

FLUCTUATIONS OF MINERAL IONS IN SALINE SOILS AND HALOPHYTIC GRASS *AELUROPUS LAGOPOIDES* L.

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ABSTRACT

Seasonal variations in mineral ion content of saline habitat and leaves, stems and roots of halophytic grass, *Aeluropus lagopoides*, growing on western coast of India were studied. The salinity (EC 1:2) of soils varied between 10.5 to 34.2 dS m⁻¹ and it reached to maximum during dry period. The Na⁺ and Cl⁻ ions were the principle constituents of soil salinity and plant tissues but the Cl⁻ content was more than Na⁺ in both the cases. Mg²⁺ exceeded the amounts of Ca²⁺, and K⁺ occurred in low concentrations in soils and plants.

INTRODUCTION

Saline wastelands are spread in about 7.2 million hectares in India and some highly salt tolerant plant species successfully grow on such soils. Flowers (1975) has given a comprehensive account of ionic relationships in halophytes. Unger (1974) observed that the distribution of halophytes was mainly controlled by edaphic conditions. Although scattered informations are available on the salinity status of the habitats of halophytes, the correlation between changing salinity in the habitat and corresponding changes in ionic composition of plant tissues has not been studied. Such information is helpful in selecting a forage species for planting on saline wastelands. The present investigation describes seasonal variations in physico-chemical characteristics of saline soils as well as in mineral ion composition of underground and above-ground parts of *Aeluropus lagopoides* Linn., which is widely used as forage grass throughout our country under different climatic conditions.

MATERIAL AND METHODS

Soils and plant samples were collected from three different habitats near Bhavnagar (21°45'N, 72°14'E) for twelve months during 1983-84. The electrical conductivity of soil extracts (1:2) was measured on EC meter. Oven dried plant material was ashed at 480 °C and the ash was dissolved in acidic water. The excess of the acid was evaporated on water bath and the subsequent extract was made in double distilled water. Na⁺ and K⁺ were measured by flame photometry; Ca²⁺ and

Mg²⁺ by EDTA titration (Vogel, 1978) and chlorides by chloride meter. Thirty six samples each of leaves, stems and roots were analysed for this study.

RESULTS AND DISCUSSION

The ionic composition of soils supporting *A. lagopoides* at three habitats (Fig. 1) indicated that electrical conductivity of soil (1:2) extracts varied between 10.5 to 34.2 and it was maximum during dry period. The concentration of Na⁺ varied between 9.9 to 26.4 m eq and that of Cl⁻ between 11.2 to 30.2 m eq g⁻¹. Ca²⁺ and Mg²⁺ fluctuated between 0.3 to 2.4 m eq and 0.7 to 6.1 m eq g⁻¹ respectively, indicating greater accumulation of the latter ion. Moreover, maximum concentration of all ions was observed in summer. The potassium occurred in low concentrations (0.14 to 0.36 m eq g⁻¹). A steady increase in salinity and concentrations of ions was observed during winter and summer (Table 1).

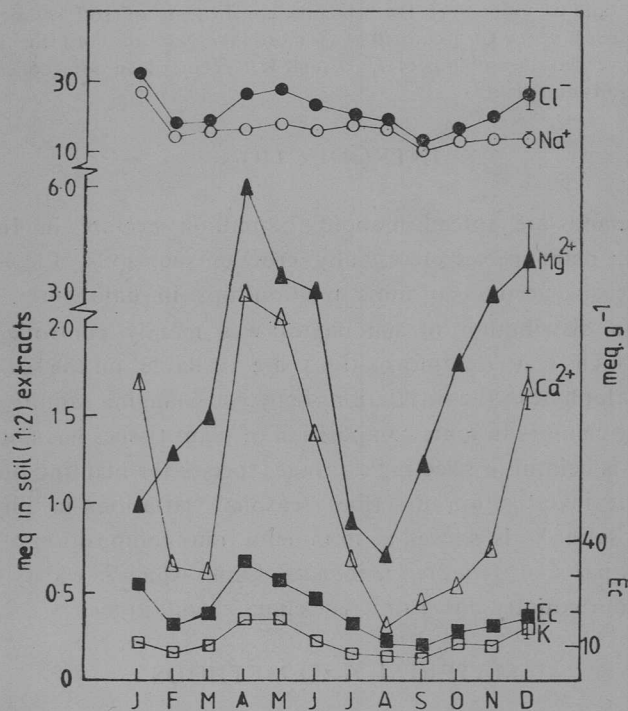


Fig. 1. Variations of mineral ions in soils supporting *Aeluropus lagopoides*; each value represents mean of three observations; the bars indicate the SEM.

Table 1. Seasonal variations of mineral ions (m eq g⁻¹ ± SEM) in soils and vegetative parts of *Aeluropus lagopoides*; each value represents mean of twelve samples collected during the same season

*Seasons	(g g ⁻¹)	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻
M	**12.9±0.1	14.12±0.82	0.17±0.01	0.05±0.05	1.16±0.04	15.35±0.62
W	**16.2±1.3	17.05±1.93	0.23±0.02	1.21±0.29	2.30±0.57	23.67±2.87
S	**25.5±2.7	16.20±0.52	0.29±0.01	1.86±0.38	3.55±0.87	24.55±1.63
			Leaves			
M	0.08±0.004	0.61±0.02	0.09±0.004	0.32±0.02	0.47±0.04	0.81±0.03
W	0.10±0.003	0.71±0.04	0.11±0.01	0.36±0.03	0.53±0.04	0.81±0.04
S	0.09±0.003	0.72±0.04	0.11±0.01	0.32±0.02	0.55±0.04	0.78±0.03
			Stem			
M	0.08±0.004	0.64±0.02	0.09±0.003	0.35±0.02	0.50±0.02	0.71±0.03
W	0.08±0.003	0.68±0.03	0.10±0.02	0.31±0.02	0.56±0.02	0.78±0.02
S	0.08±0.004	0.68±0.02	0.08±0.003	0.34±0.01	0.55±0.02	0.79±0.03
			Roots			
M	0.08±0.004	0.62±0.02	0.09±0.004	0.33±0.02	0.51±0.02	0.73±0.04
W	0.09±0.003	0.76±0.03	0.10±0.004	0.35±0.02	0.58±0.02	0.85±0.03
S	0.09±0.005	0.80±0.03	0.10±0.002	0.31±0.02	0.51±0.03	0.84±0.02

*M = Monsoon; W = Winter; S = Summer

**EC in dSm⁻¹

Mineral composition of leaves, stems and roots of *A. lagopoides* growing at three sites (Fig. 2) showed dominance of Na^+ and Cl^- but, as in the soils, Cl^- accumulated in greater concentration than Na^+ . The vegetative parts contained Na^+ between 0.67 to 0.73 m eq g^{-1} and Cl^- between 0.76 to 0.80 m eq g^{-1} . Nevertheless, the salt content in plant tissues was low, varying between 0.08 to 0.09 g g^{-1} . Although Ca^{2+} (0.33 m eq g^{-1}) and Mg^{2+} (0.51 to 0.54 m eq g^{-1}) did not show wide variations, their accumulation showed proportionate uptake from soils. The amounts of K^+ , fluctuating between 0.09 to 0.1 m eq g^{-1} , indicated its adequate uptake from highly saline environment.

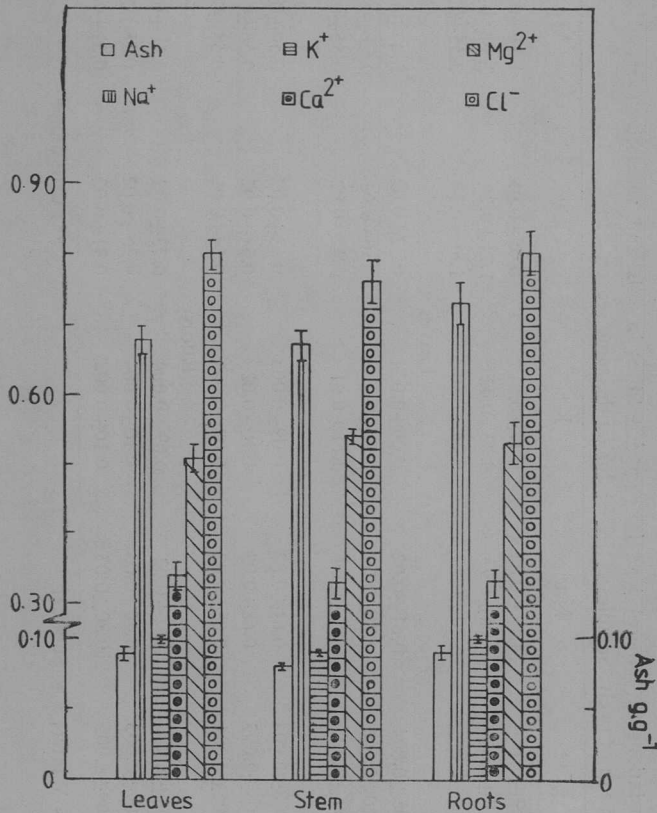


Fig. 2. Variations of mineral ions in leaves, stems and roots of *Aeluropus lagopoides*; each value represents mean of thirty six samples; the bars indicate the SEM

The data (Table 1) did not indicate any remarkable seasonal changes in ionic composition of *A. lagopoides*, though the accumulation of salt and major ions was slightly less in monsoon when salinity in the habitats was low. However, divalent cations Ca^{2+} and Mg^{2+} did not show any specific trend.

In soils supporting *A. lagopoides* about three-fold increase in salinity was noted in summer (Table 1), but the salt content of leaves, stems and roots did not reflect any changes. This suggests that the secretion of salts through glands control the salt accumulation in plant tissues and thereby the species withstands high salinity. An increase in salinity of halophytic habitats was also reported by Ungar (1974) and Joshi and Iyengar (1982). In addition, our data indicate the proportionate accumulation of all ions in decreasing order : $\text{Cl}^- > \text{Na}^{2+} > \text{Mg}^{2+} > \text{Ca}^{2+} > \text{K}^+$ in soils as well as in vegetative parts.

The pre-dominance of Na^+ and its moderate increase in soil as well as in different parts in summer show its preferential absorption. Kotmire (1983) has reported similar concentrations of Na^+ in *A. lagopoides* growing on Maharashtra coast. While discussing different 'physiotypes', Albert and Popp (1977) suggested that monocotyledonous halophytes accumulated more K^+ than Na^+ . In contrast, our findings and those by Gorham et al. (1980) clearly showed the reverse trend. It is likely that Na^+ might be useful in minimising wilting effects in this grass as suggested by Epstein (1972). High Cl^- content in soils and plant tissues may be due to its passive uptake (Joshi, 1976) and it appears to compensate the cationic balance (Waisel, 1972). This study further suggests adequate uptake of K^+ by *A. lagopoides* from Na^+ rich environment and its efficient translocation from roots to leaves.

Our results showed greater accumulation of Ca^+ than reported by Kotmire (1983). Thus, its uptake in *A. lagopoides* was not hindered by high Na^+ in soils (Waisel, 1972) and it possibly enhances the salt tolerance of this species, as reported by La Haye and Epstein (1969) in other species. Experimental evidence does not reflect any definite inter-relationship between Mg^{2+} and Ca^{2+} in halophytes (Joshi, 1986). However our studies on halophytes do indicate greater concentration of Mg^{2+} in soils and plants than that of Ca^{2+} (Joshi, 1982). Albert and Popp (1977) proposed that plants growing under saline conditions accumulated more Mg^{2+} than K^+ and this tendency was also noticed during present investigation.

Almost uniform ionic composition of vegetative parts in different seasons leads to the inference that *A. lagopoides* belongs to a group of salt secreting halophytes and the low salt content favours the use of this grass as a fodder.

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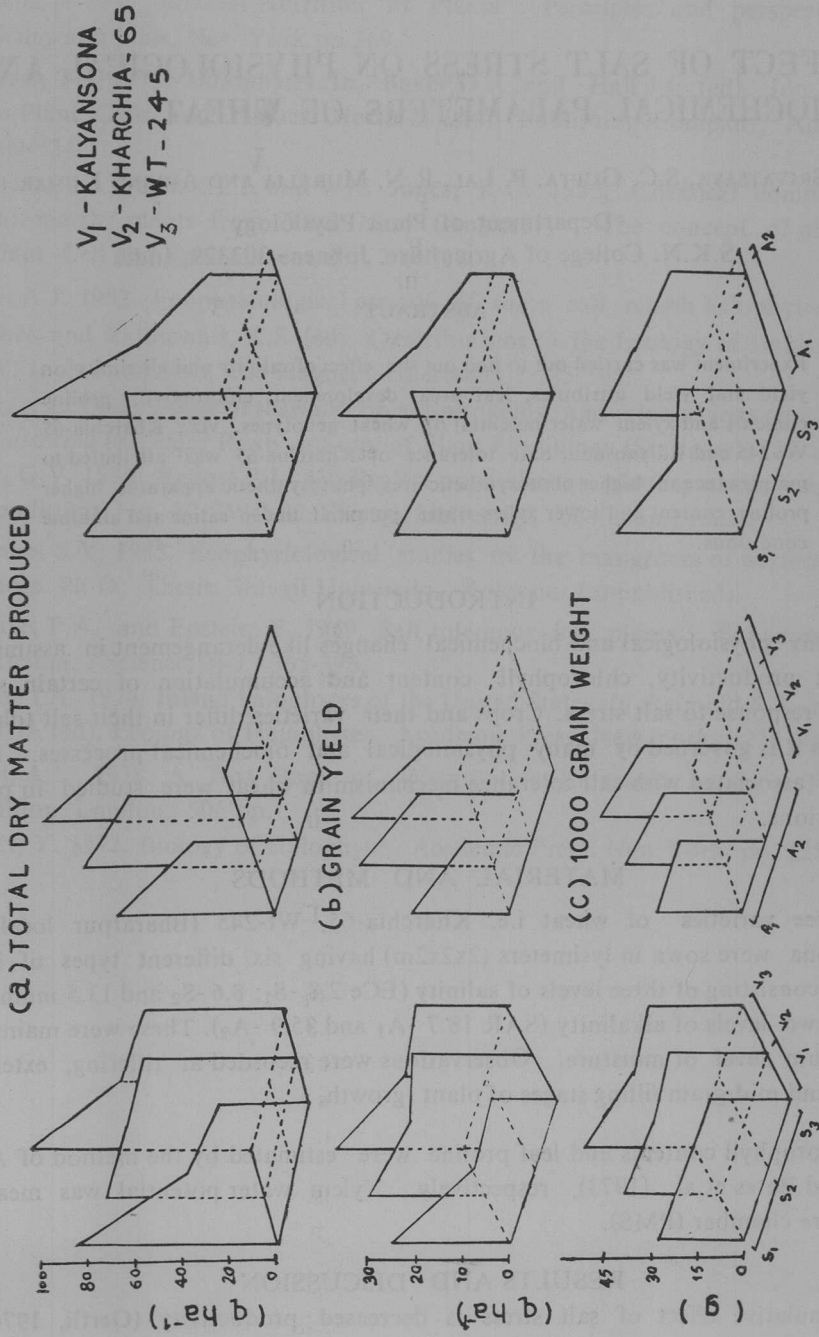


FIG. 7.-EFFECT OF SALINITY AND ALKALINITY OF SOIL ON YIELD AND YIELDING ATTRIBUTES OF WHEAT GENOTYPES

V₁- KALYANSONA

V₂- KHARCHIA- 65

V₃- WT. 245

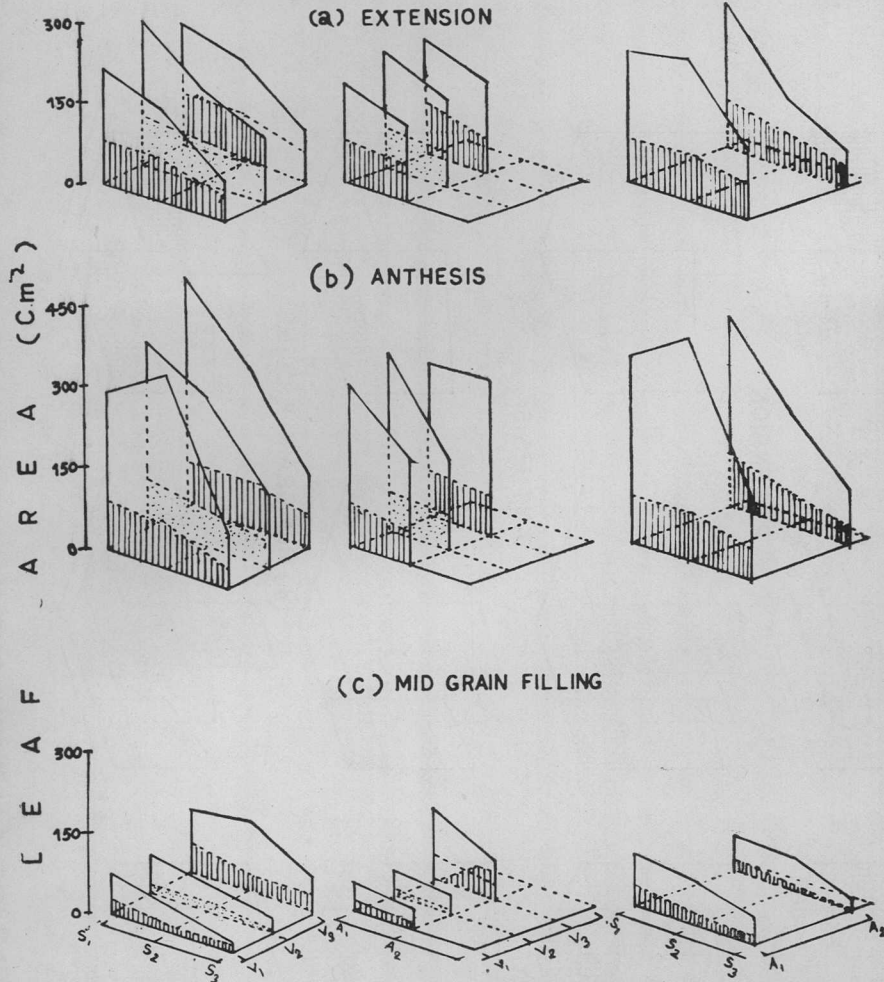


FIG.2 - EFFECT OF SALINITY AND ALKALINITY OF SOIL ON LEAF AREA PER PLANT (cm²), MOTHERSHOOT (DARK AREA) AND TILLERS (CLEAR AREA) OF WHEAT GENOTYPES AT THREE GROWTH STAGES.

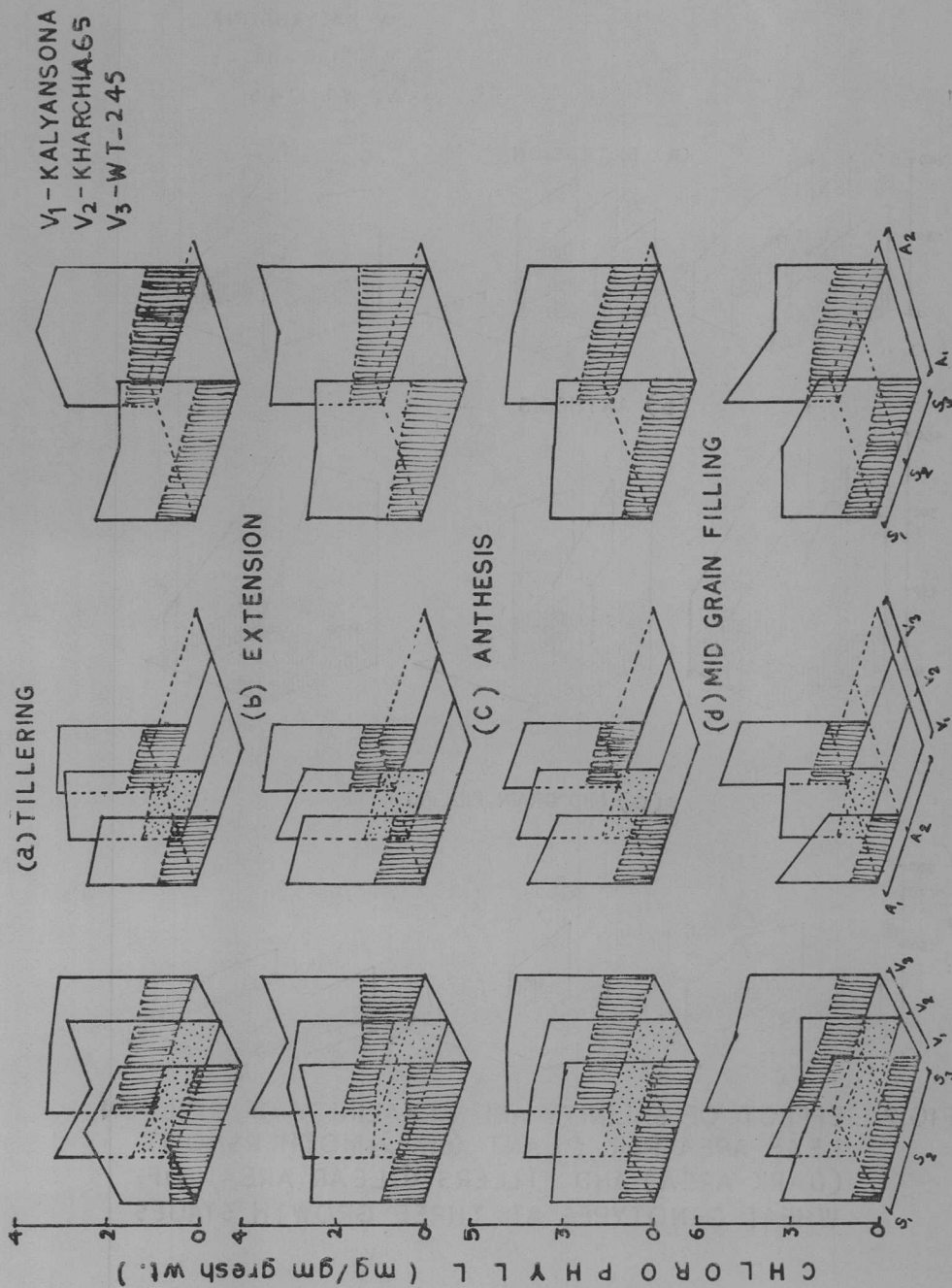


FIG. 3 -- EFFECT OF SALINITY AND ALKALINITY OF SOIL ON TOTAL CHLOROPHYLL CONTENT (mg g^{-1} FRESH WEIGHT), CHLOROPHYLL B (DARK AREA) AND CHLOROPHYLL A (CLEAR AREA) OF WHEAT GENOTYPES AT VARIOUS STAGES OF GROWTH.

Grain size seemed to be less affected unless both salinity and alkalinity increased (Fig. 1c).

Salinity stress was more injurious to leaf area development than the alkalinity (Fig. 2). Drastic reduction was observed on the leaf area of tillers especially at anthesis stage (Fig. 2b). Effect of alkalinity on leaf area development in Wt-245 was minimum. Higher levels of salinity and alkalinity in combination showed more deleterious effects. In addition to decrease in assimilation area, derangement in photosynthetic pigments are also known with salt stress (Kylin and Quatrano, 1975). Slight increase in total chlorophyll content and its components have been reported in pearl millet (Gupta et al., 1987). In general, an increased level of total chlorophyll (chlorophyll-a and chlorophyll-b) was observed in Kharchia - 65 and Wt-245 with increased salt stress (Fig. 3) probably due to more availability of some elements required for chlorophyll synthesis while reverse trend was noticed in Kalyansona. Reduced 'Source' potential (in terms of leaf area production) in Kharchia-65 and Wt-245 seemed to be offset, to some extent, by increased chlorophyll content. Maintenance of higher leaf area and chlorophyll content, particularly at later phase of crop growth in Kharchia-65 and Wt-245, might be attributed to their better yielding ability under salt stress.

Level of proline is found to be elevated under salt stress condition (Gupta et al. 1987). Although its role in stress tolerance is still debatable, yet it is supposed to be involved in bio-polymer protection and osmotic adjustment (Greenway and Munns, 1980). In pearl millet salinity stress was found to stimulate proline accumulation while alkalinity had no effect (Gupta et al. 1987). In present study proline accumulation increased with age of the plant (Fig. 4). At all the stages, except mid grain filling stage, increased salinity and alkalinity enhanced the proline accumulation, which was maximum at higher level of salinity and alkalinity. In general, tolerant genotype Kharchia-65 accumulated more proline, followed by Wt-245 and Kalyansona (Fig. 4).

Leaf xylem water potential was determined at extension and anthesis stages (Table 1). Increased salinity reduced the xylem water potential. The reduction was more in Kharchia-65. In contrast to salinity, alkalinity increased the xylem water potential. It was interesting to note that increased salinity decreased the water potential more at lower level of alkalinity than at higher level. Lower water potential of Kharchia-65 might be attributed to the better protoplasmic tolerance of this genotype.

Present investigations reveal that effects of salinity and alkalinity stresses on physiological and biochemical parameters were different. The severity became more when both were higher. However, salt tolerant genotype maintained higher productivity by maintaining higher photosynthetic area, higher photosynthetic apparatus (in terms of chlorophyll content), higher solute accumulation and maintaining the cell metabolism at reduced water potential.

V₁ - KALYANSONA
 V₂ - KHARCHIA - 65
 V₃ - WT-245

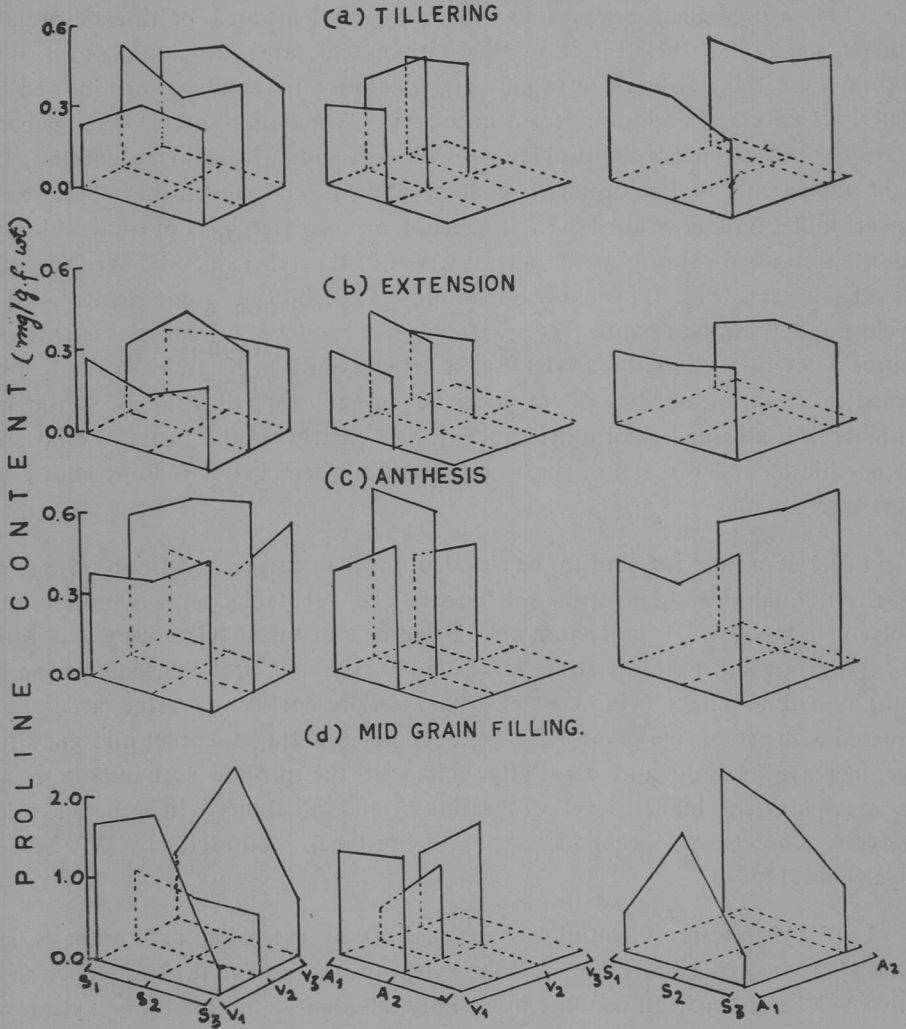


FIG. 4 - EFFECT OF SALINITY AND ALKALINITY OF SOIL ON PROLINE ACCUMULATION (mg.g⁻¹ FRESH WEIGHT) BY WHEAT GENOTYPES AT DIFFERENT STAGES OF GROWTH

Table 1. Effect of salinity and alkalinity on cumulative xylem water potential (-bars) of leaf in wheat genotypes at two stages of growth

Growth stage and genotype	Salinity level			Alkalinity level		Salinity level	Alkalinity level	
	S ₁	S ₂	S ₃	A ₁	A ₂		A ₁	A ₂
Extension								
Kalyansona	17.75	18.34	21.42	19.61	18.72	S ₁	18.22	18.17
Kharchia-65	18.75	18.84	22.67	20.78	19.39	S ₂	19.39	11.06
Wt-245	18.09	19.00	20.42	19.39	18.94	S ₃	22.17	20.83
Anthesis								
Kalyansona	22.50	33.59	30.00	30.61	28.78	S ₁	22.50	25.89
Kharchia-65	26.67	29.92	32.17	30.39	21.78	S ₂	31.72	28.72
Wt-245	23.42	27.14	24.25	25.33	24.56	S ₃	30.11	27.50

S₁ - ECe 2.8; S₂ - 8.6; S₃ - 13.5 mmhos/cmA₁ - SAR 18.7, A₂ - 35.9

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