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Effects of Organic and Mineral Fertilizers on Yield and Nutritional Status of Lettuce

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The effects of different organic and mineral fertilizers were investigated on yield and nutritional status of lettuce. Yield of lettuce was measured and total nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, manganese and copper were analyzed to determine the effects of different fertilizers [liquid poultry manure (LPM), solid poultry manure (SPM), blood meal (BM) and mineral fertilization (MF)] in two different periods. Yields were increased by fertilizer applications in the rate of 17.0 and 221.2 % when compared with the control values in two different periods. While the highest yield in autumn experiment was determined at LPM 300 kg da^{-1} + SPM 300 kg da^{-1}, the highest yield in spring experiment was determined at mineral fertilization. While the most effective fertilizers on yield were the ones with high phosphorus content in autumn experiment, fertilizers with high in nitrogen content were the most effective in spring experiment. It was determined that seasonal effects (*i.e.* temperature) might be important on the selection of combinations and amounts of organic fertilizers. As far as the nutrient elements content of lettuce leaves is concerned; N, P, K, Ca and Mg contents of lettuce leaves were insufficient in both the spring and autumn experiments, but Fe, Mn, Zn and Cu contents of leaves were sufficient. These results indicated that the present fertilizer applications were insufficient for a higher productive lettuce growth. Particularly, in organic farming; it was seen that the combinations of different organic fertilizers were important for sufficient and balanced plant nutrition and that seasonal conditions might have considerable effects on the effectiveness of the fertilizers.

Key Words: Organic farming, Nutrient elements, Organic fertilizers, Nitrogen content, Phosphorus content, N/P Ratio.

INTRODUCTION

Lettuce is one of the most widely planted and consumed salad vegetables. Lettuce responds well to a moist and rich soil, full exposure to sun and cool weather conditions. Nutrient availability is relatively more

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important for lettuce compared to other plants since it has a small root system[1]. The production of high-quality lettuce depends to a great extent on soil fertility. Under most conditions, lettuce shows a pronounced yield and quality response to fertilizers[2], but plants fertilization in large quantities results in excess nutrient presence in soil[3]. Especially the excess of nitrogen fertilization lead to accumulation of nitrate predominately in green leafy part of the plants[4,5]. Nitrate can be reduced to nitrite in plants. When they consumed by humans, nitrite can cause a respiratory disfuction called methaemoglabinema[6,7]. It may also be responsible for the formation of carcinogenic nitrosamines[8]. To eliminate the negative effects of mineral fertilizers, organic farming that requires utilization of organic fertilizers has gained popularity in recent years. Consequently, researches have increased on the effects of organic and mineral fertilizers in plant growing.

In a study in which the effects of different organic fertilizers and mineral fertilization on potato quality was investigated, Roinila *et al.*[9] found that the mineral-fertilized potatoes showed a lower dry matter content than the organic-fertilized potatoes. They also reported that in contrast to farmyard manure, the high application rate of mineral fertilizer raised the concentration of nitrogenous compounds (nitrate and free amino acids) in potato.

Mohamed and Abdu[10] conducted an experiment to investigate the effects of irrigation and organic fertilization on growth and oil production of fennel. They reported that all organic fertilizers (chicken manure, cattle manure and plant compost) increased plant growth and yield parameters. Ceylan *et al.*[11] found that the application of cattle and chicken manure increased tuber yields by 21 and 22 %, respectively compared with control. They also pointed that maximum N, K, Ca content of leaves and N, Ca content of tubers was determined at 2 t da^{-1} chicken manure and 6 t da^{-1} cattle manure doses.

It is known that organic fertilizers must continuously be used in organic farming, but the effects of organic fertilizers on yield and nutritional status of plants change during the year. Therefore, the combinations of this fertilizers need to be replanned depending on seasons. For this purpose, this study was conducted to investigate the effects of different organic fertilization practices and mineral fertilization on yield and nutritional status of lettuce grown in two different seasons (autumn and spring).

EXPERIMENTAL

Experiments were conducted in autumn of 2000 (14 November 2000) and in spring of 2001 (22 March 2001) at Akdeniz University, Agricultural Faculty, Research Station, Antalya, Turkey. To observe effects of different organic and mineral fertilization on yield and nutritional status of lettuce in two different seasons (autumn and spring), the spring experiment was conducted in the same plots that had been used for the autumn experiment. Therefore, the soil had tested to determine its fertility in the beginning of autumn and spring seasons. For this purpose, soil samples were taken from the study area in the beginning of autumn experiment. Soil samples were analyzed for physical and chemical properties. The soil of used area in the beginning of autumn experiment was a Lithic Xerorthent (Entisol) having the following chemical and physical properties before the application of the treatments; clayey textured (434.4 g kg^{-1} clay, 300.0 g kg^{-1} silt, 261.6 g kg^{-1} sand), pH 7.6 (1.0:2.5 soil:water ratio), electrical conductivity (EC) 2.55 dS m^{-1}, 35.8 g kg^{-1} organic matter, total carbonates equivalent to 61.7 g kg^{-1}, total N 0.26 %, extractable P 1.27 mg kg^{-1}, extractable K 347.1 mg kg^{-1}, extractable Ca 5492 mg kg^{-1}, extractable Mg 171.6 mg kg^{-1}, DTPA-extractable Fe 3.08 mg kg^{-1}, DTPA-extractable Mn 16.3 mg kg^{-1}, DTPA-extractable Zn 1.37 mg kg^{-1} and DTPA-extractable Cu 1.33 mg kg^{-1}. The soil used in the experiments was chemically analyzed after they had been air-dried and passed through a 2 mm sieve. Total carbonates were determined according to the calcimeter method of Nelson[12]. Soil texture was determined by hydrometer method[13] and organic matter by the Walkley-Black[14]. EC was determined according to Rhoades[15]. Total N was determined by modified Kjeldahl procedure[16]. Extractable P content was extracted by $NaHCO_3$[12] and determined by a molibdate colorometric method[17]; extractable K, Ca and Mg were extracted with NH_4-OAc and determined by atomic absorption spectrophotometry (AAS)[16]. Soil Fe, Mn, Zn and Cu were extracted with DTPA[18] and then determined in the obtained extract by AAS. Also, soil samples were taken from each application plot in the beginning of spring experiment and then analyzed for some physical and chemical properties. Some physical and chemical properties of soil samples are given in Table-1.

This region, which is situated at Akdeniz University, Agricultural Faculty, Research Station, Antalya has a climate of mild, rainy winters and hot, dry summers. Monthly climatic records for the research station during the experiments are given in Table-2. Mean temperatures during the spring experiment (22 March 2001-25 June 2001) were higher than the autumn experiment (14 November 2000-3 March 2001). In addition, the precipitation during the autumn experiment was higher than the spring experiment.

8 Treatments in both the autumn and spring experiment were applied. According to the results of soil analysis in the beginning of spring experiment, treatment applications and their rates for spring experiment were replanned. Treatment applications and their rates for two different plantation times (autumn and spring) were given in Table-3. Fertilizers and treatment applications were selected based on the economy, the obtainable and the content of fertilizers and the present local farmer applications.

TABLE-1
SOME PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL SAMPLES TAKEN FROM EACH APPLICATION PLOT IN THE BEGINNING OF SPRING EXPERIMENT

Applications	pH	Org. mat. (%)	EC (dS m^{-1})	Total N (%)	Mg kg^{-1}							
					P	K	Ca	Mg	Fe	Mn	Zn	Cu
Control	7.83	2.70	2.47	0.22	1.32	308.1	5412	208.8	3.49	14.27	1.27	1.83
LPM 500 $kgda^{-1}$	7.91	2.74	1.97	0.27	7.38	284.7	5384	186.0	3.83	14.22	0.99	1.42
LPM 750 $kgda^{-1}$	7.88	3.82	2.02	0.34	24.20	292.5	5412	198.0	3.72	15.83	1.37	1.88
LPM 300 $kgda^{-1}$+SPM 200 $kgda^{-1}$	7.73	2.96	2.31	0.32	37.00	335.4	5370	198.0	3.88	18.57	1.36	2.27
LPM 300 $kgda^{-1}$+SPM 300 $kgda^{-1}$	7.83	3.02	2.13	0.26	7.38	284.7	4986	193.2	4.04	17.64	1.52	2.58
LPM 300 $kgda^{-1}$+BM 50 $kgda^{-1}$	7.82	3.84	2.22	0.25	5.02	292.5	5584	187.2	3.62	15.63	0.86	2.12
LPM 300 $kgda^{-1}$+BM 75 $kgda^{-1}$	7.87	2.63	2.21	0.25	9.78	292.5	5582	212.4	3.64	15.39	0.91	1.65
MF (15 kg N da^{-1})	7.71	2.41	2.89	0.35	2.98	312.0	5292	181.2	3.30	16.41	1.19	2.15

TABLE-2
MONTHLY CLIMATIC RECORDS FOR RESEARCH STATION IN ANTALYA DURING THE AUTUMN AND SPRING EXPERIMENTS

Month	Year	Mean temperature (°C)	Average 1980-2000	Precipitation (mm)	Average 1980-2000
November	2000	16.3	14.0	312.4	179.4
December	2000	11.8	10.8	154.0	241.3
January	2001	11.4	9.2	217.7	195.5
February	2001	11.5	9.6	96.2	138.8
March	2001	15.9	11.7	9.5	117.1
April	2001	16.8	15.6	97.3	52.8
May	2001	21.7	20.1	62.0	29.9
June	2001	25.6	25.1	0.0	9.2

TABLE-3
FERTILIZERS AND AMOUNTS APPLIED IN AUTUMN AND SPRING EXPERIMENTS

Autumn experiment	Spring experiment
Control	Control
LPM 500 kg da^{-1}	LPM 420 kg da^{-1}
LPM 750 kg da^{-1}	LPM 630 kg da^{-1}
LPM 300 kg da^{-1} + SPM 200 kg da^{-1}	LPM 420 kg da^{-1} + SPM 200 kg da^{-1}
LPM 300 kg da^{-1} + SPM 300 kg da^{-1}	LPM 420 kg da^{-1} + SPM 300 kg da^{-1}
LPM 300 kg da^{-1} + BM 50 kg da^{-1}	LPM 420 kg da^{-1} + BM 50 kg da^{-1}
LPM 300 kg da^{-1} + BM 75 kg da^{-1}	LPM 420 kg da^{-1} + BM 75 kg da^{-1}
MF (15 kg N da^{-1})	MF (15 kg N da^{-1})

LPM = Liquid poultry manure BM = Blood meal
SPM = Solid poultry manure MF = Mineral fertilization

Solid poultry manure (SPM), liquid poultry manure (LPM) and blood meal (BM) as organic fertilizers and ammonium nitrate (33 % N) as mineral fertilizer were used for treatments in the study. The contents of used SPM, LPM and BM are given in Table-4.

TABLE-4
NUTRIENTS CONTENT OF USED SPM, LPM AND BM

Organic fertilizers	%					mg kg^{-1}			
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
BM	12.90	0.15	1.41	1.20	0.37	631.4	65.6	143.4	24.0
LPM	3.36	0.12	0.24	0.31	0.03	29.1	34.5	15.4	9.4
SPM	4.20	3.35	2.55	2.65	1.33	249.0	761.2	247.8	159.3

LPM = Liquid poultry manure; SPM = Solid poultry manure; BM = Blood meal

Lital lettuce cultivars (cos type) were used in the experiments. Seeds were germinated in turf. After the seedlings reached the stage of transplanting, the seedlings were transplanted to 1.8 m^2 plots with a 0.30 m in row and 0.30 m between rows plantation design. The experiments were designed according to a completely randomized parcel design with three replications for each treatment application.

The used SPM and BM in organic fertilization practices were broadcasted to the soil surface and mixed with it before plantation. LPM was applied with the drip irrigation system during the growing seasons once a week. The used ammonium nitrate (33 % N) in mineral fertilization was applied with the drip irrigation system during the growing seasons once a week.

Harvested plants were weighed and yields were calculated. Randomly selected 3 lettuce plants were collected from each plot for element analysis and transported to the laboratory in closed polyethylene bags. In order to eliminate surface contamination, the samples were carefully washed by distilled water. Leaves of the samples were dried in a forced-air oven at 65 ºC to constant weight. The dried samples were ground in a stainless steel mill to pass through a 20 mesh screen and kept in clean polyethylene bags for analysis. The oven-dried-ground samples of 0.5 g were wet digested with 10 mL HNO_3:$HClO_4$ (4:1) acid mixture on a hot plate. The samples were then heated until a clear solution was obtained. The same procedure was repeated several times. The samples were filtered and diluted to 100 mL using distilled water. Concentrations of K, Ca, Mg, Fe, Mn, Zn and Cu contents in the digest were determined by using AAS[19]. Phosphorus was measured by spectophotometry[20] and nitrogen was determined by Kjeldahl procedure[19].

Statistical analyses were performed on all data by using MINITAB 13.32 (Minitab Inc., PA, USA). One-way analysis of variance (Anova) was used to evaluate the statistical difference of treatment means. The level of significance was set at $p < 0.05$. Duncan's multiple range test was conducted for pairwise comparisons.

RESULTS AND DISCUSSION

Mean values of the yield and nutrient element contents of lettuce leaves as a function of the different organic and mineral fertilization are presented in Table-5 for autumn experiment and Table-6 for spring experiment. Compared with the control application, yields increased with all the organic and mineral fertilization in both autumn and spring experiment. In the autumn experiment, the highest yield was obtained with LPM 300 + SPM 300 kg da^{-1} and the second highest yields were obtained with LPM 750 kg da^{-1}, LPM 300 + SPM 200 kg da^{-1} and LPM 300 + BM 75 kg da^{-1}; the third order yields were obtained with LPM 500 kg da^{-1} LPM 300 + BM 50 kg da^{-1} and MF (Table-5). In the spring experiment, MF increased the yield more than the organic applications did. The highest yield was obtained with MF. The highest yields from organic fertilization practices were obtained with LPM 420 + SPM 300 kg da^{-1} and LPM 420 + BM 75 kg da^{-1} (Table-6). The findings revealed that the different organic fertilization practices and mineral fertilization significantly increased the lettuce yields. The yields with fertilizer applications increased in the rate of about 42.1 to 221.2 % in autumn experiment compared with the control application. Organic fertilization practices increased the yield more than the mineral fertilization. The yield increase was achieved not only with amount of organic fertilizers but also with their different combinations. The most effective results were obtained from the LPM and SPM compositions. It seems that yield increase by different compositions of organic fertilizers

TABLE-5

EFFECTS OF DIFFERENT FERTILIZATION PRACTICES AND MINERAL FERTILIZATION ON YIELD AND NUTRIENTS CONTENTS OF LETTUCE LEAVES IN AUTUMN EXPERIMENT

Applications	Yield (kg da^{-1})	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	N/P
Control	739.5 c*	2.28 b	0.21 cd	4.53	1.47	0.25 bc	128.3	73.1a	28.3c	14.5c	10.90c
LPM 500 $kgda^{-1}$	1442.0bc	2.27 b	0.30 a	5.05	1.49	0.28 bc	155.1	85.4a	30.0c	22.1bc	7.59de
LPM 750 $kgda^{-1}$	1778.6ab	2.36 b	0.27 ab	5.09	1.40	0.27 bc	176.2	84.0a	37.5abc	21.8bc	8.75de
LPM 300 $kgda^{-1}$+SPM 200 $kgda^{-1}$	1891.3ab	2.15 bc	0.27 ab	4.88	1.32	0.23 c	186.1	77.0a	33.6bc	17.5bc	8.06de
LPM 300 $kgda^{-1}$+SPM 300 $kgda^{-1}$	2299.9a	2.00 c	0.30 a	4.95	1.40	0.25 c	161.1	84.3a	34.1abc	23.5b	6.63e
LPM 300 $kgda^{-1}$+BM 50 $kgda^{-1}$	1150.2bc	2.16 bc	0.16 d	5.03	1.47	0.31 ab	211.1	76.4a	44.2a	20.9bc	13.33b
LPM 300 $kgda^{-1}$+BM 75 $kgda^{-1}$	1698.8ab	2.29 b	0.25 bc	4.82	1.43	0.35 a	167.8	78.4a	44.0a	20.0bc	9.29cd
MF (15 kg N da^{-1})	1049.8bc	2.88 a	0.16 d	4.06	1.38	0.28 bc	127.0	52.7b	42.5ab	30.6a	17.98a

*Means in the same column followed by the same letter are not significantly different at $p \leq 0.05$ (Duncan's Multiple Range Test)

TABLE-6

EFFECTS OF DIFFERENT FERTILIZATION PRACTICES AND MINERAL FERTILIZATION ON YIELD AND NUTRIENTS CONTENTS OF LETTUCE LEAVES IN SPRING EXPERIMENT

Applications	Yield (kg da^{-1})	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	N/P
Control	2300.4c*	2.11b	0.36ab	5.03	1.25	0.28	166.7	83.3ab	63.3bc	9.7bc	5.91bc
LPM 420 $kgda^{-1}$	2691.8bc	2.12b	0.37ab	5.27	1.36	0.30	149.9	95.3a	67.7bc	8.7c	5.80bc
LPM 630 $kgda^{-1}$	2961.7abc	2.18b	0.39ab	5.00	1.24	0.29	132.8	80.3ab	65.8bc	5.1d	5.71bc
LPM 420 $kgda^{-1}$+SPM 200 $kgda^{-1}$	2921.0abc	2.08b	0.38ab	5.21	1.26	0.27	136.6	69.2bc	74.1ab	4.5d	5.46bc
LPM 420 $kgda^{-1}$+SPM 300 $kgda^{-1}$	3839.0ab	2.18b	0.44a	4.75	1.29	0.29	203.2	80.9ab	67.8bc	8.9c	4.94c
LPM 420 $kgda^{-1}$+BM 50 $kgda^{-1}$	3122.4abc	2.11b	0.32b	4.29	1.10	0.27	166.5	70.5bc	66.9bc	9.2bc	6.58bc
LPM 420 $kgda^{-1}$+BM 75 $kgda^{-1}$	3702.4ab	2.26b	0.32b	4.54	1.07	0.28	139.7	71.5bc	59.3c	12.1b	7.13b
MF (15 kg N da^{-1})	4166.6a	2.89a	0.23c	4.79	1.18	0.33	166.0	60.1c	82.9a	15.0a	12.93a

*Means in the same column followed by the same letter are not significantly different at $p \leq 0.05$ (Duncan's Multiple Range Test) was due to the difference in their nutrient contents and different decomposition rates. Therefore, use of different fertilizers and their proper combinations provides an important beneficial effect for organic farming and, in long term, for sustainable agriculture. Also, the increase in the yields was mostly likely to result from the improvement of physical, chemical and biological properties of the soil by the organic fertilization practices[21-23]. In the autumn experiment, the obtained yields by using different organic fertilizers, particularly LPM and SPM compositions, nearly doubled to those of the mineral fertilization. Bulluck *et al.*[23] stated that yields of organic tomato systems following organic melon systems were higher than those of conventional systems in open fields. Çürük *et al.*[24] indicated that protected organic watermelon and melon systems in this Mediterranean region can produce more total and marketable yields than protected conventional systems.

The yields with fertilizer applications increased in the rate of about 17.0- 81.1 % in spring experiment compared with the control application. Mineral fertilization increased the yield more than the organic fertilization practices. In general, the yield values in spring experiment were higher than the yield values in autumn experiment. The increase in the yield values was mostly likely to result from the environmental factors (especially temperature) and the accumulation of fertilizers applied[25,26].

The N contents of lettuce leaves differed significantly between the different organic fertilization practices and mineral fertilization in both of the experiments. The highest N content of lettuce leaves in both autumn and spring experiment was obtained with MF (Tables 5 and 6). In autumn experiment, the lowest N content was obtained with LPM 300 + SPM 300 kg da^{-1}. Control plot samples which showed the lowest yield, had the second highest N content (Table-5). In spring experiment, no significant difference was found among all organic fertilization practices and the effect of organic fertilization practices and control application on N contents of lettuce leaves was similar (Table-6). Worthington[27] indicated that plants grown in organic environments contained less nitrogen than plants grown in conventional agricultural environments since organically managed soil have lower nitrogen than chemically fertilized soils. Clark *et al.*[28] reported that N availability was most important in limiting yields in the organic system.

In this study, the correlation coefficient between yield and N content of lettuce leaves was not significant ($r = -0.517^{ns}$) in autumn experiment. This result indicated a presence of some other important yield affecting factors other than N nutrition. In spring experiment, the application of mineral fertilization from which the highest yield was obtained had the highest N content (Table-6). A relationship between N content and yield was observed. It was determined that the correlation coefficient between the N content and yield was 0.891.

Effects of the different organic and mineral fertilizations were found to be significant for P content of lettuce leaves in both autumn and spring experiment. In autumn experiment, the highest P contents were obtained with applications of LPM 500 kg da^{-1}, LPM 300 + SPM 300 kg da^{-1}, LPM 750 kg da^{-1} and LPM 300 + SPM 200 kg da^{-1}. The lowest P contents were obtained with applications of MF, LPM 300 + BM 50 kg da^{-1} and the control application (Table-5). In spring experiment, while the highest P content was obtained with application of LPM 420 + SPM 300 kg da^{-1}, the lowest P content was obtained with MF (Table-6). In both of the experiments, the lowest P content in lettuce leaves was obtained with application of mineral fertilization. Organic fertilization practices were generally more effective than mineral fertilization (Tables 5 and 6). In autumn experiment, the relationship between P contents and yield of lettuce was found to be meaningful. The correlation coefficient between P content and yield was 0.757 ($p < 0.05$). It is clear that the P content of plants positively correlated with yield. For instance, the lowest yields were obtained with plants having lowest P concentration. It was noticed that especially the combinations of LPM 500 kg da^{-1} and SPM 750 kg da^{-1} lead to better N/P ratio. As the costs of liquid poultry manure application are taken into consideration, it seems that the applications of solid and liquid poultry manure combinations might be useful and economic for production. In spring experiment, the relationship between P content and yield was not observed and the correlation coefficient between P content and yield was -0.218^{ns}. The data indicated that the mineral fertilization where the highest yield was obtained had not the highest P contents of the lettuce leaves.

The N/P ratio in lettuce leaves was higher in autumn experiment than in spring experiment in all applications. At this point, we should mention that higher temperature in spring experiment (Table-2) was one of the effective factors. While N on yield was more effective in spring experiment than in autumn experiment, the effect of P was more limited. However, effect of temperature, as a single factor, does not explain the data obtained completely. We should also consider results indicating an efficient P nutrition in the autumn and an efficient N nutrition in the spring experiment. Especially in organic farming, these findings are evidence that more information is needed for fertilization and that continuous monitoring necessary. Daugaard[29] observed seasonal variations in N, P, K, Ca and Mg contents of organically grown plants.

There was no significant difference in K, Ca and Fe contents of lettuce leaves among the all treatments including the control in both of the experiments (Tables 5 and 6). The Mg contents of lettuce leaves in the autumn experiment differed significantly between the different organic fertilization practices and mineral fertilization. The highest Mg contents were obtained with applications of LPM 300 + BM 75 kg da^{-1} and LPM 300 + BM 50 kg da^{-1} (Table-5). In spring experiment, organic fertilization practices and mineral fertilization did not affect the Mg content of lettuce leaves (Table-6). Worthington[27] reported that plants grown in organic environments contained significantly higher Fe, Mg and P than plants grown in conventional agricultural environments.

The Mn contents of lettuce leaves differed significantly between the different organic fertilization practices and mineral fertilization in both autumn and spring experiment. The lowest Mn content was obtained with MF, but no significant difference was found among the all organic fertilization practices in autumn experiment (Table-5). In spring experiment, the highest Mn contents were obtained with applications of LPM 420 kg da^{-1}, LPM 630 kg da^{-1} and LPM 420 + SPM 300 kg da^{-1} in the different organic fertilization practices, but the effect of these applications and control application on Mn contents of lettuce leaves was similar. The lowest Mn content was obtained with MF (Table-6). The Mn contents of lettuce leaves decreased with the mineral fertilization in both autumn and spring experiments (Tables 5 and 6). This result might be explained with the dilution effect with increasing plant growth. Organic fertilization practices were more effective than mineral fertilization in both of the experiments. Polat *et al.*[30] reported that the effects of organic fertilizers on uptake of the nutrient element from soil were statistically significant and that the amounts of nutrient elements uptake from soil had the highest effect in combinations of solid and liquid poultry manure.

Effects of the different organic and mineral fertilizations were found to be significant for Zn content of lettuce leaves in both of the experiments. In autumn experiment, the highest Zn contents of lettuce leaves were obtained with applications of LPM + BM 50 kg da^{-1} and LPM 300 + BM 75 kg da^{-1}. In general, the Zn contents of lettuce leaves increased with both organic fertilization practices and mineral fertilization (Table-5). In spring experiment, the highest Zn content was obtained with MF while the lowest Zn content was obtained with application of LPM 420 + BM 75 kg da^{-1} (Table-6). The Cu content of lettuce leaves differed significantly between the different organic fertilization practices and mineral fertilization in both autumn and spring experiment. In both of the experiments, the highest Cu content of lettuce leaves was obtained with MF. MF increased the Cu content of lettuce leaves (Tables 5 and 6). As far as Cu content of lettuce leaves is concerned, the organic fertilization practices were more effective than control application, but mineral fertilization was the most effective application in both of the experiments. This result might be due to synergetic effect between N and Cu[26]. In addition, with increasing N concentration, which was appeared to be the most limited factor in the mineral fertilization, Zn and Cu contents increased in spite of dilution effect. This may be explained with fast root growth as a result of the recovery effect of N nutrition.

As we evaluated the contents of nutrient elements according to Jones *et al.*[31], the N, P, K, Ca and Mg contents of lettuce leaves were insufficient in both the spring and autumn experiment, but Fe, Mn, Zn and Cu were sufficient. In conclusion, the results of this study indicated that fertilizer applications were insufficient for a high productive lettuce growth. Doses of organic fertilizers were higher than those of our applied organic fertilizers.

It is necessary to have more information about the effectiveness of organic fertilizers. Therefore, further studies will have to be set up with modifies amounts and combinations of materials used in this study and different materials. Especially from the organic farming point of view, studies related to the effectiveness of different organic fertilizers and their combinations in different conditions are needed.

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