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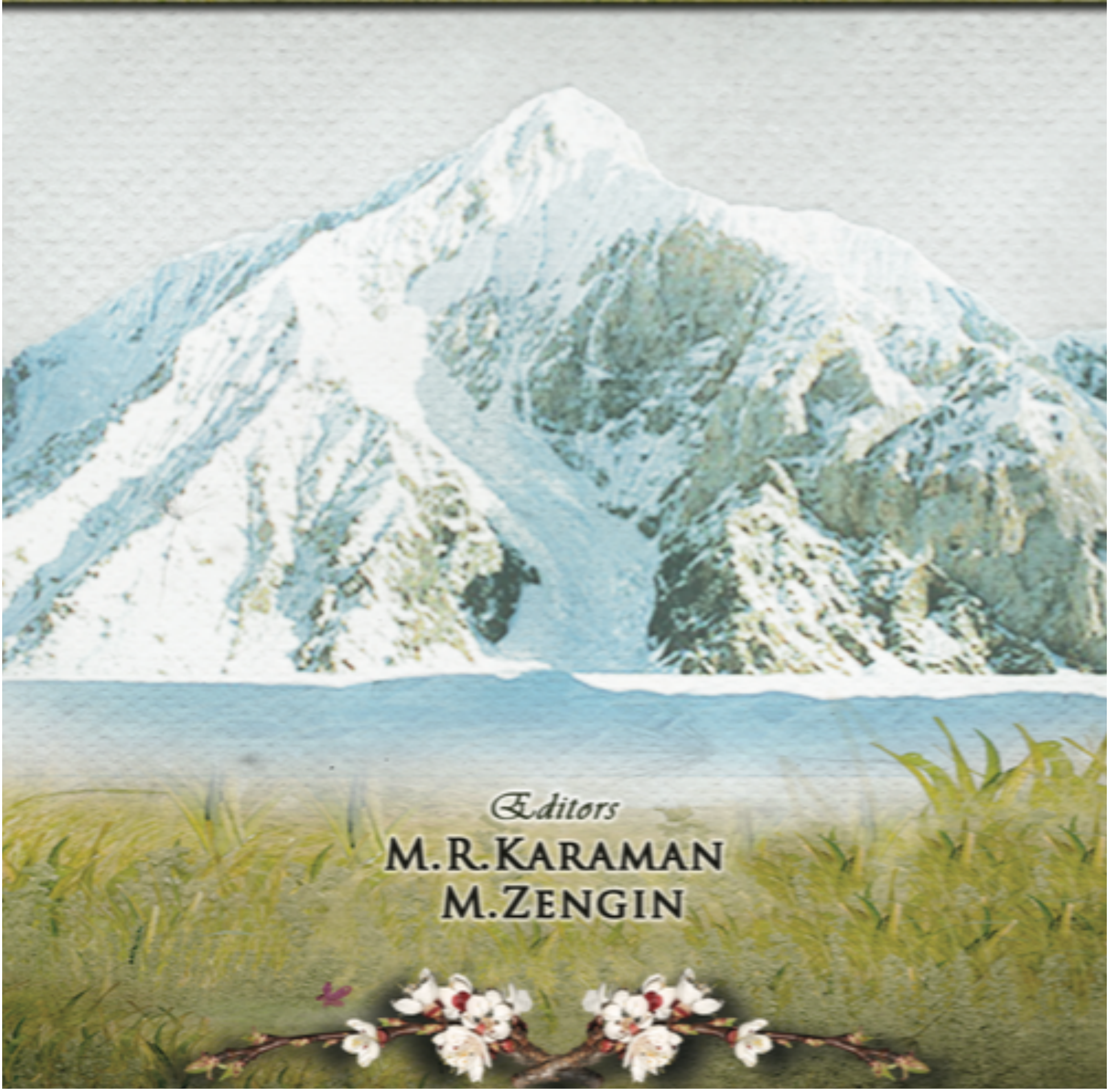

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Effects of Different Mineral Fertilizer Doses on Maize (*Zea mays* L.) Yield and Yield Parameters

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Abstract: This study was conducted to aim determined the effects of different mineral fertilizer doses on mazie plants (*Zea mays* L.) yield and yield parameters. Maize 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 40.90%; the increasing ratio of dry matter production of plant at 15 kg da^{-1} P_2O_5 application was 36.84%; the increasing ratio of dry matter production of plant at 9 kg K_2O da^{-1} application was 43.91% compared to control. According to the results, the findings have clearly indicated that mazie 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, maize, nitrogen, phosphorus, potassium

1. Introduction

Maize (*Zea mays* L.) is the most important silage plants in the world because of its high yield, high energy forage produced with lower labor and machinery requirements than other forage crops (Roth et al., 1995). Many environmental, cultural and genetic factors influence maize forage yield and quality. In Turkey, the agricultural area devoted annually to maize is 593710 hectare which is about 4% of cereal cultivating area and average grain production is 4 274 000 ton per year. Importance of corn production is increasing year by year because of its value for silage production as well as grain production. Maize grain production of Turkey is portioned as follow; about 35% for human nutrient requirement, about 65% for animal feed (Keskin et al., 2005). Traditional ruminant livestock production in Turkey is based predominantly on animals grazing natural pastures with low nutritive value especially during boron deficiency (Orak and Iptas, 1999; Kusaksiz and Kusaksiz, 2005; Yolcu and Tan, 2008, Bulut et al., 2008).

Some of the major causes of low maize yield are declining soil fertility and insufficient use of fertilizers resulting in severe nutrient depletion of soils (Buresh et al., 1997). Maize requires adequate supply of nutrients particularly nitrogen, phosphorus, and potassium for good growth and high yield. Nitrogen is a vital plant nutrient and a major factor required for maize production (Adediran and Banjoko, 1995; Shantı et al., 1997). Nitrogen is a component of protein and nucleic acids and when Nitrogen is sub-optimal, growth is reduced (Haque et al., 2001). Its availability in sufficient quantity throughout the growing season is essential for optimum maize growth. It is also a characteristic constituent element of proteins and essential for plant growth processes including chlorophyll and many enzymes. Nitrogen mediates the utilization of potassium, phosphorus, and other elements in plants (Brady, 1984). Therefore, nitrogen deficiency or excess can result in reduces maize yields.

Phosphorus is essential nutrient required to increase maize yield. The importance of phosphorus as yield limiting factor in many soils is well established (Adepetu, 1993). Phosphorus plays an important part in many physiological processes that occur within a developing and maturing plant. Phosphorus is essential for cell division because it is a constituent element of nucleoproteins, which are involved in the cell reproduction processes. It is important for seed and fruit formation and crop maturation. Phosphorus also affects the quality of the grains and it may increase the plant resistance to diseases. However, the requirement and utilization of these nutrients (phosphorus) in maize depends on environmental factors like rainfall, varieties and expected yield.

Potassium increases root growth and improves drought resistance; maintains turgor; reduces water loss and wilting reduces respiration, preventing energy losses; enhances translocation of sugars and starch; produces grain rich in starch, increases protein content of plants, builds cellulose and reduces lodging, helps retard crop diseases (Radulov et al., 2012). Potassium plays significant roles in enhancing crop quality. High levels of available K improve the physical quality, disease resistance, and shelf life of fruits and vegetables used for human consumption and the feeding value of grain and forage crops. Quality can also be affected in the field before harvesting such as when K reduces lodging of grains or enhances winter hardiness of many crops (Rehm et al., 1983). Stalk strength of annuals is favored by good K nutrition. Lodging of corn or small grains is often related to low K levels through reduced stalk strength and higher incidence of stalk disease (Welch et al., 1985). This study was conducted to aim determined the effects of different mineral fertilizer doses on maize plants (*Zea mays* L.) yield and yield parameters.

2. Materials and Methods

Plant Material and Growth Conditions

Maize plants (*Zea mays* 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). Three 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 Maize Plants Yield and Yield Parameters

After the 60 days, maize 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 maize plants were significantly ($P<0.01$) affected by nitrogen fertilizer applications. Dry weight of maize plants increased with the nitrogen fertilizer application doses (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 40.90% compared to control (without N application).

Dry matter rate of maize plants increased with the nitrogen fertilizer application doses (Table 2). The highest dry matter rate was obtained from 8 kg N da^{-1} (14.15%). The increasing ratio of dry matter rate of plant at 8 kg da^{-1} N application was 20.42% compared to control (without N application). Maize plants height and wet weight increased with the nitrogen fertilizer application until 20 kg N da^{-1}. But the next applications of nitrogen doses caused a decrease the amount of maize plant height and wet weight (Table 2). The highest plant height was obtained from 15 kg N da^{-1} (68.30cm). The increasing ratio of plant height at 15 kg da^{-1} N application was 12.15% compared to control (without N application). The highest plant wet weight was obtained from 8 kg N da^{-1} (31.10gr). The increasing ratio of plant-wet weight at 8 kg da^{-1} N application was 25.72% compared to control (without N application).

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

	Plant height, cm	Plant wet weight, gr	Plant dry weight, gr	Dry matter rate, %
0 kg N da^{-1}	60.00 c	23.10 e	2.60 d	11.26 c
4 kg N da^{-1}	62.20 b	25.90 c	3.50 b	13.51 b
8 kg N da^{-1}	67.30 a	31.10 a	4.40 a	14.15 a
15 kg N da^{-1}	68.30 a	26.90 b	3.60 b	13.38 bc
20 kg N da^{-1}	62.50 b	24.50 d	3.20 bc	13.06 bc
30 kg N da^{-1}	58.00 d	22.00 f	3.00 c	13.64 b
40 kg N da^{-1}	57.20 d	21.80 f	2.90 c	13.30 bc

Effects of Phosphorus Doses on Maize Plants Yield and Yield Parameters

After the 60 days, maize 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 maize were significantly ($P<0.01$) affected by phosphorus fertilizer applications. Dry weight of maize plants increased with the phosphorus fertilizer application doses (Table 3).

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}	66.00 d	29.90 g	3.60 d	12.04 b
3 kg P_2O_5 da^{-1}	74.60 c	42.40 d	4.10 c	9.67 e
6 kg P_2O_5 da^{-1}	76.30 b	45.10 b	4.80 b	10.64 d
9 kg P_2O_5 da^{-1}	81.20 a	48.10 a	5.60 a	11.64 c
15 kg P_2O_5 da^{-1}	82.80 a	43.90 c	5.70 a	12.98 a
25 kg P_2O_5 da^{-1}	82.30 a	41.60 e	5.00 b	12.02 b
30 kg P_2O_5 da^{-1}	74.70 c	37.70 f	4.30 c	11.41 c

The highest dry matter production was obtained from 15 kg P_2O_5 da^{-1}. The increasing ratio of dry matter production of plant at 15 kg da^{-1} P_2O_5 application was 36.84% compared to control (without P_2O_5 application). Dry matter rate of maize plants increased with the phosphorus fertilizer application doses until 15 kg P_2O_5 da^{-1} (Table 3). The highest dry matter rate was obtained from 15 kg P_2O_5 da^{-1} (12.98%). The increasing ratio of dry matter rate of plant at 15 kg P_2O_5 da^{-1} application was 7.24% compared to control (without P_2O_5 application). Maize plant height and wet weight increased with the phosphorus fertilizer application doses (Table 3). The highest plant height was obtained from 15 kg P_2O_5 da^{-1} (82.80cm). The increasing ratio of plant height at 15 kg P_2O_5 da^{-1} application was 20.29% compared to control (without P_2O_5 application). The highest plant wet weight was obtained from 9 kg P_2O_5 da^{-1} (48.10gr). The increasing ratio of plant wet weight at 9 kg P_2O_5 da^{-1} application was 37.84% compared to control (without P_2O_5 application).

Effects of Potassium Doses on Maize Plan Yield and Yield Parameters

After the 60 days, maize 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 maize 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}	56.00 e	21.30 e	2.30 d	10.80 c
3 kg K_2O da^{-1}	62.30 d	23.40 d	2.90 c	12.39 b
6 kg K_2O da^{-1}	68.30 b	28.30 b	3.60 b	12.72 b
9 kg K_2O da^{-1}	70.00 a	31.10 a	4.10 a	13.18 a
12 kg K_2O da^{-1}	65.00 c	27.70 bc	3.60 b	13.00 a
15 kg K_2O da^{-1}	66.30 c	26.90 c	3.40 b	12.64 b
20 kg K_2O da^{-1}	69.70 a	28.30 b	3.50 b	12.37 b

Dry weight of maize plants increased with the potassium fertilizer application doses (Table 4). The highest dry matter production was obtained from 9 kg K_2O da^{-1}. The increasing ratio of dry matter production of plant at 9 kg K_2O da^{-1} application was 43.91% compared to control (without K_2O application). Dry matter rate of maize plants increased with the potassium fertilizer application doses (Table 4). The highest dry matter rate was obtained from 9 kg K_2O da^{-1} (13.18%). The increasing ratio of dry matter rate of plant at 9 kg K_2O da^{-1} application was 18.06% compared to control (without K_2O application). Maize plants height and wet weight increased with the potassium fertilizer application doses (Table 4). The highest plant height was obtained from 9 kg K_2O da^{-1} (70.00cm). The increasing ratio of plant height at 9 kg K_2O da^{-1} application was 20.00% compared to control (without K_2O application). The highest plant wet weight was obtained from 9 kg K_2O da^{-1}

(31.10gr). The increasing ratio of plant wet weight at 9 kg K_2O da^{-1} application was 31.51% compared to control (without K_2O application).

Conclusions

According to this study result, data obtained from the study showed that plant wet and dry weight, plant height and dry matter rate of maize plants 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 40.90%; the increasing ratio of dry matter production of plant at 15 kg da^{-1} P_2O_5 application was 36.84%; the increasing ratio of dry matter production of plant at 9 kg K_2O da^{-1} application was 43.91% compared to control (without fertilizer applications). According to the results, the findings have clearly indicated that maize 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 decreases to plant dry matter. The results clearly indicated that evaluation of suitable fertilizer doses would improve the plant dry matter and quality properties.

References

Adediran, J.A. and Banjoko, V.A. 1995. Response of Maize to Nitrogen, Phosphorus and Potassium fertilizers in the savanna zone of Nigeria. Commun. Soil Sci. Plant Anal, 26:593-606.

Adepetu, J.A. 1993. Phosphorus fertilization of tropical crops. In: Enzman. Mutscher and Franke (Eds). Nutrients Supply to Tropical Crops. Institute of Trop. Agric, Leipzig Publ., pp. 21-288.

Anonymous, 1980. Toprak Su İstatistikleri Bülteni. Program ve Planlama Dairesi Başkanlığı Yayını, Ankara.

Brady, N.C. 1984. The nature and properties of Soils. Macmillan Publishing Company, New York, pp. 152-158.

Bulut, S., Caglar, O. and Ozturk, A. 2008. Possibilities to Grow Some Corn Cultivars in Erzurum Plain Conditions for Silage Production. Univ. of Ataturk, J. Agric. Sci. 39: 83-91. Erzurum.

Buresh, R.J., Smithson, P.C., and Hellums, D.T. 1997. Building soil P capital in Africa. In: Replenishing Soil Fertility in Africa, R.J. Buresh, P.A. Sanchez, and F. Calhoun, (eds.), SSSA Special Publication No. 51, Soil Science Society of America, Madison, Wisconsin, pp. 111-149.

FAO, 1990. Micronutrient. Assessment at the country leaves an international study

Haque, M.M., Hamıd, A. and Bhuıyan, N.I. 2001. Nutrient uptake and produetivity as affected by nitrogen and potassium application levels n maize/sweet potato intereropping system. Korean J. Crop Sci., 46(1):1-5.

Keskin, B, Akdeniz, H., Yilmaz, I.H. and Turan, N. 2005. Yield and Quality of Forage Corn (*Zea mays* L.) as Influenced by Cultivar and Nitrogen Rate. J. Agron., 4(2):138-141.

Kusaksiz T. and Kusaksiz, E. 2005. A Study on The Herbage Yield and its Components of Different Maize (*Zea mays* L.) Cultivars Under Irrigated Conditions of Manisa. Turkish Journal of Field Crops, Volume:10, Number:1, ISSN:1301-1111, İzmir, pp. 8-15.

Mclean, E.O. 1982. Soil pH and Lime Requirement. Methods of Soil Analysis Part 2. Chemical and Microbiological Properties Second Edition. Agronomy. No: 9 Part 2 . Edition, pp. 199-224.

Nelson, D.W. and Sommers, L.E. 1982. Organic Matter. Methods of Soil Analysis Part2. Chemical and Microbiological Properties Second Edition. Agronamy. No: 9 Part 2 . Edition, pp. 574-579.

Olsen, S.R., Cole, C.V. Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus bicarbonate. USDA Circular 939:1-19, Washington, DC.

Orak A. and Iptas, S. 1999. Silo Yem bitkileri ve Silaj. Çayır Mer'a ve Amenajmanı ve Islahı, Mer'a Kanunu Eğitim ve Uygulama El Kitabı-I, T.C. Tarım ve Köyişleri Bakanlığı, Tarımsal Üretim ve Gel. Gen. Müd., Ankara, pp. 49-68.

Page, A.L., Miller, R.H. and Keeney, D.R. 1982. Methods of Soil Analysis. 2nd Edn., Amercen Society of Agronomy, Madison, WI., USA.

Radulov, I., Berbecea, A., Crista, F., Lato, A. and Sala, F. 2012. Mineral fertilization effect on soil potassium and corn quality and yield. Research Journal of Agricultural Science, 44(3):108-114.

Rehm, G.W., Sorensen, R.C. and Wiese, R.A. 1983. Application of phosphorus, potassium,and zinc to corn grown for grain or silage: Nutrient concentration and uptake. Soil Sci. Soc. Am. J. 47:697-700.

Rhoades, J.D. 1996. Salinity: Electrical Conductivity and Total Dissolved Solids. In: Methods of Soil Analysis, Part 3. Chemical Methods, Sparks, D.L. (Ed.). Soil Science Society of America, Madison, WI., USA., pp. 417-435.

Roth, G., Undersander, D., Allen, M., Ford, S., Harrison, J. and Hunt, C. 1995. Corn Silage Production, Management, and Feeding. ASA, Madison, WI. NCR574.

Shantı, K.V.P., Rao, M.R., Reddy, M.S. and Sarma, R.S. 1997. Response of maize (Zea mays) hybrid and composite to different levels of nitrogen. Indian J. Agric. Scı., 67:424-425.

SPSS, 2004. SPSS 13.0 for Windows Evaluation version. (SPSS Inc., Illinois, USA).

Sumner, M.E. and Miller, W.P. 1996. Cation exchange capacity, and exchange coefficients. In: D. L. Sparks (ed.) Methods of soil analysis. Part 2: Chemical. properties, (3rd ed.) ASA, SSSA, CSSA, Madison, WI.

Thomas, G.W. 1982. Exchangeable cations. In: A.L. Page (ed.) Methods of soil analysis, Part 2 Chemical and microbiological properties, 2nd edition. Agronomy 9: 159-165.

TOVEP, 1991. Türkiye Toprakları Verimlilik Envanteri. T.C. Tarım Orman ve Köy İşleri Bakanlığı. Köy Hizmetleri Genel Müdürlüğü ve dayanıklılık ıslahı. Uludağ Üni., Zir. Fak. Derg, (9):193-204.

Welch, L.F. and Flannery, R.L. 1985. Potassium nutrition of corn. In: Munson RD (ed) Potassium in Agriculture. ASA, CSSA, SSSA, Madison, WI, pp. 647-664.

Yolcu, H. and Tan, M. 2008. General View to Turkey Forage Crops Cultivation. Univ.of Ankara. J. Agriculture Science, 14:303- 312, Ankara.