of plant growth promoting rhizobacteria in growth enhancement and sustainable production of tomato. Microbial strategies for vegetable production: Springer; p. 125–49.

Adak, Ş.E. (2016). Vermikompostun domates ve biberin büyüme ve besin elementi içeriğine etkisi (Master's thesis, Namık Kemal Üniversitesi). Tekirdağ

Adiloglu, A., Buyukfiliz, F., M. R. ve Karaman, M.R. (2018). The effect of vermicompost application on some macroelement contents of sunflower (Helianthus annuusL.) plant in Tekirdag. International Eurasian Congress on'Natural Nutrition and Healthy Life'2018, 12-15 July, Ankara, Turkey. Proceedings book, 394–8.

Aloo, B.N., Makumba, BA. & Mbega, E.R. (2019). The potential of bacilli rhizobacteria for sustainable crop production and environmental sustainability. Microbiol Res. ;219: 26–39

Armstrong, H. (2001). Natural Supression of Pathogens in Soilless Systems, Flower Tech, 4(7):8-11.

Aybak, H.Ç. (2002). Salad / Lettuce Cultivation. Hasad Publishing Ltd.Sti., 96 p., Istanbul.

Backman, A.C., Bengtsson, M., & WitzgalL, P. (1997). Pheromone Release by İndividual Females of Codling Moth, Cydia pomonella. Journal of Chemical Ecology, 23: 807- 815.

Belliturk, K., Hinisli, N. ve Adiloglu, A. (2017). The effect of vermicompost. Sheep manure. and cow manure onnutrition content of curly lettuce (Lactucasativavar.).Fresenius Environmental Bulletin26 (1a):1116–20.

Buchanan, MA., Russell, E. & Block S.D. (1988). Chemical Characterization and Nitrogen Earthworms in Environmental and Waste Management In C.A.Edwards and E.F. Neuhauser (Eds.), SPB Acad. Publ., The Netherlands, 231-240.

Cıtak, S., Sonmez, S., Kocak, F. ve Yasin, S. (2011). Vermikompost ve Ahir Gubresi Uygulamalarinin Ispanak (Spinacia Oleraceavar. L.) Bitkisinin Gelisimi ve Toprak Verimliligi Uzerine Etkileri. BatıAkdeniz TarımsalAras ţırma Enstitüsü. Derim Dergisi28 (1):56–69.

Choudhary, M., Ghasal, P.C., Yadav, R.P., Meena, V.S., Mondal, T. & Bisht, J.(2018).Towards plant-beneficiary rhizobacteria and agricultural sustainability. Role of rhizospheric microbes in soil: Springer; p. 1–46.

Deniel, F, Renault, D., Tirilly, Y., Barbier, G. & Rey, P. (2006). A Dynamic Biofilter to Remove Pathogens During Tomato Soilless Culture, Agron. Sustain. Dev., 26:185-193.

Eşiyok, D. (2012). Winter and Summer Vegetable Growing. Ege University, Faculty of Agriculture Publications, 404 p, Bornava-İzmir.

Gunay, A. (2005). Vegetable Cultivation, Special Vegetable Cultivation.Volume 2., 531 pp, Izmir.

Gül, A., Kıdoğlu, F., Tüzel, Y. ve Tüzel, İ.H. (2007). Different Treatments for İncreasing Sustainability in Soilless Culture, Acta Hort., 747:595-602.

Gül, A., Kıdoğlu, F., Tüzel, Y., ve Tüzel, İ.H. (2008a). Effects of Nutrition and *Bacillus Amyloliquefaciens* on Tomato (*Solanum lycopersicum* L.) Growing in Perlite, Spanish Journal of Agricultural Research, 6(3):422-429.

Gül A, Özaktan, H.ve Kidoğlu, F. (2008b). The Effect of Selected Root Bacteria on Cultivation of Head Salad on Different Substrates, Ege University Scientific Research Project Final Report, Project No: 2007 ZRF 027.

Gül, A., Özaktan, H., Legal, Y., ve Öztan-Kıdoğlu, F. (2008c).Effects of Some Root Bacteria on Plant Growth, Yield and Nutrient Uptake in Important Greenhouse Vegetable Species, Project no. 105 O 571, TÜBİTAK.

Hınıslı, N. (2014). Determination of the Effect of Vermicompost Fertilizer on the Growth of Curly Plants and Comparison with Some Other Organic Fertilizers.b Namik Kemal University.Graduate School of Natural and Applied Sciences, Master Thesis, 50s, Tekirdag.

Kacar, B. ve Inal, A., (2008). Plant analysis. Nobel publication, Ankara.

Kıdoğlu, F., Gül, A. ve Tüzel, Y. (2007). The Effects of Root Bacteria on the Development of Head Salad Seedlings, Turkey V. National Horticultural Congress, 4-7 September 2007, Erzurum, 2:1-5.

Kıdoğlu, F., Gül, A. ve Tüzel, Y. (2008). The Effects of Root Bacteria on the Development of Pepper Plants Grown in Soilless Environment, VII. Vegetable Agriculture Symposium, 26-29 August 2008, Yalova, 155-159.

Mondal, T., Datta, J.K. & Mondal N.K. (2015). Chemical Fertilizer inConjunction with Biofertilizer and Vermicompost Induced Changes inMorpho-Physiological and Bio-Chemical Traits of Mustard Crop, KingSaud University, Journal of the Saudi Society of Agricaltural Science, 16,135-144.

Nicolle, C., Cardinault, N., Gueux, E., Jaffrelo, L., Rock, E. & Mazur, A. (2004). Health effect of Vegetable-Based Diet: Lettuce Consumption İmproves Cholesterol Metabolism and Antioxidant Status in the Rat. Clinical Nutrition, 23, 605–614.

Parewa, H.P., Meena, V.S, Jain, L.K. & Choudhary, A. (2018). Sustainable crop production and soil health management through plant growth-promoting rhizobacteria. Role of rhizospheric microbes in soil: Springer; . p. 299–329.

Pezeshkpour, P., Ardakani, M.R., Paknejad, F. & Vazan, S. (2014). Effects of Vermicompost. mycorrhizal symbiosisand biphosphate solubilizing bacteria on seed yield and quality of chickpea as autumn plantation in rain fedconditions. Bulletin of Environment, Pharmacology and Life Sciences3 (2):53–8.

Pierce, L.C. (1987). Vegetables: Caracteristics, Production And Maketing, John Wiley and Sons, 433 p,USA.

Postma, J., Willimsen de Klein, M.J.E.I.M., Rattink, H. & Van Os, E.A. (2001). Disease Suppressive Soilless Culture Systems; Characterisation of its microflora, Acta Hort., 554: 323-331.

Ryder E.J. (1979). Leafy Solad Vegetables. The AVI Publishing Company. Inc. ABD.

Shirani, H., Hajabbasi, M.A., Afyuni, M. & Hemmat, A. (2002). Effect of Farmyard Manure and Tillage Systems on Soil Physical Praperties and Corn Yield in Central Iran. Soil and Tillage Research 68, 101-108.

Sinha, R.K., Valani, D., Chauhan, K. & Agarwal S. (2014). Embarking on a secondgreen revolution for sustainable agricultureby vermiculture biotechnology usingearthworms: reviving the dreams of SirCharles Darwin. Int J Agric Health Saf2014, 1:50–64.

Sharma, I.P., Chandra, S., Kumar, N. & Chandra, D. (2017). PGPR: Heart of soil and their role in soil fertility. Agriculturally important microbes for sustainable agriculture: Springer; p. 51–67.

Soltanpour, P.N. & Workman, SM. (1981). Soil-testing methods used at Colorado State University Soil-Testing Laboratory for the evaluation of fertility, salinity, sodicity, and trace-element toxicity. Technical Bulletin 142 (No.NP-2906200). Colorado State Univ., Fort Collins (USA). Colorado State Univ. Experiment Station.

Sönmez, S., Çıtak, S., Koçak, F. ve Yassin, S. (2011). The Effects of Vermicompost and Barn Manure Applications on the Development of Spinach (*Spinacia Oleracea Var. L.*) Plant Soil Fertility. West Mediterranean Agricultural Research Institute Derim Journal, 2011, 28(1):56-69.

Tavalı, İ.E, Uz, İ.ve Orman, Ş.(2014). The Effects of Vermicompost and Chicken Manure on the Yield and Quality of Summer Squash (*Cucurbita pepo L. cv. Gum*) and Some Chemical Properties of the Soil. Akdeniz Univ. Faculty of AgricultureJournal, 27(2), 119-124.

Thompson, R.C. (1957). Vegetable Croms, Mc Graw Hill Book company Inc. New York. Toranto.

Yıldız, N. (2008). Fundamentals of Plant Nutrition and Symptoms of Nutritional Disorder in Plants Atatürk University, Faculty of Agriculture, ISBN 975-442-110-2.(2nd Edition).

Yolcu, H., ve Daşcı, M. (2008). The Current Situation of Organic Forage Crops Production in Our Country. Harvest Journal of Livestock, 24, 40-46.

Zaller, J.G. (2007). Vermicompost as a substitute for peat in potting media: Effects on germination. biomass alloca-tion. yields and fruit quality of three tomato varieties. Scientia Horticulturae112 (2):191–9. doi:10,1016/j.sci-enta.2006.12.023.

Weller, DM. (1988). Biological Control of Soilborne Plant Pathogens in the Rhizosphere with Bacteria. Annual Review of Phytopathology, 26, 379.