Original Research

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BIOMASS, LEAF NITROGEN AND POTASSIUM CONCENTRATION OF MAIZE GROWN IN SOILS WITH VARIOUS SALINITY LEVELS IN HARRAN PLAIN

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ABSTRACT

A short term experiment was carried out under greenhouse conditions using different soil types from Harran plains; Akcakale (EC: 11.6 - 28.58 dS m^{-1}), Ekinyazi (EC: 1.95 - 5.39 dS m^{-1}), Cepkenli (EC: 0.49 - 1.40 dS m^{-1}), and Harran (EC: 0.54 - 1.40), having various salinity levels. The soil samples were taken at three different depths (0-20, 20-40 and 40-60 cm) and in four periods (February, May, August and November). The soil samples taken from different soil depth were filled in tubes. The aim of the study was to assess the effects of different soil types having different salinity levels (i.e. EC ranging 0.49 to 28.58 dS m^{-1}) on maize (*Zea mays* L. cv. Dramca) growth. The plant growth was suppressed in the Akcakale soil having high salinity levels compared to the other three soil types. Lower concentrations of nitrogen and potassium while higher concentration of sodium were found in the leaves of plants grown in the Akcakale soil than those plants grown in other soil types. It can be concluded that reduction in the growth of plants grown in Akcakale soil may be due to the combined effects of lower concentrations of K and N and excess accumulation of Na in the plant leaves.

Keywords: salinity, maize, nitrogen, potassium, biomass

HARRAN OVASINDA FARKLI DÜZEYLERDE TUZ İÇEREN TOPRAKLARDA YETİŞEN MISIRIN, BİYOKİTLESİ, YAPRAKTAKİ AZOT ve POTASYUM KONSANTRASYONU

ÖZET

Sera koşullarında, Harran ovasında farklı seviyelerde tuz içeren farklı toprak serileri, Akçakale (EC: 11.6-28.58 dS m^{-1}), Ekinyazi (EC: 1.95 - 5.39 dS m^{-1}), Cepkenli (EC: 0.49 - 1.40 dS m^{-1}) ve Harran'da (EC: 0.54 - 1.40) kısa dönemli bir deneme yapılmıştır. Toprak örnekleri üç farklı derinlikte (0-20, 20-40 ve 40-60 cm) ve dört farklı zamanda (Şubat, Mayıs, Ağustos ve Kasım) alınmıştır. Farklı toprak derinliğinden alınan toprak örnekleri borular içerisine doldurulmuştur. Çalışmanın amacı farklı tip ve farklı tuz (EC 0.49 - 28.58 dS m^{-1}) içeren toprakların mısır (*Zea mays* L. cv. Dramca) bitkisinin gelişimi üzerine etkisini belirlemektir. Yüksek tuz içeren Akçakale toprak serisinde, diğer üç toprak serileriyle karşılaştırıldığında, bitki gelişmesi azalmıştır. Akçakale toprak serisinde gelişen bitkilerin yapraklarında, diğer toprak serileriyle karşılaştırıldığında daha düşük azot ve potasyum ile yüksek Na bulunmuştur. Akçakale toprak serisinde yetişen mısır bitkisinin gelişmesindeki azalma bu bitkinin yapraklarındaki düşük N ve K ile yüksek Na nedeniyle olabilir sonucuna varılabilinir.

Anahtar sözcükler: tuzluluk, mısır, azot, potasyum, biyokitle

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INTRODUCTION

Soil salinity and improper agricultural management practices have left extensive arable lands at the potential risk of total degradation. Salinity and soil nutrient deficiencies are the main factors reducing plant productivity in arid and semiarid areas of the world (Irshad *et al*., 2002; Ashraf and Harris, 2004). Excessive accumulation of soluble salts in the rhizosphere is a major reason for reduced osmotic potential of soil or nutrient solution and for unbalanced nutrition and specific ion toxicity in plants in salt affected soils (Pessarakli and Tucker, 1988a). The general effect of salinity is to reduce the growth rate resulting in smaller leaves, and sometimes fewer leaves. The initial and primary effect of salinity, especially at low to moderate concentrations, is due to its osmotic effects (Munns and Termaat, 1986; Jacoby, 1994). Roots are also reduced in length and mass but may become thinner or thicker. Maturity rate may be delayed or advanced depending on species. The degree to which growth is reduced by salinity differs greatly with species and to a lesser extent with varieties within a species (Shannon and Grieve, 1999). Exposure of plants to salt stress usually begins with the exposure of the roots to that stress factor. Salt stress leads to changes in growth, morphology and physiology of the roots that will in turn change water and ion uptake and the production of signals such as hormones that can communicate information to the shoot and then the whole plant is affected when roots are growing in a salty medium (Cuartero and Fernandez-Munoz, 1999).

The nutrient imbalance due to salt stress is well known. For example, high NaCl concentration induced potassium deficiencies in spinach (Chow *et al*., 1990) artichoke (Graifenberg *et al*., 1995) tomato (Perez-Alfocea *et al*., 1996; Song and Fujiyama, 1996a; Lopez and Satti, 1996), maize (Botella *et al*., 1997) and chickpea (Ozcan *et al*., 2000). Furthermore, high salinity induces nitrogen deficiency in cucumber (Cerda and Martinez, 1988), tomato (Pessarakli and Tucker, 1988b), lettuce and cabbage (Feigin *et al*., 1991)

The aim of this study was to study the effects of different soil series having various salinity levels and taken in different periods on the plant growth and some mineral contents of maize plants.

MATERIALS and METHODS

The experiment was conducted in glasshouse at the Agriculture Faculty Research Station of Harran University (Turkey) from May to June, 2001 with maize (*Zea mays* L., cv. Dramca). The soil was taken from four different series (Akcakale, Ekinyazi, Cepkenli and Harran), different soil depths (0-20, 20-40 and 40-60 cm) and different periods (February, May, August and November).

The selected properties of the soil are given in Tables 1 and 2. The collected soil was filled in tubes (65 cm in height and 10 cm in diameter) with the same soil depth as taken from field after soil was passed through 2 mm sieve.

Three seeds of maize were sown directly in PVC tubes. After germination seedlings were thinned to one plant per tube and were grown for a 3-week period. Each treatment was replicated three times in a randomized block design and each replicate included 3 plants (i.e., 9 plants per treatment). Plants were daily irrigated tap water (EC = 0.50 dS m^{-1} , and pH = 7.1).

Soil Analysis

Soil texture was determined by hydrometric method (Bouyoucus, 1951). Exchangeable cations were leached from the soil using ammonium acetate, while cation exchange capacity (CEC) was determined by sodium acetate extraction method. The pH, electrical conductivity and water soluble anions and cations of soil were determined in extraction water (Richards, 1954). Total lime and organic matter were determined by using Scheibler calsimetry (Allison and Moode, 1965) and Walckley Black method (Allison, 1965), respectively. The contents of Na and K were determined using Flame Photometer (Jenway, PFP7) and Ca and Mg were determined using AAS (Hitachi 911). The chloride content was determined by cholorometric method.

Plant Analysis

The plants were harvested after 3 weeks from sowing. The Shoot was oven-dried at 65 °C and grounded for plant analysis. Ground samples were dry-ashed at 550 ºC for six hours, mixed with 2 M hot HCl, filtered, and then brought to a final volume of 50 ml with distilled water. Nitrogen was determined in the samples of 0.1 g dry weight using a Kjeldahl method. Potassium was determined in these sample solutions using a Jenway, PFP7 flame photometer (Chapman and Pratt, 1982). Chemical analyses are reported on dry weight basis.

Statistical Analysis

Data were analysed using a Statview computer program (Version, 4.54, 1997). Means were compared with the LSD test ($P \leq 0.05$).

Table 1. Some chemical properties of soil.

Region	Soil taken periods	Soil depth (cm) 0-20 pH	0-20 EC (dS m^{-1})	0-20 K (meq l^{-1})	20-40 pH	20-40 EC (dS m^{-1})	20-40 K (meq l^{-1})	40-60 pH	40-60 EC (dS m^{-1})	40-60 K (meq l^{-1})
Akçakale	February	7.77	11.06	0.31	7.51	19.30	0.30	7.78	14.23	0.20
	May	8.00	18.59	0.34	8.14	14.35	0.24	8.13	11.96	0.17
	August	7.50	20.13	0.54	7.67	12.32	0.31	7.50	12.07	0.25
	November	7.60	28.58	0.37	7.81	12.52	0.19	7.81	12.51	0.18
Ekinyazı	February	8.33	5.39	0.22	8.26	7.07	0.11	7.95	5.87	0.07
	May	8.39	5.01	0.22	8.22	6.82	0.11	8.14	5.26	0.07
	August	7.93	5.53	0.28	7.83	3.65	0.11	7.85	3.54	0.09
	November	7.91	1.95	0.14	7.79	3.98	0.10	7.73	3.85	0.06
Cepkenli	February	8.31	1.08	0.15	8.08	2.19	0.14	7.92	3.68	0.18
	May	7.77	1.23	0.12	7.86	1.15	0.07	7.98	1.05	0.06
	August	7.83	0.49	0.13	8.00	0.55	0.09	7.96	0.70	0.11
	November	7.94	0.87	0.16	7.99	0.72	0.09	8.01	0.72	0.09
Harran	February	7.95	1.40	0.12	7.78	1.36	0.15	7.67	1.42	0.11
	May	8.32	0.65	0.11	8.00	0.71	0.08	7.86	0.88	0.05
	August	8.10	0.54	0.12	8.12	0.41	0.06	7.83	0.43	0.08
	November	7.96	0.57	0.15	7.61	0.49	0.06	7.69	0.44	0.06

Table 2. Sodium, Chloride concentrations (meq l^{-1}) and Exchangeable sodium percentage (ESP) of different soil series taken from different soil depth and periods

Region	Soil taken periods	Soil depth (cm) 0-20 Na	0-20 Cl	0-20 ESP	20-40 Na	20-40 Cl	20-40 ESP	40-60 Na	40-60 Cl	40-60 ESP
Akçakale	February	65.3	12.34	27.49	116.3	28.32	26.01	89.4	17.04	30.18
	May	83.9	35.10	42.05	71.3	17.89	37.40	70.2	14.62	41.11
	August	182.3	62.23	23.60	124.1	20.88	26.10	119.6	21.65	28.27
	November	246.7	14.35	28.88	111.6	25.51	24.43	114.2	22.15	30.19
Ekinyazı	February	18.7	3.58	9.56	31.7	4.48	4.98	29.4	3.64	15.02
	May	21.6	2.76	2.97	36.0	3.99	18.17	25.6	1.81	15.18
	August	36.1	2.54	6.52	23.3	1.29	6.06	24.7	1.17	6.75
	November	8.6	1.33	4.36	21.9	0.83	6.27	23.4	1.25	7.89
Cepkenli	February	4.3	1.07	3.99	9.9	1.37	7.79	11.6	2.36	6.73
	May	4.8	1.07	5.45	4.7	0.98	6.92	4.4	1.01	6.38
	August	2.6	0.22	3.28	2.9	0.16	4.56	4.9	0.28	5.99
	November	3.2	0.97	3.09	3.1	0.41	3.74	3.4	0.87	4.62
Harran	February	4.9	1.69	3.03	4.3	1.61	3.22	5.2	1.96	3.25
	May	1.5	1.03	2.42	1.9	1.03	2.84	1.8	1.05	2.39
	August	2.1	0.26	2.88	1.3	0.44	2.47	1.6	0.46	2.46
	November	1.6	0.55	2.31	1.6	0.22	2.26	1.4	0.32	2.24

RESULTS and DISCUSSION

Generally, shoot dry weight was much lower in plants grown in Akcakale soil than those in other soil series (Table 3).

This could be related to the higher values in salinity parameters of Akcakale soil. Dry weights of the plants grown in Akcakale soil taken in August in was lowest compared to the soil taken in other periods. This may be related to the higher concentration of Cl in the soil taken in August. The highest shoot dry weight was obtained from plant in the Harran and Ekinyazi soil series in February. The salinity induced reduction in plant growth is reported elsewhere (Cramer *et al*., 1990; Salim, 1991; Song and Fujiyama, 1996b; Irshad *et al*., 2002). Saline soils inhibit plant growth through reduced water absorption, reduced metabolic activities due to salt toxicity, and nutrient deficiencies caused by ionic interferences (Yeo, 1983). Probably the negative effect of salinity on plants provoked osmotic potential by salt in the culture medium, so root cells do not obtain required water from medium. In this way, the uptake of some mineral nutrients dissolved in water is also restricted.

Mineral Elements

Nitrogen

Nitrogen content decreased in the plants grown in the Akcakale soil having higher salinity compared to the other soil series (Table 3). Excess salt in the soil or nutrient solution caused a decrease in total N uptake by plants (Luque and Bingham, 1981; Pessarakli and Tucker, 1985). Nitrogen, in one form or another, accounts for about 80% of the total mineral nutriaents absorbed by plants (Marschner, 1995). Moreover, inadequate nitrogen is often the growth-limiting nutritional stress in field soils. Consequently, addition of N usually improves plant growth and yield regardless of whether the crop is salt-stressed or not. Despite the lack of evidence indicating that N applied to saline soils or media above a level considered optimal under non-saline conditions improves plant growth or yield, a number of laboratory and greenhouse studies have shown that salinity can reduce N accumulation in plants In many field studies, horticulturists and agronomists set out to test the hypothesis that N-fertiliser additions alleviate, at least to some extent, the deleterious effect of salinity on plants (Grattan and Grieve, 1999). Despite the lack of evidence indicating that N applied to saline soils or media above a level considered optimal under non-saline conditions improves plant growth or yield, a number of laboratory and greenhouse studies have shown that salinity can reduce N accumulation in plants (Cram,1973;Pessarakli and Tucker,1988b;Feigin *et al*.,1991; Pessarak-

Table 3. Shoot, root and whole plant dry weights, leaf N and K of corn plants grown in tubes containing soil from different series

Region	Soil taken periods	Shoot dry weight (g plant^{-1})	Leaf N (%)	Leaf K (%)
Akçakale	February	1.3b*	2.2 a	1.1ab
	May	2.2c	2.7cd	1.3ab
	August	0.4a	2.9d	1.0a
	November	1.2b	2.5 bc	1.4bc
Ekinyazı	February	5.7g	3.0 de	1.7cd
	May	3.9e	3.1 ef	1.6cd
	August	11.2i	2.8c	1.3ab
	November	4.3e	3.3f	1.6c
Cepkenli	February	2.7d	3.3f	1.8d
	May	5.2f	3.4f	1.6cd
	August	6.5h	3.1ef	1.6cd
	November	6.5h	3.2ef	1.6cd
Harran	February	5.1f	3.1 ef	1.3ab
	May	6.8h	3.2ef	1.8d
	August	5.4fg	3.2ef	1.4bc
	November	4.3e	3.3 f	1.3ab

*Within each column, same letter indicates no significant difference between treatments (P<0.05) li, 1991; Al-Rawahy *et al*., 1992).

Potassium

Potassium concentration was suppressed in the plants grown in Akcakale soil having higher salinity (Table 3) despite the higher potassium concentration in this soil series compared to the other series (Table 4). Ortas *et al.* (1999) shown that slowly available K in Akçakale series was much higher than others. Maintenance of adequate levels of K is essential for plant survival in saline habitats. Potassium is the most prominent inorganic plant solute, and as such makes a major contribution to the low osmotic potential in the stele of the roots that is a prerequisite for turgor-pressure-driven solute transport in the xylem and the water balance of plants (Marschner, 1995). Under saline-sodic or sodic conditions, high levels of external Na not only interfere with K acquisition by the roots, but also may disrupt the integrity of root membranes and alter their selectivity. The selectivity of the root system for K over Na must be sufficient to meet the levels of K required for metabolic processes, regulation of ion transport, and osmotic adjustment (Grattan and Grieve, 1999). It is generally held that K availability is impaired by the presence of Ca, Mg, and Na cations in the rhizosphere (Classen and Wilcox, 1974). Our future experiments will be focused on the ameliorative effects of some supplemented nutrients on plant grown at high salinity levels.

CONCLUSION

It can be concluded that soils containing high levels of salt could suppress the growth and uptake of nitrogen and potassium in maize plants. Our results also suggest that low N and K are jointly responsible for the demonstrated reducetions in growth of maize plants grown in high salt levels. So in the future, it can be tested to supply additional N/K to the soil to mitigate the adverse effects of salinity on plant growth.

Table 4. Potassium concentration (meq L^{-1}) of different soil series taken from different soil depth and periods.

Region	Soil taken periods	Soil depth (cm) 0-20 K	20-40 K	40-60 K
Akçakale	February	0.31	0.30	0.20
	May	0.34	0.24	0.17
	August	0.54	0.31	0.25
	November	0.37	0.19	0.18
Ekinyazı	February	0.22	0.11	0.07
	May	0.22	0.11	0.07
	August	0.28	0.11	0.09
	November	0.14	0.10	0.06
Cepkenli	February	0.15	0.14	0.18
	May	0.12	0.07	0.06
	August	0.13	0.09	0.11
	November	0.16	0.09	0.09
Harran	February	0.12	0.15	0.11
	May	0.11	0.08	0.05
	August	0.12	0.06	0.08
	November	0.15	0.06	0.06

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