Forage Res., **40** (2) : pp. 109-115 (2014) **http://forageresearch.in**

STUDIES ON EFFECT OF SODICITY LEVELS ON DRY MATTER YIELD, CONTENT PROTEIN AND NUTRIENT UPTAKE IN SORGHUM

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(Received : 6 June 2014; Accepted : 25 July 2014)

SUMMARY

The experiment was carried out in the Department of Soil Science, CCSHAU, Hisar during **kharif** season in screen house. The experiment was conducted on a sandy loam soil having initial pH (1 : 2) 8.21 and ESP 7.88. Soil of different ESP (15, 30 and 45) was prepared. The results on the studies oF different ESP levels revealed that the dry matter yield of sorghum decreased with increasing ESP levels (control, 15, 30 and 45). The maximum (48.18 g/pot) and minimum (19.78 g/pot) dry matter yield of sorghum was 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. The Na uptake by sorghum crop increased significantly up to an ESP of 15, as compared to control, whereas further increase in ESP at 30 and 45, it decreased significantly, over 15 ESP. The uptake of micronutrients (Zn, Cu, Mn and Fe) also decreased with increasing ESP levels. The maximum uptake was observed at control, whereas minimum at an ESP of 45.

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

Dairy farming is the integral component of agriculture and contributes significantly towards national economy. Though India possesses the largest livestock population in the world, yet the production per animal is very low. This is because of the fact that grazing and quality fodder resources in India are inadequate to meet the requirement of the huge livestock population of the country. The reasons for such an unsatisfactory situations are low acreage under forage cultivation (i. e. only 3.5% of the total cultivated area), competition between grain and fodder crops, poor yielding ability of fodder crops, poor cultivation and management practices and above all, human prejudice against the use of animal source of food. Hence, a big gap exists between the supply and demand of animal feeding stuffs and our cattle remain underfed during most part of the year. This situation becomes more acute during the summer/**kharif** season because of scarcity of green fodder. Moreover, the grazing material also dries up due to adverse weather conditions. The most feasible way of making up this deficiency is by sowing quick growing and high yielding fodder crops.

Sorghum has a wider adaptability, drought tolerance and can be grown under relatively medium to low soil fertility and moisture conditions in semi-arid areas. It provides nutritious fodder of good quality for fairly long periods of time. Because of the ever increasing demand for food grains to meet the requirements of teaming population, there is very little, rather no scope to increase the area under fodder crops. Furthermore, as it is difficult to devote more acreage under fodder crops, we are left with only one alternative to increase the fodder production in the country by increasing the areas by growing fodder crops on salt affected soils. 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 the soil (Marlet *et al.*, 1998) which ultimately adversely affects

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growth, yield, chemical composition and nutrient uptake by plants (Sandhu *et al.*, 1980; Singh and Abrol, 1985). Moreover, due to global warming the global climate is changing, resulting in high temperature and scanty rainfall along with increased evapotranspiration, which ultimately invites upward movement of salts in soil profile. Therefore, problem of akalinity/sodicity is increasing. The yields and quality of fodder crops are greatly influenced by the soil condition, type and amount of salts present and the agronomic practices including application of fertilizer, irrigation schedule, etc. Generally sodic soils are found deficient in nitrogen. Hence, the requirement of nitrogen for growing crops in these soils is relatively more. Urea is a major nitrogen fertilizer used in the country, which supplies more than 80 per cent of total nitrogen demand. The information on effect of sodicity levels on fodder sorghum is scanty. Therefore, keeping the above 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 experiment was conducted in screen house to study the effect of different ESP levels (control, 15, 30 and 45) on sorghum with fixed 80 kg N/ha dose. 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 was studied on sorghum (HC-308) 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 Dry Matter Yield, Plant Height and Crude Protein Content

Data in Table 1 reveal that the dry matter yield of sorghum crop decreased significantly with increasing ESP levels. The maximum dry matter yield (48.18 g/ pot) was obtained in control and minimum (19.78 g/ pot) at an ESP of 45 (Fig. 1). The reduction in dry matter yield over control was 41.49 and 58.95 per cent at 30 and 45 ESP levels, respectively. Above findings were supported by Singh *et al.* (1988). Increasing salt levels of the growth caused a marked inhibitory effect on fresh and dry weights and maximum reduction in biomass was observed at highest salt level (Ashraf and Orooj, 2006; Uppadyay *et al*., 2012). The decrease in dry matter yield of pearl millet with increase in ESP levels was reported by Singh *et al.* (2014).

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

ESP levels	Dry matter yield (g/pot)	Plant height (cm)	Protein content (%)
Control	48.18	147.25	9.00
15	44.83	142.21	8.63
30	28.19	131.79	8.19
45	19.78	118.11	7.63
C. D. (P=0.05)	1.75	2.54	0.22

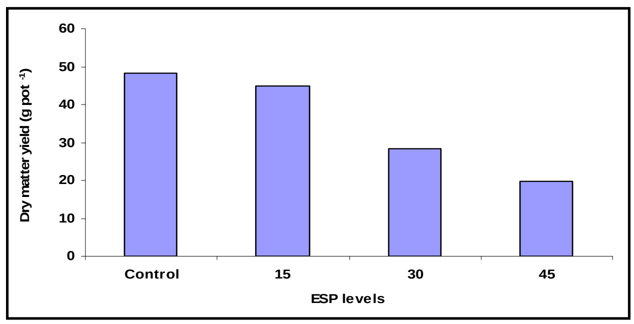

Fig. 1. Effect of ESP levels on dry matter yield of sorghum crop.

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. The structural wear and tear of physical properties of soils, direct toxic effect, production of toxic substances within plants, etc. were put forth to explain the detrimental effects of exchangeable Na on plant growth (Sadaria, 1989). Similarly, Bains and Fireman (1979) and Singh *et al.* (2014) also reported the decrease in dry matter yield of pearl millet with increasing ESP levels.

Plant height of sorghum also decreased significantly with increasing ESP levels (Table 1). It was found maximum (147.25 cm) in control and minimum (118.11 cm) at an ESP of 45. The reduction in plant height was 10.50 and 19.79 per cent at ESP levels of 30 and 45, respectively, as compared to control. The adverse effect of ESP on plant height was mediated through its effect on nutritional disorders related to high soil pH, deteriorated soil physical properties and direct effect of excess sodium, or a combination of these factors. Similar results of decreasing plant height in sorghum, with increasing ESP are in agreement with the findings of Bains and Fireman (1979). Above findings were also supported by Bagada and Patel (1983), Patel and Parmar (1987) and Singh *et al*. (2014) in pearl millet. The detrimental effects of increased ESP levels in sodic soil on plant growth could be attributed to presence of high Na content in soil in available form.

Likewise, crude protein content in sorghum also decreased significantly with increasing ESP levels. It was found maximum (9.00%) in control soil and minimum (7.63%) at an ESP of 45. The per cent decrease in crude protein content, as compared with control, was 9.00 and 15.22 at 30 and 45 ESP level, respectively. The decrease in crude protein content with increasing ESP was due to decrease in nitrogen content with the increasing soil ESP which may be attributed to reduced losses of soil nitrogen through ammonia volatilization (Rao and Batra, 1983) and deteriorated soil physico-chemical characteristics resulting in poor root development. These results are in accordance with the findings of Singh and Abrol (1985) who also observed a significant decrease in protein content with increasing ESP levels in groundnut.

Effect of ESP Levels on Nutrient Uptake

The data of nitrogen uptake by sorghum crop presented in Table 2 indicate decreasing trend with increasing ESP from control to 45. The maximum N uptake (693.79 mg/pot) was observed at control and minimum (241.32 mg /pot) at an ESP of 45 (Fig. 2). 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. Decreased nitrogen uptake with increasing ESP is in agreement with the findings of Sarode and Bhalkar (1981) in wheat; Singh and Abrol (1985) in groundnut; Ray and Khadder (1990) in mustard and Sharma *et al.* (2001) in pigeonpea. The results of increasing N uptake in sodic soil are in agreement with the findings of Zanti *et al.* (1977) and Nitant and Chillar (1983) in wheat.

Phosphorus uptake by sorghum crop also decreased as the ESP of the soil increased from control to 45 (Table 2 and Fig. 2). The maximum P uptake (115.63 mg/pot) was found in control and minimum (33.63 mg/pot) at 45 ESP. The reduction in P uptake over control was 14.70, 51.24 and 70.92 per cent at 15, 30 and 45 ESP levels, respectively. Zanti *et al.* (1977) also reported an increase in P uptake with increasing nitrogen doses in wheat, irrespective of ESP levels.

Potassium uptake by sorghum decreased as the soil ESP increased from control to 45 (Table 2). The maximum K uptake (881.69 mg/pot) was found in control soil and minimum (304.61 mg/pot) at an ESP of 45 (Fig. 2). The per cent decrease in K uptake over control was 45.33 and 65.45 at 30 and 45 ESP levels, respectively. Decreased P and K uptake was also confirmed by Singh and Abrol (1983) in pea, and Balak Ram and Misra (2004) in German chamomile. The increasing level of ESP, on the other hand, resulted in progressive decline in the uptake of K by sorghum crop, at each level of N application. These results are in agreement with the findings of Zanti *et al.* (1977) in wheat, in which, K uptake increased with increasing nitrogen doses, irrespective of ESP levels.

Calcium uptake by sorghum decreased as the soil ESP increased from control to 45. The maximum Ca uptake (245.72 mg/pot) was found in control soil and minimum (75.16 mg/pot) at an ESP of 45 (Table 2). The reduction in Ca uptake over control was 12.43, 50.67 and 69.41 per cent at 15, 30 and 45 ESP levels,

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

ESP levels	N	P	K	Ca	Mg	Na	S
Control	693.79	115.63	881.69	245.72	120.45	72.27	139.72
15	618.65	98.63	797.97	215.18	98.63	85.18	116.56
30	369.29	56.38	482.05	121.22	53.57	67.66	62.02
45	241.32	33.63	304.61	75.16	29.67	61.32	35.60
C. D. (P=0.05)	32.79	6.60	30.79	13.64	14.09	11.12	11.80

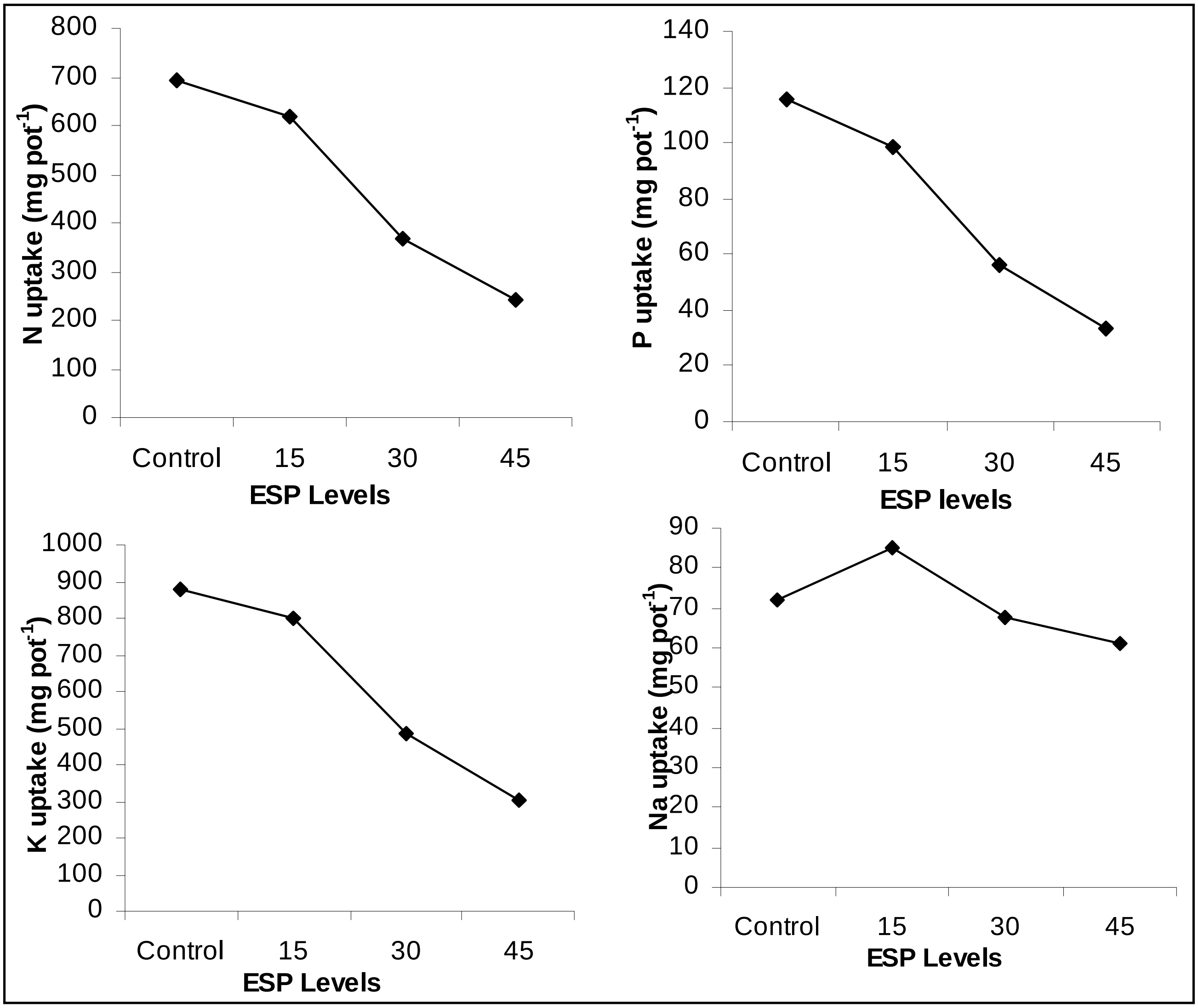

Fig. 2. Effect of ESP levels on uptake of N, P, K and Na by sorghum crop.

respectively. The decrease in calcium uptake with increasing ESP is in accordance with the findings of Singh and Abrol (1983) in pea.

Magnesium uptake decreased as the soil ESP increased from control to 45. The maximum Mg uptake (120.45 mg/pot) was found in control soil and minimum (29.67 mg/pot) at an ESP of 45 (Table 2). The per cent decrease in Mg uptake over control was 18.12, 55.53 and 75.37 at 15, 30 and 45 ESP levels, respectively. In pearl millet, similar findings were reported by Singh *et al*. (2014).

The sodium uptake by sorghum crop increased significantly up to an ESP of 15, as compared to control, whereas further increase in ESP at 30 and 45 it decreased significantly as compared to an ESP level of 15 (Table 2). The maximum Na uptake (85.18 mg/pot) was found at 15 ESP soil and minimum (61.32 mg/pot) at an ESP of 45 (Fig. 2). These findings are also in accordance with the findings of Balak Ram and Misra (2004) in German chamomile and Sarode and Bhalkar (1981) in wheat.

Sulphur uptake by sorghum decreased with increasing ESP of the soils. The maximum S uptake (139.72 mg/pot) was found in control soil and minimum (35.60 mg/pot) at an ESP of 45 (Table 2). The reduction in S uptake over control was 23.16, 55.61 and 74.52 per cent at 15, 30 and 45 ESP levels, respectively. It is clear from the data that with increasing ESP levels, decreased uptake of nutrients resulted in decreased dry matter yield of sorghum. In pearl millet, similar results were reported by Singh *et al*. (2014).

Effect of ESP Levels on Micronutrient Uptake

The uptake of Zn, Cu, Mn and Fe by sorghum crop decreased significantly with increasing ESP levels (Table 3 and Fig. 3). The maximum Zn, Cu, Mn and Fe uptake was 1.42, 0.24, 1.44 and 13.52 mg/pot, respectively, at control, whereas minimum uptake of Zn, Cu, Mn and Fe was 0.41, 0.07, 0.39 and 5.09 mg/pot, respectively at an ESP of 45. The reduction in uptake over control was 51.41 and 71.13 per cent in Zn, 50.00 and 70.83 per cent in Cu, 54.17 and 72.92 per cent in Mn and 44.08 and 62.35 per cent in Fe at 30 and 45 ESP levels, respectively. Sarode and Bhalkar (1981) also observed the decrease in uptake of Zn, Cu and Mn with increasing ESP up to 53.46 in wheat. Uppadyay *et al*. (2012) while experimenting on *Ammi majus* reported that the accumulation of Zn and Cu in test plant was decreased on increasing ESP levels. In maize and beans, the salt treatments lowered the uptake of micro-elements (Kudo *et al*., 2010). In pearl millet, similar results were reported by Singh *et al*. (2014).

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

ESP levels	Zn	Cu	Mn	Fe
Control	1.42	0.24	1.44	13.52
15	1.22	0.21	1.25	12.39
30	0.69	0.12	0.66	7.56
45	0.41	0.07	0.39	5.09
C. D. (P=0.05)	0.05	0.02	0.05	0.50

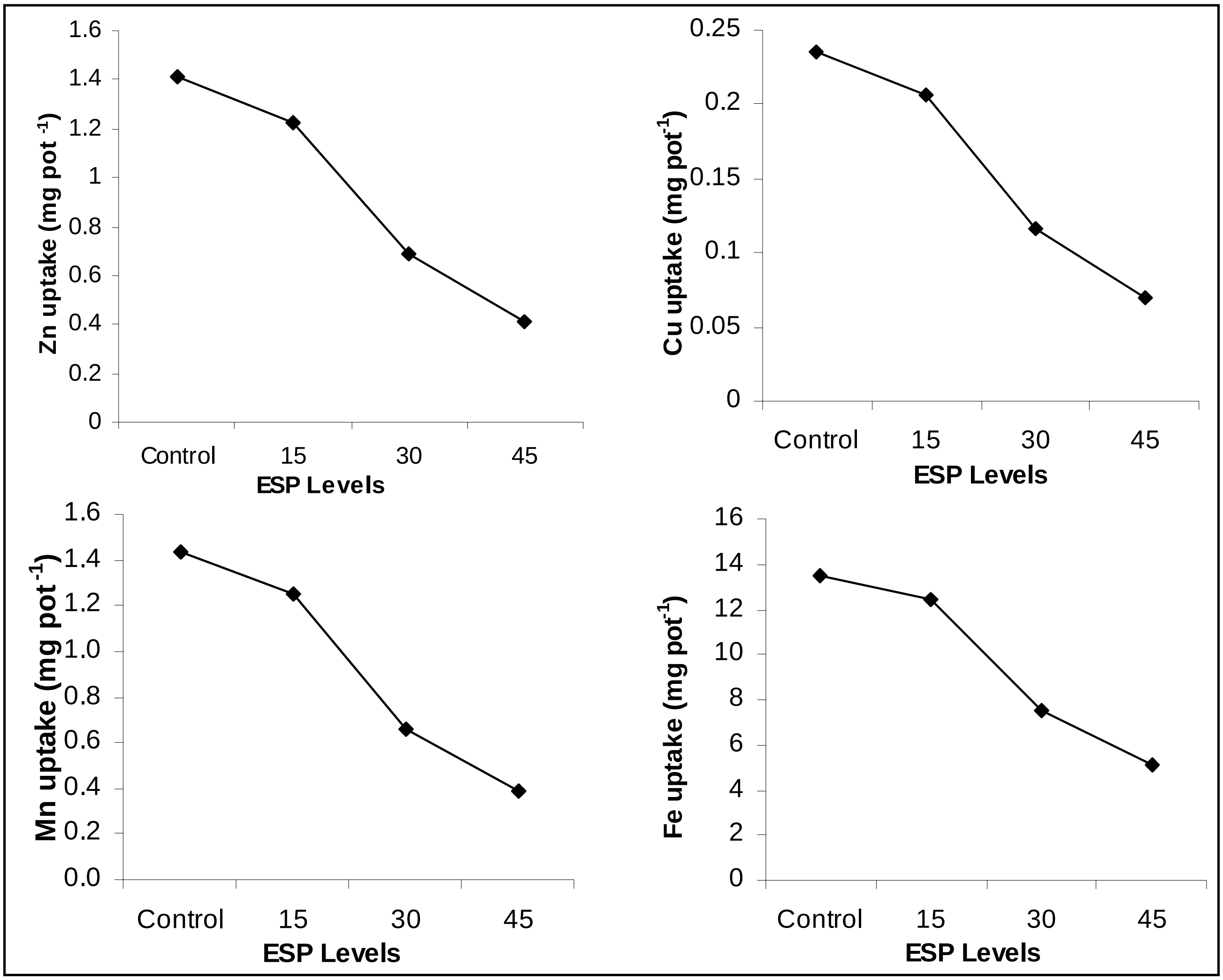

Fig. 3. Effect of ESP levels on uptake of Zn, Cu, Mn and Fe by sorghum crop.

Before and After Crop Harvest Soil Sampling

Soil samples at sowing and harvest of different forage crops at each ESP level were collected. The effects of crops on different soil parameters are discussed as :

Soil EC and pH

The soil pH after harvesting of forage crops decreased as compared to initial pH at all the ESP levels. No trend was observed on the EC values of soil due to growing forage crops (Table 4). This is in agreement with the findings of Singh *et al.* (1971).

Calcium

It is evident from Table 4 that there was a declining trend in concentration of water soluble calcium of soil with all increasing ESP levels at before and after crop harvest. The availability of Ca increased slightly after crop harvest in comparison to initial Ca status. Solankey *et al.* (1991) also observed a declining trend of Ca content (50.2 to 26.4%) of soil with increasing ESP levels from 0 to 45. This was attributed to the decrease in Ca content in plant because of antagonistic effect of Na and K with Ca in plants. Reduced Ca uptake by plant in sodic soil conditions was reported by Chauhan and Chauhan (1975). The higher Ca in soil after crop harvest also may be due to replacement of Ca from exchange sites by excessive Na.

TABLE 4

Soil status at different ESP levels at sowing and harvest of forage sorghum

Time of sampling	ESP levels			
	Control	15	30	45
	Soil pH (1 : 2)			
Sowing	8.21	8.65	9.32	9.68
Harvest	8.06	8.30	8.88	9.41
	$EC_{1:2}$ (dS/m)			
Sowing	0.19	0.25	0.40	0.85
Harvest	0.21	0.31	0.37	0.80
	Exchangeable Na (me/100 g)			
Sowing	1.07	1.68	3.90	5.18
Harvest	0.91	1.44	3.43	4.18
	Water soluble soil Ca (me/l)			
Sowing	0.49	0.43	0.38	0.35
Harvest	0.60	0.49	0.44	0.41
	Water soluble soil Mg (me/l)			
Sowing	0.22	0.28	0.34	0.48
Harvest	0.20	0.25	0.31	0.40

Magnesium

The concentration of water soluble magnesium in soil increased with increasing ESP level in initial and after crop harvest samples. But its conc. was statistically at par in initial and after crop harvest samples. Solankey *et al.* (1991) and Wright and Rajper (2000) also reported that there was no marked change in concentration of Mg in initial and after crop harvesting.

Exchangeable Na

Exchangeable Na in soil increased with increasing ESP levels in initial samples and after crop harvest samples (Table 4). Na content was higher in initial soil samples as compared to post-harvest soil samples. Ray and Khadder (1990) reported an increase in exchangeable Na from 6.3 to 57.8 per cent with increasing ESP levels from 0 to 60. However, they reported a marginal increase in soil pH with increasing $NaHCO_3$ content due to increase in soil buffering capacity. Wright and Rajper (2000) also suggested that with addition of higher amount of $NaHCO_3$ to soil the SAR ratio increased from 27 to 77 and ESP from 14 to 51. They also reported that exchangeable Na was also lower in crop harvest samples over pre-sowing samples.

CONCLUSIONS

It was concluded that the dry matter yield, plant height, protein content and uptake of nutrients (N, P, K, Ca, Mg and S) decreased with increasing ESP levels. The uptake of micronutrients (Zn, Cu, Mn and Fe) in sorghum decreased with increasing ESP levels. The drastic reduction in N uptake over control was 46.77 and 65.22 per cent at 30 and 45 ESP levels, respectively. Na uptake by sorghum crop increased significantly up to an ESP of 15, as compared to control, whereas further increase in ESP at 30 and 45, it decreased significantly over 15 ESP.

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