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Effects of Chemical Fertilizer, Algea Compost and Zeolite on Green Bean Yield

Aysun Türkmen*, Yalçın Kütük

Department of Chemistry, Faculty of Science And Art, Giresun University, 28000 Giresun, Turkey

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* Corresponding Author:
E-mail: aturkmen72@hotmail.com

A B S T R A C T

The present study used chemical fertilizer, brown algae compost and zeolite carried out in the field of Giresun Hazelnut Research Center between May-November 2014 in pots according to randomized blog design as three replicate each. Treatment groups were consist of eight different combinations as follow; G1-Control, G2-Zeolite, G3-Compost, G4-Chemical Fertilizer, G5-Zeolite+Compost, G6-Zeolite+Chemical Fertilizer, G7-Compost+ Chemical Fertilizer, G8-Compost+Zeolite+ Chemical Fertilizer. The brown algae (*Cystoseira* sp.) were used as compost material. These combinations were applied to green beans (*Phaseolus vulgaris*). The green beans were seeded by hand to arrange planting depth of 5-6 cm and 20 seeds/m^2. Except control group, each treatment was added fertilizers as 50 g zeolite, 50 g compost, and 25 g chemical according to treatment design. Half of the chemical fertilizers were added at seeding time and the rest after two weeks. Collected soil samples were analyzed right after harvest, the greatest values of treatment groups were determined as; Carbon% G1: 5.08, nitrogen G3: 0.09 ppm, sodium G5: 139 ppm, potassium G6 and G8: 5 ppm, magnesium G2: 1865 ppm, calcium G6: 8.33 ppm, manganese G2: 359 ppm, iron G6 : 16070 ppm, cobalt G6 and G7: 7.91 ppm, copper G2: 17.5 ppm, zinc G8: 28.0 ppm, selenium G7: 4.17 ppm, cadmium G5: 0.08 ppm, lead G4: 5.31 ppm. The greatest harvest value as g/m^2 was obtained from zeolite only group G2 with 273 while the lowest was obtained from Compost only group G3 with 113 g/m^2, obviously showing the effectiveness of zeolite only application moreover, also thinking that better results may get if the present study run for longer period.

Introduction

The lands to be used as agricultural areas are almost extinct on all over the world. Depending on the increased number of population there is now more need of food production to feed this population. Therefore, it is needed to obtain more crops per area and as a result of this there is a dramatic increase in the use of chemical components. As a consequence of this intense use of crop yield and production amount has increased; however, sustainable soil fertility and natural balance have been affected negatively. Consequently, mostly in the economically powerful countries, producers and consumers in many countries have founded organizations and started to prefer agricultural products which are non-toxic to humans and produced with methods which do no harm to environment.

Brown seaweed of *Cystoseira* type is one of these and they generally grow on rocky shores. It is more common in warm, clean and oxygenated seas. Also it is an important trade iodine resource (Çakı, 2009; Altuner, 2010). When the sea algae products stay for a long time under the soil, they decompose easily under natural circumstances and create ample amount of nitrogen (N) and calcium (Ca). Moreover, it involves magnesium (Mg), manganese (Mn), boron (B), iron (Fe), zinc (Zn), copper (Cu) and cobalt (Co). Marine brown seaweed has high capacities of combining and accumulating metals in the environment so it is a good indicator (Davis et al., 2003; Ostapczuk et al., 1997; Krishnani and Ayyappan, 2006). Today, it is known that, marine seaweed is used in agriculture and especially in biological agriculture in many parts of the world to increase fertility and durability, improve soil structure and feed cattle.

In this study, brown algae are buried after being composted. Because compost used in reclamation of the lands used in cultivation has positive effects on plant growth directly and indirectly. For example, it has been observed that the application of compost to the soil results in the increase in quality and fertility of the land and also it helps the development of the plant roots (Güvenç and Yıldırım, 1999). Having the characteristics of humus, composts are obtained by the mineralization due to the microbial decomposition of garbage, animal wastes, tailings like hay or straw, kitchen residues, municipal wastes and organic factory wastes after various operations. These are organic fertilizers that are free of pathogens and smells and looks like heather humus, as they were subjected to aerobic decomposition.

Zeolite as an organic fertilizer was used in this study. In agriculture, only the clinoptilolite type of zeolite $[(Na_3.K_3)(Al_6Si_{30}O_{72}).24H_2O]$ is used. Preventing the washing of NH_4^+ used as a fertilizer, clinoptilolite ensures that NH_4^+ is kept in the soil. Zeolite being in crystal structure, containing alkaline earth cations is an easy and abundant silicate. It is characterized by its nature of losing and gaining water and its cation exchange without a major change in its structure (Altan et al., 1998).

When we classify the green bean *(P. vulgaris*) used as a plant material, we can say the following information about it: Ordo: Fabales, Family: Fabaceae, Genus: Phaseolus, Species: *P.vulgaris*. There are pilous, green compound leaves at its gnarling stem. Butterfly flowers clustering at the axils are white, pink or purple. Green beans are rich with vitamins A, B1, B2, and C. Green beans has also base excess which can neutralize the acid accumulated in human body. Digestibility ratio of green bean is %84.1. Phasol and phaseolin which are found in green bean pods are reported to be holding the same features as insulin that is used to cure diabetes thus these substances are put into use in order to lower the amount of sugar in blood. Cultivation of beans is getting more and more important recent days when the applications of sustainable agriculture and environmentalism are becoming widespread because of its positive features such as nitrogen deposition and correction of the soil structure (Ülker and Ceyhan 2008).

Because of the ignorant and excessive use of the chemical fertilizers and continuously growing the same kind of plant species, the natural structure of the soil is deteriorating; serious problems for agriculture such as soil fatigue arises. The use of organic fertilizer will have an important role in overcoming these problems which result in decrease in quality and fertility. After the applying the compost state of brown seaweed (*Cystoseria* sp.), zeolite, and chemical fertilizer at the same concentrations but with various combinations to the soil and observing the effects on green bean plant (*P.vulgaris*), this study will reveal the most efficient combination for the plant.

Materials and Method

Collecting Cystoseria sp.

Algae (Cystoseira sp.) used in the experiment was collected from the surrounding areas of Hotel New Jasmin which is located in coastline of the Gemiler Çekeği district of Giresun at latitude 40°54'59.02"N and longitude 38°25'09.13" E. Research was conducted using the pots in the area of Giresun Hazelnut Research Center applying Randomized Complete Block Design between May and November in 2014 with three replications.

Preparation of Compost Organic Fertilizer

Handpicked algae was washed with sea water and cleaned from epiphyte, sediment and other organic matter. The samples were carried in polyethylene bags to the laboratory, washed one more time with tap water to remove the salt and contamination, and then aged in fresh water in plastic containers for a day. Then the sample was left to dry (Sivasankari et al., 2006). After drying, the sample was left for fermentation for 25 days to be composted in fermenter under anaerobic condition. At the end of the fermentation the material was milled and analyzed in terms of plant nutrient elements.

Zeolite Material

In the experiments, zeolite clinoptilolite $[(Na_3.K_3)(Al_6Si_{30}O_{72}).24H_2O]$ type belonging to Manisa - Gördes is used as ion exchanger. The dimensions of the materials vary between 5-15 µm. Chemical composition of clinoptilolite were as follows; SiO_2; 71.3, Al_2O_3; 13.6, Fe_2O_3; 1.15, K_2O; 3.50, CaO; 1.96, MgO; 0.70, Na_2O; 0.60, Ag; 0.004 and Ti; 0.02 as percentage, and B; 30 as ppm (Altan et al., 1998).

Chemical Fertilizer

Chemical fertilizer used in the experiment is NPK (20-20-20) fertilizer which is widely employed in agriculture. Fertilizer groups were created in order that a total amount of 25 kg chemical fertilizer would be added to each pot.

Seed Material

The seeds of green bean (*P. vulgaris*) were bought from a company that sells certified seeds. The seeds were kept in their special packets in an atmosphere of 5°C until the beginning of the experiment.

Seeding Method

Research was conducted using the pots in the area of Giresun Hazelnut Research Center applying Randomized Complete Block Design between May and November in 2014 with three replications. Seeding was done by hand in order that 20 seeds/m^2 should be in depth of 5-6 cm on 30^{th} May, 2014. At the seedling stage, each pot was left with six saplings and other conditions were also equalized with this arrangement with the exception of fertilization.

The Fertilization Method

Apart from control group, other pots were given 50g zeolite, 50g compost and 25 g chemical fertilizer in respect to their experimental group. Half of the chemical fertilizer was added during the planting, the other half was added two weeks after the planting. Combinations of Experimental Group are shown in Table 1.

Analytical Methods

While some of the material analyses used in the experiment were performed by a Private Laboratory and some of them were performed by Giresun University Central Research Laboratory Research and Application Center. In soil samples, the levels of Mg, Ca, Mn, Fe, Co, Cu, Zn, Se, Cd, Pb were analyzed as ppm by ICP-MS and C, H, N levels were analyzed as percentage by Elemental analyzer. Organic matter in Cystoseira, compost and soil samples were analyzed by dry-ashing method as percentage, and in soil samples, Na by flame photometry, K by K_2O(ppm) x 0,83 and total P by Ascorbic Acid Method as ppm, and salt(ppt), EC (µS/cm) and pH by multiprobic measurement. In *Cystoseira* and compost samples, total humic+fulvic acid was analyzed by TS 5869 ISO 5073 as percentage, soluble K_2O, total and soluble B by ICP-MS as ppm, $CaCO_3$ by Scheibler calsimetric as percentage. In soil samples, P was analyzed by TS 8340 (Olsen) as ppm, K_2O by TS 8341 (ammonium acetate) as kg/da, moisture by TS ISO 11465

(Gravimetric) as percentage, pH by TS ISO 10390, EC by TS ISO 11265 as dS/m, salt by TS 8334 as ppt, lime by TS 8335 ISO 10693 (Scheibler Calsimetric) as percentage, B by TS ISO 14870 ICP-OES (DTPA) as ppm and class structure by TS ISO 11270.

Statistical Calculations

The mean and standard error values of soil, compost and seaweed samples were calculated. Data was analyzed by one-way analysis of variance (ANOVA) (Şenocak, 1998; Özdamar, 1999). All statistical analyses were performed via "SPSS" and "Statistica" software.

Results and Discussion

Results of Analyses of Brown Seaweed, Compost and Initial Soil

In this study, physical and chemical features of compost, brown seaweed and initial soil were examined and the results are presented below in Table 2, 3. In this study, physical and chemical features of compost, brown seaweed and initial soil were examined. It was found out that salt which was normally 42.7 ppt in seaweed, decreased to 7.79 ppt when composted. Soil salinity has an adverse effect on plant respiration, transpiration and water intake, which results in destruction in the hormonal balance, decrease in photosynthesis and protein level, and height of the plant is reduced (Dölarslan and Gül, 2012). Its pH level increased to 7.8 from 7.4 when it was compost state. While *Cystoseira* sp. consists of 0.02 ppm P, 2.21% N, 12.9 ppm Zn, 9.28 ppm Se, 0.06 ppm Cd on average when it is in dry state, in compost state it includes 0.79 ppm phosphorus, 3.19% nitrogen, 23.2 ppm zinc, 10.3 ppm selenium, 0.17 ppm cadmium.

Results of Analysis of the Experiment Groups

Eight combinations were created in the experiment. These combinations and the results of the soil analysis of these groups were presented in Table 4. While the most organic matter content is observed in G4 and G5 with 10%, the least is observed in G1 with 8%. The highest pH amount is observed in G5 with 7.19 and the lowest pH amount is observed in G4 with 6.49. With the addition of chemical fertilizer, pH values of G4, G7 and G8 decreased and the setting became slightly acidic. While urea applied to the soils had a basic effect in the beginning, as the last effect nitric acid is formed in the soil and it has an acidic effect in the soil (Topbaş, 1987). N% rate is found high in compost, namely is group G3. It is observed that there has been a decrease in the amount of salt and an increase in parameters such as N, P, pH, lime and moisture, when the results of about the moss after it was composted in its natural state are examined.

The total amount of the iron in the algae used in the experiment was measured as 2458 ppm while amount in the compost obtained from this alga is measured as 1982 ppm. The changes in the amount of *Cystoseira barbata*'s iron existing in dry matter has been examined and the amount of iron was reported in January as 3100 ppm, in March as 2600 ppm, in May as 2880 ppm, in July as 2770 ppm, in September as 1200 ppm and in November as 2100 ppm (Atay, 1978). Our results also show similarities with this study. P value is found high in G4, chemical fertilizer; and Na value is high in zeolite, compost group, G5. K and K_2O values were higher than the others in G6, zeolite+ chemical fertilizer. Potassium level was measured as 86 ppm in zeolite. The effects of soil conditioners and organic fertilizers on the fertility of hazelnut trees were researched and the potassium amount in the soil including clinoptilolit+organic fertilizer was found as 75/94 kg/da (Özyazıcı et al., 2010). The results of that research are consistent with our study. The highest values of Mn, Na, Ca, Mg, Fe, Cu, Co elements were found high in the soil in which zeolite and chemical fertilizer were added. In a study, researchers have examined whether zeolite facilitates effectiveness of the use of water and fertilizer in spinach production and came up with positive results (Burriesci et al., 1984). In another study, researchers found positive results for the water and fertilizer economy about tomato plants grown in hydroponic environment with natural zeolite (Gonzales, 1988).

Table 1 Combinations of experimental group

Groups	Component
G1	Control (soil)
G2	Soil + Zeolite
G3	Soil + Compost
G4	Soil + Chemical fertilizer
G5	Soil + Zeolite + Compost
G6	Soil + Zeolite + Chemical fertilizer
G7	Soil + Compost + Chemical fertilizer
G8	Soil + Zeolite + Compost + Chemical fertilizer

Table 2 Some of the chemical and physical properties of brown seaweed and compost.

Parameter	Brown seaweed	Compost
Organic matter (%)	71	68
pH	7.40	7.80
EC(dS/cm)	1.36	1.22
THFA	36.3	34.3
K_2O (%)	3.06	2.57
Lime (%)	2.29	2.82
Salt (ppt)	42.7	7.79
Moisture (%)	*	14.3
N (%)	2.21	3.19
P (ppm)	0.02	0.79
Bor (ppm)	1617	9.62
Soluble Boron (ppm)	1502	1.25
Na (ppm)	399	361
K (ppm)	5234	825
Mg (ppm)	7409	6660
Ca (ppm)	587	427
Mn (ppm)	138	62.5
Fe (ppm)	2458	1982
Co (ppm)	1.57	1.00
Cu (ppm)	5.89	5.19
Zn (ppm)	12.9	23.2
Se (ppm)	9.28	10.3
Cd (ppm)	0.06	0.17
Pb (ppm)	1.09	0.69

*Not found; Total humic and fulvic acid (%)

Table 3 Some of the chemical and physical properties of first soil material (ppm).

Parameter	Result	Parameter	Result	Parameter	Result
pH	7.13	Silt %	31.7	Mn (ppm)	348
EC (dS/m)	0.22	Sand %	51.3	Fe (ppm)	14808
Organic matter (%)	10.5	P (ppm)	0.01	Co (ppm)	7.56
C %	5.08	Bor (ppm)	<0.001	Cu (ppm)	16.7
H %	0.23	K_20 (ppm)	88	Zn (ppm)	25.9
N %	0.05	K_20 (Kg/Da)	26.8	Se (ppm)	3.74
Salt %	0.008	Na (ppm)	47	Cd (ppm)	0.02
Lime %	1.24	K (ppm)	4.00	Pb (ppm)	4.88
Texture	TIN	Clay %	17.0	Mg (ppm)	1595
Moisture %	4.62	Ca (ppm)	4.03		

Table 4 Results of the analysis performed in experiment groups

Parameters	G1	G2	G3	G4	G5	G6	G7	G8
Organic Matter (%)	8.00	9.50	9.50	10.00	10.00	9.00	9.50	9.00
C %	5.08	3.83	4.22	4.01	3.36	3.33	4.99	2.23
H %	0.23	0.12	0.35	0.44	0.09	0.11	0.17	0.17
N %	0.05	0.01	0.09	0.04	*	0.01	0.06	0.03
Salt %o	0.08	0.07	0.08	0.06	0.05	0.10	0.08	0.09
Lime %	1.24	1.05	1.34	1.48	1.29	1.34	1.43	1.62
Moisture %	4.62	4.77	4.67	5.16	4.64	4.65	4.65	4.70
pH	7.13	7.09	7.14	6.49	7.19	7.05	6.66	6.92
EC (dS/m)	0.22	0.18	0.21	0.19	0.14	0.27	0.23	0.24
Clay %	17.0	16.33	18.9	16.9	17.7	18.9	18.3	18.3
Silt %	31.7	34.5	32.9	32.3	30.9	30.3	31.7	33.7
Sand %	51.3	49.2	48.0	50.7	51.3	50.7	50.0	48.0
Total P (ppm)	0.01	0.02	0.02	0.07	0.02	0.04	0.02	0.25
Boron (ppm)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Na (ppm)	47	54	49	42	139	37	56	21
K (ppm)	73.4	86.1	72.6	222	116	247	210	208
K_20 (Kg/Da)	26.8	31.4	26.5	80.8	42.2	90.2	76.4	75.9
Ca (ppm)	4.03	7.26	3.69	2.00	1.79	8.33	1.17	0.75
Mg (ppm)	1595	1865	1682	1477	1582	1828	1668	1534
Mn (ppm)	348	359	330	321	339	344	351	343
Fe (ppm)	14808	15729	15263	14798	14827	16070	15257	15075
Co (ppm)	7.56	7.90	7.33	7.19	7.47	7.91	7.91	7.50
Cu (ppm)	16.7	17.5	17.3	16.0	16.7	17.4	17.1	16.9
Zn (ppm)	25.9	25.7	26.6	26.9	25.9	27.6	26.3	28.0
Se (ppm)	3.74	3.67	2.98	2.79	3.21	3.14	4.17	2.92
Cd (ppm)	0.020	0.017	0.024	0.024	0.083	0.024	0.018	0.022
Pb (ppm)	4.88	4.63	4.97	5.31	5.01	4.62	4.83	5.23
Texture	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN

*Found, but under the limits, G1: Control, G2: Zeolite, G3: Compost, G4: Chemical Fertilizer, G5: Zeolite + Compost, G6: Zeolite + Chemical Fertilizer, G7: Compost + Chemical Fertilizer, G8: Compost + Zeolite + Chemical Fertilizer

Statistical Analysis of Heavy Metal Concentrations

Statistical calculations of heavy metal contents of the soil samples in different combinations were calculated according to ANOVA (Table 5). The heavy metal concentrations at the highest values for the experimentation groups were shown in the chart. The elements with the highest amount in experimental groups are: Mn and Cu in zeolite, Fe and Co mostly in zeolite + chemical fertilizer; Zn in compost+ zeolite + chemical fertilizer; Se in Compost + chemical fertilizer; Cd in zeolite + chemical fertilizer; Pb in zeolite+compost. There is a statistically meaningful relationship among the ones represented with different letters from top to bottom ($P<0.05$).

When we examine statistically, it is found out that there is not an important difference among experimental groups for Mn, Se, Cd, Pb and Zn elements. While there is not a meaningful difference among G1, G4 and G5 for Fe element, a statistically meaningful difference between G6 and Fe is defined ($P<0.05$). There is a meaningful difference between G4 and G6, G7 for Cu element. And for Cu element there is meaningful difference between G2 and G4 experimental groups ($P<0.05$).

Table 5 Statistical calculations of heavy metal contents of the soil samples in different combinations.

	Mn	Fe	Co	Cu	Zn	Se	Cd	Pb
G1	348 [a]	14808[a]	7.56 [ab]	16.7[ab]	25.9 [a]	3.74 [a]	0.02 [a]	4.88 [a]
G2	359 [a]	15729 [ab]	7.90 [ab]	17.5[b]	25.7 [a]	3.67 [a]	0.02 [a]	4.63 [a]
G3	330 [a]	15263 [ab]	7.34 [ab]	17.3[ab]	26.6 [a]	2.98 [a]	0.02 [a]	4.97 [a]
G4	321 [a]	14798 [a]	7.19 [a]	16.0[a]	26.6 [a]	2.79 [a]	0.02 [a]	5.31 [a]
G5	339 [a]	14827[a]	7.47 [ab]	16.7[ab]	25.9 [a]	3.21 [a]	0.08 [a]	5.01 [a]
G6	344 [a]	16070 [b]	7.91 [b]	17.4[ab]	27.6 [a]	3.14 [a]	0.02 [a]	4.62 [a]
G7	351 [a]	15257 [ab]	7.91 [b]	17.1[ab]	26.3[a]	4.17 [a]	0.02 [a]	4.83 [a]
G8	343 [a]	15075 [ab]	7.50 [ab]	16.9[ab]	28.0 [a]	2.92 [a]	0.02 [a]	5.23 [a]

The Yield Analysis of the Green Bean

The green beans were harvested three times and the average yields to groups were found as following: G1: 133; G2: 273; G3:113; G4:174; G5: 250; G6:166; G7: 232; G8: 135 gr/m^2. The highest yield was in G2 (zeolite), while the lowest yield was in G3 (compost). The amount of the harvest is also high in group G5 in which zeolite and compost added to the soil. When added chemical fertilizers, an increase in yield was observed. However when compost is used with zeolite and chemical fertilizers, it was observed that yield decreased and lowered to the same level with the G1 control group. In a previous research the effect of fresh chicken manure (TTG), mature chicken manure (OTG) and Zeolite (Z) on wheat corn yield was studied and it was found out that when zeolite was applied fertility of wheat planted after corn increased to 40,72%; and when OTG and OTG+Z were applied, the fertility increased 44,07% and 57,96% respectively. Considering the average numbers obtained in different years, it can be concluded that there has been an increase in the fertility (Gümüş and Şeker, 2014).

This study reveals that usage of seaweed as organic fertilizer is sufficient for plant nutrition elements while its solid fertilizer form is richer in plant nutrition elements. However, a long time is required for the solid fertilizer form which may decrease the demand for it. One of the difficulties is that seaweed, as a raw material, does not meet the demand. Therefore attempts for seaweed cultivation should be given more importance. Moreover if conducted for an extended time period of many years, this study, which was done with different experimentation groups, might enlighten us better with respect to fertility.

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