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EFFECT OF SODICITY AND NITROGEN LEVELS ON DRY MATTER YIELD, PROTEIN AND NUTRIENT UPTAKE IN MAIZE

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SUMMARY

The present study was carried out at Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experiment was conducted on a sandy loam soil having initial pH (1 : 2) 8.21 and ESP 7.88 collected from Research Area of Department of Soil Science, CCS Haryana Agricultural University, Hisar. Soils of different ESP (15, 30 and 45) were prepared by adding desired amount of $NaHCO_3$ to this soil on saturation basis. The observed ESP were 7.88, 13.86, 31.15 and 43.79, respectively. The first experiment was conducted in screen house to study the effects of different ESP levels (control, 15, 30 and 45) on forage maize crop with fixed 80 kg N/ha. In second experiment, the effect of four N levels (0, 40, 80 and 120 kg N/ha) at 45 ESP level was studied on maize forage crop. The results revealed that the dry matter yield of maize decreased with increasing ESP levels (control, 15, 30 and 45). The maximum (38.82 g/pot) and minimum (15.09 g/pot) dry matter yield of maize were observed at control and 45 ESP, respectively. The plant height and protein content also decreased with increasing ESP levels. The uptake of N, P, K, Ca, Mg and S decreased with increasing ESP levels. The reduction in N uptake over control was 10.83, 46.77 and 65.22 per cent at 15, 30 and 45 ESP levels respectively. Non-significant difference was observed in Na uptake by maize, within control and 15 ESP treatments, whereas it decreased significantly with further increase in ESP levels, over 15 ESP. The uptake of micronutrients (Zn, Cu, Mn and Fe) in the maize crop decreased with increasing ESP levels. The maximum uptake was observed at control, whereas minimum at an ESP of 45. The results of experiment conducted on different levels of N (0, 40, 80 and 120 kg/ha) on different forage crops at a constant ESP level (45 ESP) indicated that dry matter yield increased with increasing N levels. The maximum dry matter yield (17.11 g/pot) at 120 kg N/ha and minimum (7.83 g/pot) were obtained at N control in maize. The plant height and protein content in these crops also increased with increasing N levels. Effect of different levels of N (0, 40, 80 and 120 kg/ha) on various forage crops at a constant ESP level (45 ESP) indicated that uptake of nutrients N, P, K, Ca, Mg, Na, S, Zn, Cu, Mn and Fe by maize increased with increasing N levels. The uptake of nutrients was found minimum at N control and maximum at 120 kg N/ha. The results of the experiment conducted on four ESP levels (control, 15, 30 and 45) soil and four N levels (0, 40, 80 and 120 kg/ha) indicated that overall dry matter yield of sorghum decreased with increasing ESP levels and increased with increasing N levels.

Key words : ESP, nitrogen, nutrients uptake, dry matter yield, protein content, maize

Among salt affected soils, sodic soils have prominent place. Excess exchangeable sodium and high pH characteristics of sodic soils are responsible for deterioration in soil physico-chemical characteristics resulting in poor air and water movement in soil (Marlet *et al*., 1998), which ultimately adversely affects growth, yield and chemical composition and nutrient uptake by plants (Singh *et al*., 1980). The potential of maize as an excellent forage crop is well known, particularly in arid and semi-arid regions of the world. It is a multipurpose cereal crop grown for grain, stover and green fodder. With its wide ability to adapt to diverse agro-ecological conditions, it has unique position in the world forage crops. However, yield and quality of fodder maize are greatly influenced by soil condition, type and amount of salts present, and agronomic practices including

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application of fertilizers, irrigation schedules, etc. generally, sodic soils are found deficient in nitrogen. Hence, the requirement of nitrogen for growing maize in these soils is relatively more. The information on effect of sodicity at different nitrogen levels on fodder maize is scanty. Therefore, keeping the points in view, present investigation was undertaken.

MATERIALS AND METHODS

The present study was carried out in the Department of Soil Science, CCS Haryana Agricultural University, Hisar during **kharif** season in screen house in the pots. The experiments were conducted on a sandy soil having initial pH (1 : 2) 8.21 and ESP 7.88. Soil of different ESP (15, 30 and 45) was prepared adopting the standard procedure given by Bains and Fireman (1964). Observed ESP was 7.88, 13.86, 31.15 and 43.79, respectively. The first experiment was conducted in screen house to study the effect of different ESP levels (control, 15, 30 and 45) on maize with fixed 80 kg N/ha dose. In second experiment, different nitrogen levels (0, 40, 80, 120 kg N/ha) on maize at an ESP of 45 were studied. Soil samples from each pot were collected after harvest of crop and analyzed for their pH, EC, soluble calcium and magnesium and exchangeable sodium. Effect of different ESP levels were studied on maize at 80 kg N/pot in three replications in CRD. For data recording, above ground plant was harvested at 50 per cent flowering. Analyses of plant and soil samples were carried out as per prescribed laboratory standard procedures.

RESULTS AND DISCUSSION

Effect of ESP Levels on Plant Height, Dry Matter Yield and Protein Content of Maize

Dry matter yield of maize crop decreased significantly with increasing ESP levels. The maximum dry matter (38.82 g/pot) was obtained in control and minimum (15.09 g/pot) at an ESP of 45 (Table 1 and Fig. 1). The per cent decrease in dry matter yield over control was 17.49, 48.82 and 61.13 at 15, 30 and 45 ESP levels, respectively. Similar results were also obtained by Gupta *et al.* (1975), Joshi and Singh (1975), Bains and Fireman (1979), Jumberi *et al.* (2001) in maize and Singh *et al.* (2014) in pearl millet.

TABLE 1
Effect of ESP levels on dry matter yield, plant height and protein content of maize crop

ESP levels	Dry matter yield (g/pot)	Plant height (cm)	Protein content (%)
0	38.82	150.43	8.75
15	32.03	142.18	8.50
30	19.87	128.07	8.13
45	15.09	115.87	7.56
C. D. (P=0.05)	1.59	2.71	0.22

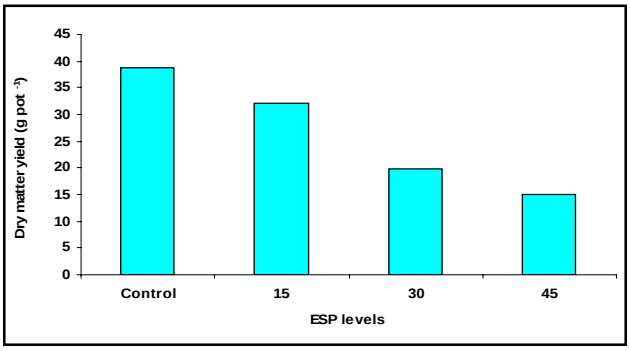

Fig. 1. Effect of ESP levels on dry matter yield of maize crop.

Similarly, plant height also decreased significantly with increasing ESP levels (Table 1). It was found maximum (150.43 cm) in control soil and minimum (115.87 cm) in 45 ESP soil. The reduction in plant height was 5.48, 14.86 and 22.97 at 15, 30 and 45 ESP levels, respectively, as compared with control. The present experimental findings are in conformity with the findings of Bains and Fireman (1979) in corn and sorghum and Singh *et al.* (2014) in pearl millet.

Likewise, crude protein content also decreased significantly with increasing ESP levels. It was found maximum (8.75%) in control soil and minimum (7.56%) at 45 ESP soil. The per cent decrease in crude protein content as compared with control was 7.09 and 13.60 at 30 and 45 ESP levels, respectively.

The growth suppression in sodic soils may be due to poor soil structure leading to the problem of aeration, low water availability and nutritional disorders. Structural deterioration of physical properties of soils, direct toxic effect, production of toxic substances within plants, etc. have been put forth to explain the detrimental effects of exchangeable Na on plant growth. Similarly, Bains and Fireman (1979) and Singh *et al.* (2014) also reported the decrease in dry matter yield of sorghum with increasing ESP levels.

Effect of ESP Levels on Nutrient Uptake by Maize

Uptake of N, P and K by maize decreased with increasing ESP level (Table 2 and Fig. 2). The maximum N uptake (543.48 mg/pot) was observed at control and minimum (182.59 mg/pot) at 45 ESP. The maximum P (85.40 mg/pot) and K (590.06 mg/pot) uptake was observed at control, whereas minimum P (25.65 mg/pot) and K (182.59 mg/pot) uptake was observed at 45 ESP. The reduction was 52.47 and 66.40 per cent in N uptake; 58.11 and 69.96 per cent in P uptake and 53.53 and 69.06 per cent in K uptake at 30 and 45 ESP levels, respectively, as compared to control. Decreased P uptake by maize with increasing ESP levels, confirms the finding of Gupta *et al.* (1975). Similar trend of decreased nutrient uptake with increaseing ESP levels was reported by Singh *et al*. (2014) in pearl millet.

Calcium and magnesium uptake by maize also decreased with increasing ESP level (Table 2). The maximum Ca (186.34 mg/pot) and Mg (151.40 mg/pot) uptake was observed at control, whereas minimum Ca (48.29 mg/pot) and Mg (39.23 mg/pot) uptake was observed at 45 ESP. The reduction was 59.27 and 74.09 per cent in Ca uptake and 59.11 and 74.09 per cent in Mg uptake at 30 and 45 ESP levels, respectively, as compared to control.

TABLE 2
Effect of ESP levels on nutrient uptake (mg/pot) by maize crop

ESP levels	N	P	K	Ca	Mg	Na	S
Control	543.48	85.40	590.06	186.34	151.40	85.40	186.34
15	435.61	64.06	470.84	140.93	112.11	83.28	140.93
30	258.31	35.77	274.21	75.89	61.91	59.91	79.88
45	182.59	25.65	182.59	48.29	39.23	54.32	52.82
C. D. (P=0.05)	30.39	9.72	27.26	15.91	17.05	12.51	14.91

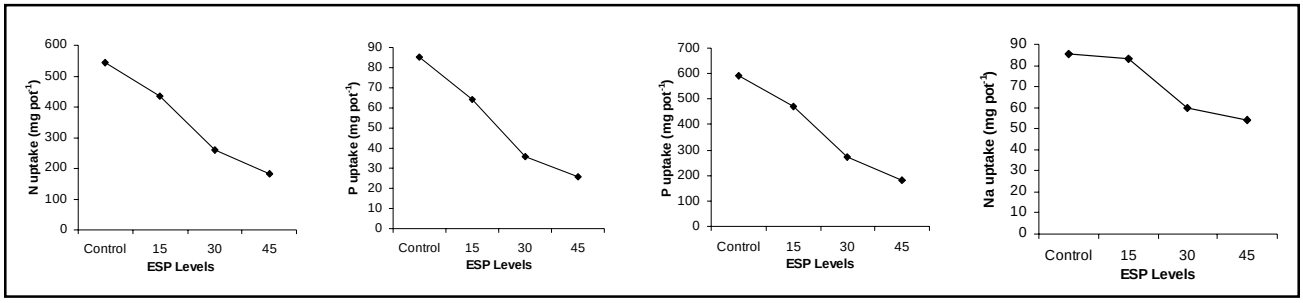

Fig. 2. Effect of ESP levels on uptake of N, P, K and Na by maize crop.

Non-significant difference was observed in Na uptake by maize within control and 15 ESP treatments, whereas it decreased significantly with further increase in ESP levels, over 15 ESP (Table 2 and Fig. 2). It was found maximum (85.40 mg/pot) at control and minimum (54.32 mg/pot) at 45 ESP (Fig. 2). The per cent reduction was 36.39 at 45 ESP, over control. Above findings were supported by Singh *et al.* (2014) in pearl millet.

Sulphur uptake decreased with increasing ESP level (Table 2). The maximum S uptake (186.34 mg/pot) was found in control and minimum (52.82 mg/pot) at 45 ESP. The reduction in S uptake over control was 24.37, 57.13 and 71.65 per cent at 15, 30 and 45 ESP levels, respectively.

Effect of ESP Levels on Uptake of Micronutrient by Maize

The uptake of Zn, Cu, Mn and Fe by maize decreased significantly with increasing ESP levels (Table 3 and Fig. 3). The maximum Zn, Cu, Mn and Fe uptake was 0.98, 0.24, 1.38 and 7.41 mg/pot, respectively, at control and minimum Zn, Cu, Mn and Fe uptake was 0.23, 0.06, 0.32 and 2.44 mg/pot, respectively, at 45 ESP. The reduction in uptake over control was 59.18 and 76.53 per cent in Zn, 58.33 and 75.00 per cent in Cu, 60.14 and 76.81 per cent in Mn and 53.58 and 67.07 per cent in Fe at 30 and 45 ESP levels, respectively. Above findings were supported by Singh *et al.* (2014) in pearl millet.

TABLE 3
Effect of ESP levels on micronutrient uptake (mg/pot) by maize crop

ESP levels	Zn	Cu	Mn	Fe
Control	0.98	0.24	1.38	7.41
15	0.74	0.19	1.04	5.85
30	0.40	0.10	0.55	3.44
45	0.23	0.06	0.32	2.44
C. D. (P=0.05)	0.08	0.02	0.05	0.45

Effect of Nitrogen Levels on Dry Matter Yield, Plant Height and Crude Protein Content of Maize at 45 ESP

The dry matter yield of maize at 45 ESP increased significantly with application of nitrogen up to 120 kg/ha (Table 4). The minimum dry matter yield (7.83 g/pot) was observed at 0 and maximum (17.11 g/pot) at 120 kg N/ha. The per cent increase in yield was 32.95, 90.55 and 118.52 at 40, 80 and 120 kg N/ha,

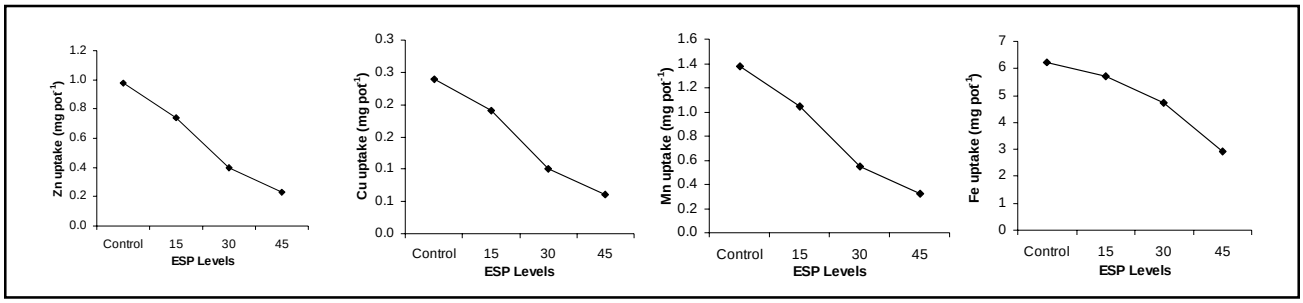

Fig. 3. Effect of ESP levels on uptake of Zn, Cu, Mn and Fe by maize crop.

TABLE 4
Effect of nitrogen levels on dry matter yield, plant height and protein content of forage maize crop at 45 ESP

Nitrogen levels (kg/ha)	Dry matter yield (g/pot)	Plant height (cm)	Protein content (%)
0	7.83	104.11	6.69
40	10.41	111.83	7.13
80	14.92	116.31	7.50
120	17.11	120.03	7.81
C. D. (P=0.05)	1.63	2.79	0.24

respectively, as compared with the control. Similar results were supported by Singh *et al.* (2014) in pearl millet.

It was observed that 120 kg N/ha produced significantly higher yield as compared to 80 kg N/ha which is an optimum dose for maize in normal soil in this region. This showed that maize in sodic soils responded to higher doses of applied N owing to their poor organic matter and available N status. Similar types of results were also obtained by Nehra *et al.* (1981) and Devi (2002) in maize.

Increasing level of N application from 0 to 40, 80 and 120 kg/ha increased the plant height of maize (Table 4). The minimum plant height (104.11 cm) was observed at control and maximum (120.03 cm) at 120 kg N/ha. Increasing trend of crude protein content was observed with successive increments of N levels (Table 4). The highest level of nitrogen (120 kg/ha) produced maximum crude protein content than other levels of nitrogen. The application of higher doses of N levels in crop plants produced significantly higher crude protein yield in green forage (Damame *et al*., 2013).

Effect of Nitrogen Levels on Nutrient Uptake by Maize at an ESP of 45

Nitrogen uptake (Table 5 and Fig. 4) by maize increased significantly at all the levels of N application over control. The extent of increase observed was 41.64, 113.70 and 155.29 per cent, respectively, over control, with the respective application of 40, 80 and 120 kg N/ha.

The uptake of P and K by maize also showed the same trend as nitrogen uptake. The minimum P (10.18 mg/pot) and K (87.70 mg/pot) uptake was found at control, whereas maximum P (34.22 mg/pot) and K (213.88 mg/pot) uptake was observed at 120 kg N/ha (Table 5 and Fig. 4).

Increasing trend of Ca, Mg, Na and S uptake by maize was observed up to 120 kg N/ha. The minimum uptake was found at control and maximum at 120 kg N/ha (Table 5 and Fig. 4).

The findings of Verma *et al.* (1999) in respect of uptake of nitrogen in fodder maize, in which they observed that nitrogen uptake increased significantly with

TABLE 5
Effect of nitrogen levels on uptake of nutrient (mg/pot) by maize crop at an ESP of 45

Nitrogen levels (kg/ha)	N	P	K	Ca	Mg	Na	S
0	83.78	10.18	87.70	18.01	11.75	21.92	19.58
40	118.67	15.62	121.80	29.15	21.86	33.31	31.23
80	179.04	25.36	180.53	49.24	37.30	52.22	50.73
120	213.88	34.22	213.88	63.31	47.91	65.02	66.73
C. D. (P=0.05)	31.70	3.16	28.17	8.64	8.98	6.34	9.32

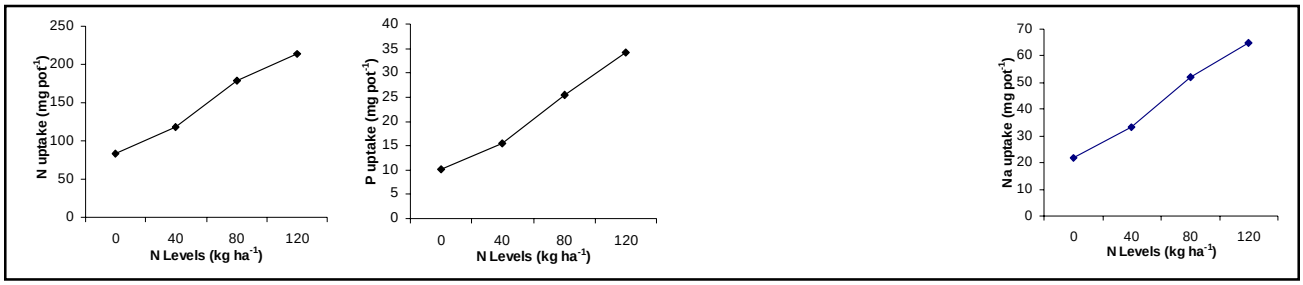

Fig. 4. Effect of nitrogen levels on uptake of N, P, K and Na by maize crop at 45 ESP.

increase in nitrogen up to 120 kg N/ha, confirmed the results.

Effect of Nitrogen Levels on Micronutrient Uptake by Maize at an ESP of 45

Uptake of micronutrients (Zn, Cu, Mn, Fe) by maize, at 45 ESP, increased significantly with application of nitrogen up to 120 kg/ha (Table 6 and Fig. 5). The minimum Zn (0.07 mg/pot), Cu (0.03 mg/pot), Mn (0.10 mg/pot) and Fe (1.18 mg/pot) uptake was found at 0 kg

TABLE 6
Effect of nitrogen levels on the uptake of micronutrient (mg/pot) by maize crop at 45 ESP

Nitrogen levels (kg/ha)	Zn	Cu	Mn	Fe
0	0.07	0.03	0.10	1.18
40	0.13	0.04	0.17	1.64
80	0.23	0.06	0.31	2.42
120	0.30	0.08	0.40	2.84
C. D. (P=0.05)	0.05	0.01	0.06	0.42

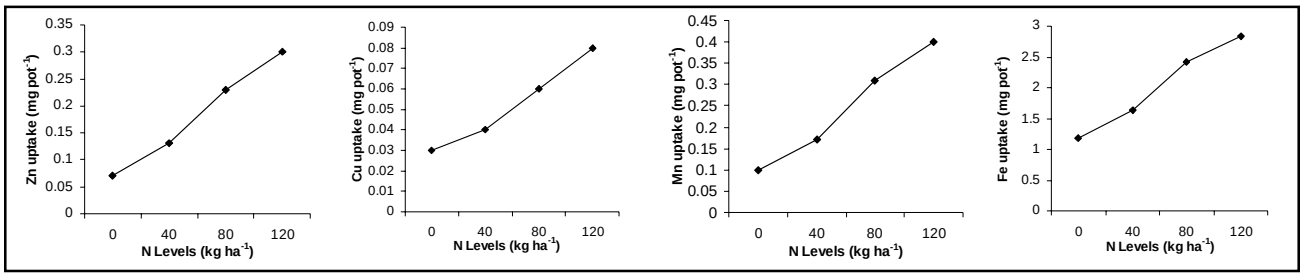

Fig. 5. Effect of nitrogen levels on uptake of Zn, Cu, Mn and Fe by maize crop at 45 ESP.

N/ha, whereas maximum Zn (0.30 mg/pot), Cu (0.08 mg/pot), Mn (0.40 mg/pot) and Fe (2.84 mg/pot) uptake was observed at120 kg N/ha.

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