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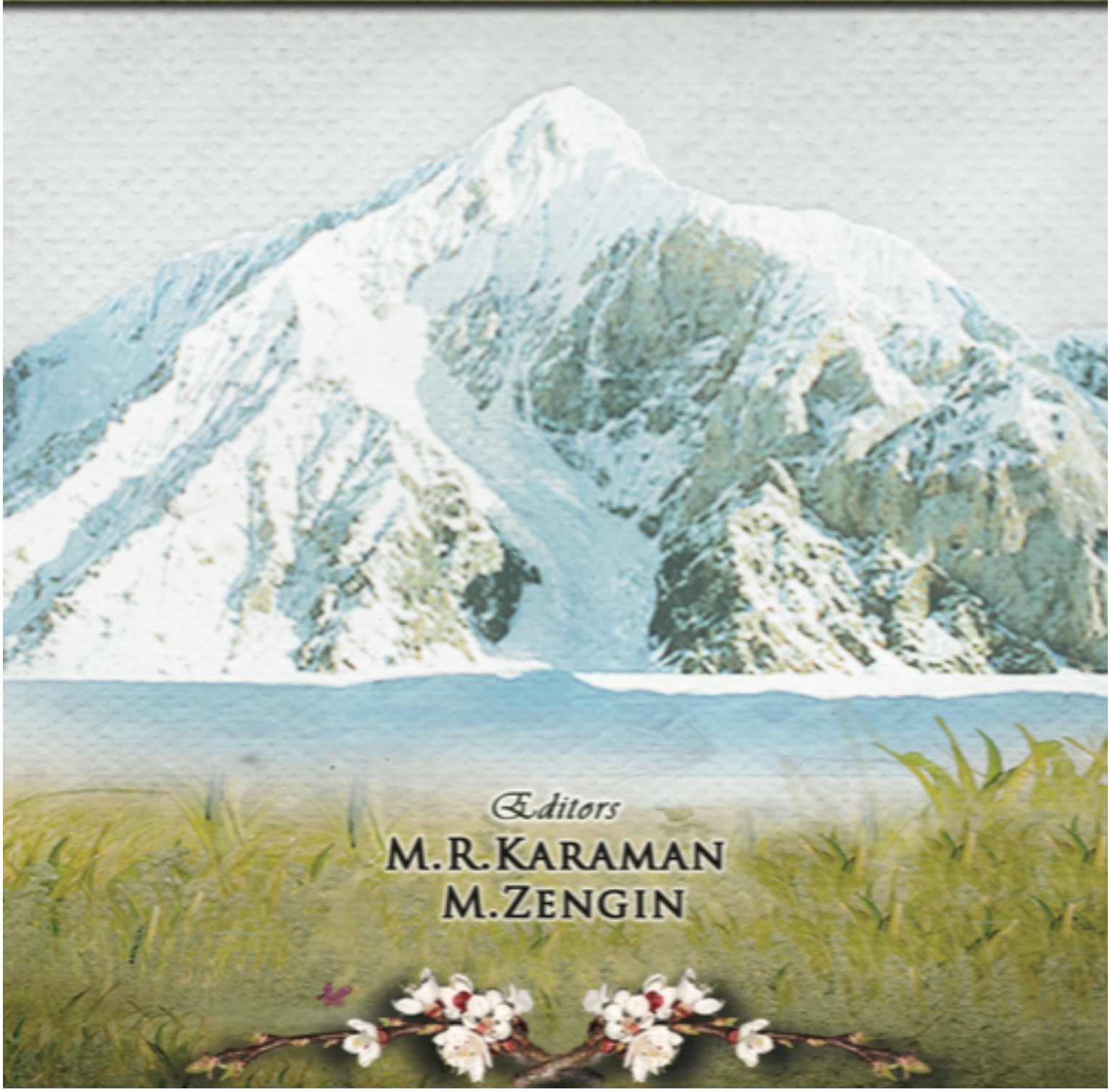

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Effects of Different Mineral Fertilizer Doses on Lettuce (*Lactuca sativa* L.) Yield and Yield Parameters

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Abstract: This study was conducted to aim determined the effects of different mineral fertilizer doses on lettuce plants (*Lactuca sativa* L.) yield and yield parameters. Lettuce plants were grown in pots under the controlled greenhouse conditions, in Erzurum, Turkey. The experimental design consisted of three completely randomized blocks in a factorial arrangement having 3 mineral fertilizer (ammonium sulphate, triple superphosphate, potassium sulphate), 7 different fertilizer doses of 0, 4, 8, 15, 20, 30, 40 kg N da^{-1}; 0, 3, 6, 9, 15, 25, 30 kg P_2O_5 da^{-1}; 0, 3, 6, 9, 12, 15, 20 kg K_2O da^{-1}. Thus, total 63 pots were used in the experiment. Before fertilizers application soil samples were taken from each pot, and some physical and chemical properties of soil were determined. The increasing ratio of dry matter production of plant at 8 kg da^{-1} N application was 42.41%; the increasing ratio of dry matter production of plant at 30 kg da^{-1} P_2O_5 application was 199.64%; the increasing ratio of dry matter production of plant at 12 kg K_2O da^{-1} application was 46.84% compared to control (without fertilizer applications). According to the results, the findings have clearly indicated that lettuce plant dry and wet weight dry matter rate and plant height were widely varied depending on the nitrogen phosphorus, potassium fertilizer application doses.

Keywords: Fertilizer, lettuce, nitrogen, phosphorus, potassium

1. Introduction

To be plentiful and good quality of produced as an agricultural product, it was great importance as balanced as amounts of plant nutrients in the soil (Karaman and Turan, 2012). Plant nutrients in the soil evenly when there are several negative effects on each other during their uptake and plant growth becomes adversely affected. Eating a balanced diet, and the amount of time needed nutrients needed by plants take it. Therefore, determining the soil nutrient status of elements, deficient elements must be provided by fertilization or other sources. Fageria and Baligar (1999) was conducted a study that investigated to 15 wheat plants phosphorus efficiency with application 0 (low P), 75 mg kg^{-1} (moderately P), and 150 mg kg^{-1} (high P). In this study that they observed to be significantly different the terms of phosphorus use. In addition to the other study was made about the subject, they

determined to show significant different the terms of corn plant weight, shoot and root weight, uptake of plant nutrient and use in grown low and high phosphorus.

Lettuce requires to high amounts of nitrogen for growth and development. The high amounts of nitrogen fertilizers has caused adverse effects in the plant and soil pollution (Tehrani and Malakouti, 1997). They reported that nitrogen application significantly increased yield increasing doses up to a level. Tittonell et al. (2003) observed to nitrogen application on lettuce yield significantly increased with increasing concentrations until 150 kg ha^{-1} nitrogen fertilizer doses. Rincon et al. (1998) conducted a study determined to increase the lettuce yield until 100 kg ha^{-1} of nitrogen application, but after 200 kg ha^{-1} of nitrogen application doses, causing significant reductions in the total found in the product. This study was conducted to aim determined the effects of different mineral fertilizer doses on lettuce plants (Lactuca sativa L.) yield and yield parameters.

2. Materials and Methods

Plant Material and Growth Conditions

Lettuce plants (*Lactuca sativa* L.) were grown in pots under the controlled greenhouse conditions, 25-30 °C day/10 °C night temperatures and 30-40 % relative humidity, in Erzurum, Turkey. Day length was approximately 14 h during the experimental period. The soil samples were taken from depth of 0-30 cm from agricultural fields in Erzurum province (39°55' N, 41°61' E) of Turkey, dried indoors until it could be crumbled to pass through 4 mm for pots experiment and 2 mm sieves for analyses of physicochemical properties. Three kg of soils were filled in polyethylene pots (20 cm diameter and 30 cm depth). The experimental design consisted of three completely randomized blocks in a factorial arrangement having 3 mineral fertilizer (ammonium sulphate, triple superphosphate, potassium sulphate), 7 different fertilizer doses (0, 4, 8, 15, 20, 30, 40 kg N da^{-1}; 0, 3, 6, 9, 15, 25, 30 kg P_2O_5 da^{-1}; 0, 3, 6, 9, 12, 15, 20 kg K_2O da^{-1}). Thus, total 63 pots were used in the experiment. Before fertilizers application soil samples were taken from each pot, and some physical and chemical properties of soil were determined (Table 1). Six seeds were sown in each pot and 15 days after emergence seedlings were thinned to one plants per pot. Seeds were sown in pots. No pesticides were applied.

Initially, the soil moisture content of all plots was adjusted to field capacity. Soil water content was carefully controlled with datalogger (testo 175-H2 V01.10). Plants were harvested in each replicate 60 days after sowing, and plant height, plant weight in fresh plant and dry weight were measured. The plant material was dried at 70°C for two days to determine dry weight and macro-micro nutrient contents.

Soil Analysis

To determine initial some physical and chemical properties of soil, soil samples were air-dried, crushed, and passed through a 2-mm sieve prior to analysis. Particle size distribution was determined by the methods described by Page et al.

(1982). Cation exchange capacity (CEC) was determined using sodium acetate (buffered at pH 8.2) and ammonium acetate (buffered at pH 7.0) according to Sumner and Miller (1996). The Kjeldahl method (Bremner, 1996) was used to determine organic N while plant-available P was determined by using the sodium bicarbonate method of Olsen et al. (1954). Electrical conductivity (EC) was measured in saturation extracts according to Rhoades (1996). Soil pH was determined in 1:2 extracts, and calcium carbonate concentrations were determined according to McLean (1982). Soil organic matter was determined using the Smith-Weldon method according to Nelson and Sommers (1982). Ammonium acetate buffered at pH 7 (Thomas, 1982) was used to determine exchangeable cations. Some physical and chemical properties of soil were given Table 1.

Statistical Analysis

The data were subjected to analysis of variance (ANOVA) and mean values separated according to Duncan's multiple range tests using SPSS statistical software (SPSS, 2004).

3. Results and Discussion

Some Physical and Chemical Properties of The Experimental Soil

The results of some of the physical and chemical analysis of soil are given in Table 1. The soils were neutral to slightly alkaline, low in organic matter, nitrogen, phosphorus and lime contents, Clay contents in soils a mean of 33.40%. The CEC ranged from 21.12 cmol kg^{-1} (Anonymous, 1980; FAO, 1990; TOVEP, 1991).

Table 1. Some physical and chemical properties of the experimental soil

Properties	Value
pH (1:2.5 s/w)	7.45±0.35
Organic matter (%)	1.40±0.22
Total N (%)	0.12±0.05
$CaCO_3$ (%)	0.82±0.12
CEC, cmol kg^{-1}	21.12±1,10
K, cmol kg^{-1}	2.42±0.15
Ca, cmol kg^{-1}	12.48±1.13
Mg, cmol kg^{-1}	2.12±0.03
Na, cmol kg^{-1}	0.35±0.01
Available P, mg kg^{-1}	5.20±0.40
Electrical conductivity (dS m^{-1})	1.20±0.03
Sand (%)	30.70±1.12
Silt (%)	35.90±0.95
Clay (%)	33.40±1.40
Texture	Loam

Effects of Nitrogen Doses on Lettuce Plants Yield and Yield Parameters

After the 60 days, lettuce plants were harvested and determined plant wet weight, plant height and plant dry weight (Table 2). As shown in Table 2, data obtained from the study showed that plant wet and dry weight, plant height and dry matter rate of lettuce were significantly ($P<0.01$) affected by nitrogen fertilizer applications.

Table 2. Amounts of plants yield and yield parameters as nitrogen fertilizer

	Plant height, cm	Plant wet weight, gr	Plant dry weight, gr	Dry matter rate, %
0 kg N da^{-1}	16.60b	20.80b	4.81c	23.13e
4 kg N da^{-1}	19.70a	20.90b	6.25a	29.90b
8 kg N da^{-1}	20.70a	21.50a	6.85a	31.86a
15 kg N da^{-1}	17.80b	22.70a	5.83b	25.68d
20 kg N da^{-1}	13.70c	13.90c	4.27c	30.72b
30 kg N da^{-1}	16.30b	14.50c	3.91d	26.97c
40 kg N da^{-1}	11.83d	11.10d	2.38e	21.44f

Dry weight of lettuce plants increased with the nitrogen fertilizer application until 8 kg N da^{-1}, but the next applications of nitrogen doses caused a decrease the amount of lettuce dry matter (Table 2). The highest dry matter production was obtained from 8 kg N da^{-1}. The increasing ratio of dry matter production of plant at 8 kg da^{-1} N application was 42.41% compared to control (without N application). On the other hand dry matter production of the lettuce plant was significantly decreased after at 20 kg N da^{-1} application doses.

Dry matter rate of lettuce plants increased with the nitrogen fertilizer application until 30 kg N da^{-1}, but the next applications of nitrogen doses caused a decrease the amount of lettuce dry matter rate (Table 2). The highest dry matter rate was obtained from 8 kg N da^{-1} (31.86%). The increasing ratio of dry matter rate of plant at 8 kg da^{-1} N application was 37.74% compared to control (without N application). On the other hand dry matter rate of the lettuce plant was significantly decreased after at 40 kg N da^{-1} application doses.

Lettuce plant height and wet weight increased with the nitrogen fertilizer application until 8 kg N da^{-1} and 15 kg N da^{-1}, respectively. But the next applications of nitrogen doses caused a decrease the amount of lettuce plant height and wet weight (Table 2). The highest plant height was obtained from 8 kg N da^{-1} (20.70cm). The increasing ratio of plant height at 8 kg da^{-1} N application was 24.70% compared to control (without N application). The highest plant wet weight was obtained from 15 kg N da^{-1} (22.70gr). The increasing ratio of plant wet weight at 15 kg da^{-1} N application was 9.13% compared to control (without N application).

The similar studies carried out by Rincon et al. (1998) on lettuce showed that increasing nitrogen fertilizer level to 10 kg da^{-1} increased lettuce yield. Tei et all. (2000) applied N fertilizer at different levels for two lettuce cultivars and estimated N fertilizer rate to obtain maximum fresh weight at about 15.5 kg N da^{-1} for both cultivars and they reported that increasing the rate of nitrogen fertilizer significantly increased the dry weight of leaves (Boroujerdnia and Ansari 2007)

Effects of Phosphorus Doses on Lettuce Plants Yield and Yield Parameters

After the 60 days, lettuce plants were harvested and determined effects of phosphorus fertilizer applications on plant wet weight, plant height and plant dry weight (Table 3). As shown in Table 3, data obtained from the study showed that plant wet and dry weight, plant height and dry matter rate of lettuce were significantly ($P<0.01$) affected by phosphorus fertilizer applications.

Table 3. Amounts of plants yield and yield parameters as phosphorus fertilizer

	Plant height, cm	Plant wet weight, gr	Plant dry weight, gr	Dry matter rate, %
0 kg P_2O_5 da^{-1}	14.80e	16.60f	2.80f	16.87e
3 kg P_2O_5 da^{-1}	15.80d	19.30e	3.24e	16.79e
6 kg P_2O_5 da^{-1}	16.16d	22.20d	4.03d	18.15d
9 kg P_2O_5 da^{-1}	17.30c	23.50c	4.70c	20.00c
15 kg P_2O_5 da^{-1}	17.80c	25.60b	5.68b	22.19b
25 kg P_2O_5 da^{-1}	18.67b	28.10a	8.16a	29.04a
30 kg P_2O_5 da^{-1}	19.52a	28.60a	8.39a	29.34a

Dry weight of lettuce plants increased with the phosphorus fertilizer application doses (Table 3). The highest dry matter production was obtained from 30 kg P_2O_5 da^{-1}. The increasing ratio of dry matter production of plant at 30 kg da^{-1} P_2O_5 application was 199.64% compared to control (without P_2O_5 application).

Dry matter rate of lettuce plants increased with the phosphorus fertilizer application doses (Table 3). The highest dry matter rate was obtained from 8 kg P_2O_5 da^{-1} (31.86%). The increasing ratio of dry matter rate of plant at 30 kg P_2O_5 da^{-1} application was 73.92% compared to control (without P_2O_5 application).

Lettuce plant height and wet weight increased with the phosphorus fertilizer application doses (Table 3). The highest plant height was obtained from 30 kg P_2O_5 da^{-1} (19.52cm). The increasing ratio of plant height at 30 kg P_2O_5 da^{-1} application was 31.89% compared to control (without P_2O_5 application). The highest plant wet weight was obtained from 30 kg P_2O_5 da^{-1} (28.60gr). The increasing ratio of plant wet weight at 30 kg P_2O_5 da^{-1} application was 72.29% compared to control (without P_2O_5 application).

Effects of Potassium Doses on Lettuce Plants Yield and Yield Parameters

After the 60 days, lettuce plants were harvested and determined effects of potassium fertilizer applications on plant wet weight, plant height and plant dry weight (Table 4). As shown in Table 4, data obtained from the study showed that plant wet and dry weight, plant height and dry matter rate of lettuce were significantly ($P<0.01$) affected by potassium fertilizer applications.

Table 4. Amounts of plants yield and yield parameters as potassium fertilizer

	Plant height, cm	Plant wet weight, gr	Plant dry weight, gr	Dry matter rate, %
0 kg K_2O da^{-1}	15.80c	22.10e	5.38de	24.34f
3 kg K_2O da^{-1}	17.70b	22.20e	5.88d	26.49d
6 kg K_2O da^{-1}	18.17b	23.80d	6.60c	27.73c
9 kg K_2O da^{-1}	19.30a	24.40c	7.50ab	30.74a
12 kg K_2O da^{-1}	15.67c	26.40a	7.90a	29.92b
15 kg K_2O da^{-1}	15.17c	25.60b	7.10b	27.73c
20 kg K_2O da^{-1}	13.30d	20.12f	5.10e	25.35e

Dry weight of lettuce plants increased with the potassium fertilizer application until 15 kg K_2O da^{-1}, but the next applications of potassium doses caused a decrease the amount of lettuce dry matter (Table 4). The highest dry matter production was obtained from 12 kg K_2O da^{-1}. The increasing ratio of dry matter production of plant at 12 kg K_2O da^{-1} application was 46.84% compared to control (without K_2O application). On the other hand dry matter production of the lettuce plant was significantly decreased after at 20 kg K_2O da^{-1}application doses.

Dry matter rate of lettuce plants increased with the potassium fertilizer application doses (Table 4). The highest dry matter rate was obtained from 9 kg K_2O da^{-1} (30.74%). The increasing ratio of dry matter rate of plant at 9 kg K_2O da^{-1} application was 26.29% compared to control (without K_2O application).

Lettuce plant height and wet weight increased with the potassium fertilizer application until 9 kg K_2O da^{-1} and 15 kg K_2O da^{-1}, respectively. But the next applications of potassium fertilizer doses caused a decrease the amount of lettuce plant height (Table 4). The highest plant height was obtained from 9 kg K_2O da^{-1} (19.30cm). The increasing ratio of plant height at 9 kg K_2O da^{-1}application was 22.15% compared to control (without K_2O application). The highest plant wet weight was obtained from 12 kg K_2O da^{-1} (26.40gr). The increasing ratio of plant wet weight at 12 kg K_2O da^{-1} application was 19.46% compared to control (without K_2O application).

Conclusion

According to this study results, data obtained from the study showed that plant wet and dry weight, plant height and dry matter rate of lettuce were significantly affected by nitrogen, phosphorus and potassium fertilizer doses applications. The increasing ratio of dry matter production of plant at 8 kg da^{-1} N application was 42.41%; the increasing ratio of dry matter production of plant at 30 kg da^{-1} P_2O_5 application was 199,64%; the increasing ratio of dry matter production of plant at 12 kg K_2O da^{-1} application was 46.84% compared to control (without fertilizer applications). According to the results, the findings have clearly indicated that lettuce plant dry and wet weight dry matter rate and plant height were widely varied depending on the nitrogen phosphorus, potassium fertilizer application doses. In general, high level fertilizer decrease to plant dry matter. The results clearly indicated that evaluation of suitable fertilizer doses will improve the plant dry matter and quality properties.

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