GROWTH RESPONSE AND CATIONIC UPTAKE OF EUCALYPTUS HYBRID AT VARYING LEVELS OF SOIL SALINITY AND SODICITY

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Introduction

Eucalyptus is an exotic, fast growing ganus having several species of multiferious uses, such as a source of pulpwood, fuelwood, hard boards and particle boards, match industries, construction timber, carving wood, low cost furniture, oil and such other purposes. This genus is found to grow on a wide range of altitude, climate, topography, soil and other edaphic conditions. Trials on a large number of *Eucalyptus* species have been conducted in India and abroad under different environmental and soil conditions. In the Negev region of Israel *Eucalyptus camaldulensis* has been found to be one of the most tolerant species on chloride solonchak soil having ECe between 12-17 m.mhos/cm in the upper 30 cm depth and about 22 m.mhos/cm below this depth, and pH between 7 and 8.2 (Binder-Barhava and Ramati, 1967). Karschon (1966) reported very high degree of salt tolerance of *E. camaldulensis* in the Rift valley of Israel on soils containing high amount of $CaCO_3$ and of soluble salts mainly of chlorides and sulphates with pH 7.6-8.1. He also reported that *E. camaldulensis* gave good results under saline water irrigation in French sahara. Raja Singh (1965) found *E. camaldulensis* to be the most promising species in arid and saline sites of Kuwait and Sudan. Other species of *Eucalyptus reported to be tolerent under* such conditions are *E. microtheca* and *E. tereticornis* in Sudan and *E. comphocephala* and *E. obtusa* in Kuwait.

In India, Qureshi and Yadav (1971) reported that some Eucalypts species like *E. tereticornis, E. tesselaris, E. papuna, E. melonophloia, E. populnia, E. Obeosa* and *E. radia* are suitable for afforestation in arid and semi-arid regions of this country. Yadav and Tomar (1981) observed that *Eucalyptus hybrid* failed to grow at EC 4 m mhos/cm and above due to development of high soil salinity as a result of irrigation with high EC water. Tomar and Yadav (1977) found appreciable decrease in the growth of *Eucalyptus hybrid* with increasing level of salinity in irrigation waters. Tomar and Yadav (1980) reported that water of EC less than 2 m.mhos/cm can be used for irrigation in case of *Eucalyptus hybrid.*

Performance of *Eucalyptus*

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hybrid was reported to be promising on sodic soils by Yadav (1981). It could grow satisfactorily on the soils having pH upto 9 and soluble salts upto 0.3 per cent, but failed to grow on soils which had pH above 10 and soluble salt content above 0.7 per cent in Haryana and Punjab (Kaushik *et al.* 1969). Yadav and Tomar (1981) reported that the successful growth of *Eucalyptus hybrid* can be expected on the light textured soil having upto EC 8.5 m.mhos/cm, pH 9.4 and SAR about 60.

Systematic inestigations to evaluate the growth response and nutrient uptake of *E. hybrid* at varying levels of soil salinity and sodicity are, however, lacking. In view of the scope of growing *Eucalyptus* species on salt effected soils, present investigation was carried out to study the performance of *Eucalyptus hybrid* in early stages of its growth at varying levels of soil ECe and ESP.

Material and Methods

Response of *Eucalyptus hybrid* was evaluated by carrying out two separate sets of experiments - (i) with varying levels of salinity (ECe), and (ii) with varying levels of soil sodicity (ESP), in glazed earthen pots each filled with 10 kg soil. The salinity levels were created artificially in a normal silty clay loam soil (clay 29.4%), silt 39.2% and sand 31.4%) by adding salts of chlorides, sulphates and bicarbonates (6:3:1) of sodium and calcium (4:1), and the different ECe levels actually attained after equilibrium were 0.7, 4.2, 8.1, 16.3 and 32.5 m.mhos/cm. A polythene lining was provided inside the pots and suitable arrangement was made to add water to the pots from the top and bottom alternatively. Each treatment was replicated three times. Nine month old seedlings of *Eucalyptus hybrid* raised in nursery were transplanted in the pots on November 25, 1979. Irrigation with deionized water was given as and when required during the entire growth period of about 28 months. Observations on height and girth of each plant were recorded regulaly at an interval of every three months.

In the other experiment ESP levels were created artificially in a normal silty clay loam soil by addition of varying amounts of $NaHCO_3$, using the method as described by Bains and Fireman (1964). Different levels of ESP actually attained in the experiment were 1.1, 15.2, 30.6, 61.4 and 88.7. Replication of treatments, time of transplanting, recording of observations and other details were the same as described in the salinity experiment.

At the termination of the experiments the whole plants were uprooted from the pots, washed thoroughly with distilled water and dried in the air. Observations on average fresh weight and oven dry weight of plants in each treatment were made. After cutting and grinding, the plant samples were wet digested and Na^+ and K^+ were determined flame photomatrically and Ca^{++} and Mg^{++} on Baird Atomic Absorption

Spectrophotometer using the methods outlined by Jackson (1967).

Results and Discussion

Growth Response : The periodic measurements of height and girth of plants revealed that *Eucalyptus hybrid* failed to grow at ECe 32.5 m.mhos/cm and ESP 61.4, and therefore, the data in Figure 1, 2, 3, 4, 5 and 6 have been reported only in respect of ECe upto 16.3 m.mhos/cm and ESP upto 30.6 levels. These observations indicate that *E. hybrid* can tolerate a fair degree of salinity and sodicity. The tolerance limit of this tree species might be higher under field conditions as compared to the pot culture conditions due to better growth environment like greater soil depth, greater root development, better drainage conditions, more aeration and such other related characteristics in the field as was observed in a field study conducted in a forested area of a Western part of Uttar Pradesh (Table 1). The observations made on *E. hybrid* plantations along canals and roads in Vrijbjumi Forest Division (U.P) revealed that *E. hybrid* was able to grow in saline soils (coarse-loamy, Aeric Helaquepts/Fine-loamy Typic Camborthids) which possessed ECe below 18.5 m.mhos/cm, pH below 7.5 and predominantly neutral salts of $Cl+SO_4$ in the root zone (Table 2). Higher concentration of salts upto ECe 45 m.mhos/cm in top 12 or 17 cm soil did not appear to affect the plant growth much adversely, as seedlings with greater root length were used for planting. The varied performance of *Eucalyptus* species in saline soils or under saline water irrigation was also reported earlier (Tomar and Yadav, 1977; qureshi and Yadav, 1971; Binder Berhava and Ramati, 1967; Karschon, 1966; Raja Singh, 1965).

Height and girth of plants during the entire study period and fresh and dry weight of plants at the termination of the experiment decreased with increase in ECe or ESP values (Fig. 1, 2 and 3; Table 3). Although the decrease was perceptible even at lower ECe level of 4.2 and 8.1 m mhos/cm, it was significantly more marked at higher level of ECe 16.3 m mhos/cm. Similarly, quite sharp reduction in height growth was noticed at ESP 30.6 as compared to ESP 15.2 and control. Dry weight per plant exhibited a sharp reduction when the ESP value reached 30.6. In case of soil salinity the dry weight per plant showed relatively a gentle slope with increasing values of ECe upto 16.3 m mhos/cm. Taking control as 100, *E. hybrid* showed 22%, 28%, 47% and 39% reduction at ECe 16.3 m mhos/cm and 23%, 36%, 51% and 54% reduction at ESP 30.6 in height, girth, fresh weight and dry weight respectively. On the basis of 50% reduction in height growth the critical limit of salinity tolerance of *E. hybrid* might fall above ECe 16.3 m mhos/cm and alkali tolerance above ESP 30.6 under pot culture conditions (Fig. 5 and 6).

Cationic Uptake : The relevant data on plant analysis given in Fig. 4 show that the uptake of Sodium increased

Table 1

Site characteristics, vegetation and morphology of soil profiles from Vrijbhumi Forest Divn. (U.P.)

Profile 1 :	Locality :	Radhakund (Mathura), Relief : Undulated plain. Profile depth : Very deep. Ground water table 4 m.
	Drainage :	Surface and internal both medium. Vegetation: 1953 plantation of *Dalbergia sissoo* (31.5%, H.7.7, G 0.34 *Holoptelia integrifolia* (15.7%, H 6.3, G 0.26), *Pongamia pinnata* (5.26%, H 5, G 0.44), *Prosopis juliflora* (5.26%, H 5.5, G 0.62), *Eucaluptus hybrid* on road sides (5.26%, H 27.5, G 1.32).
	Natural species :	*Salvadora oleoides* (30.92%, H 4.5, G 0.45) and *Prosopis cineraria* (5.26%, H 6, G 0.53)
	Horizons	
	0-12 cm	Yellowish brown 10 YR 5/8; 4/4 moist) hard sandy clay loam without lime nodules and with many roots and krotovinas upto 1 cm dia.
	12-80 cm	Brownish yellow (10 YR 5.5/6; 4/4 moist) firm sandy clay loam without lime nodules and with many roots upto 3 cm dia. and many krotovinas upto 2 cm dia.
	80-106 cm	Brownish yellow (10 YR 6/6; 4/4 moist) very firm clay loam without lime nodules and with many roots upto 26 cm dia.
	106-145cm	Brownish yellow (10 YR 6/6; 4/4 moist) friable clay loam without lime nodules and with many fine roots.
	Soil type :	Saline soilks (fine-loamy, mixed, hyperthermic, typic *Camborthids*).

(Contd.)

Profile 2: **Locality:** 24 L.B. Kanpur branch canal, Shikohabad (Mainpuri) **Relief:** Undulated plain. Profile depth very deep. Ground water table : 2m, rises in rains, Drainage: Surface - medium and internal slow. Vegetation : 1969-70 plantation of *Prosopis juliflora* (82.5, H 2, G 0.25 bushy), *Eucalyptus hybrid* (9.5%, H 16.5, G 0.83), *Cassia saemia* (6.3%, H 4, G 0.40) and *Dalbergia sissoo* (1.6%, H 6, G 0.55)

Horizons	Soil morphology
0-17 cm	Light yellowish brown (2.5 Y 6/4 ; 5/2 moist) *firm silty loam without lime nodules*
17-43 cm	Light yellowish brown (2.5 Y 6/4; 5/2 moist) firm silty loam without lime nodules and with few fine krotovinas.
43-75 cm	Light brownish grey (2.5 Y 6/2; 4/2 moist) firm silty loam without lime nodules and with many krotovinas upto 2 cm dia.
75-133 cm	Light brownish grey (2.5 Y 6/2; 4/2 moist) very firm silty loam without lime nodules and with many krotovians upto 2 cm dia.
133-180 cm	Light brownish grey (2.5 Y 6/2; 4/2 moist) firm silty loam without lime nodules and krotovinas. Roots few fine.

Soil type: Saline soils (Coarse-loamy, Mixed, Hyperthermic, Aeric Halaquepts)

Note: '%': Percentage distribution, 'H': Average height (m) and 'G' Average G.B.H (m) of vegetation are shown in brackets.

Table 2

Chemical characteristics of soil profiles from Vrijbhumi Forest Division (U.P.)

Profile	Depth (cm)	pH (1:2.5)	ECe (m.mhos/cm)	Composition of saturation extract (me/l) Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	ESP	Organic matter	Clay (%)
1.	0-12	6.7	45.0	305.0	108.75	33.91	1.20	Nil	0.86	434.2	22.4	2.2	0.50	24.1
	12-80	6.8	15.0	62.5	46.20	38.69	0.15	Nil	0.58	115.0	14.4	4.7	0.21	29.2
	80-106	7.2	17.0	60.0	52.82	61.46	0.10	Nil	0.58	131.8	18.4	6.4	0.17	30.0
	106-145	7.5	18.5	57.5	61.82	63.75	0.13	Nil	0.58	147.8	22.4	7.2	0.10	27.9
2.	0-17	8.3	16.0	4.5	7.50	133.04	1.70	Traces	3.71	19.8	126.6	14.6	1.36	14.5
	17-43	8.8	10.0	2.7	5.00	84.78	0.15	-do-	2.00	17.0	89.6	14.4	0.65	14.5
	43-75	8.4	11.0	4.2	8.30	86.95	0.18	-do-	1.71	11.8	94.4	13.0	0.55	18.8
	75-133	8.7	3.9	1.6	4.17	33.04	0.13	-do-	2.00	3.0	39.6	15.4	0.60	16.8
	133-180	8.4	0.4	0.4	1.67	1.89	0.06	-do-	2.29	0.2	1.6	4.2	0.45	17.1

Table 3

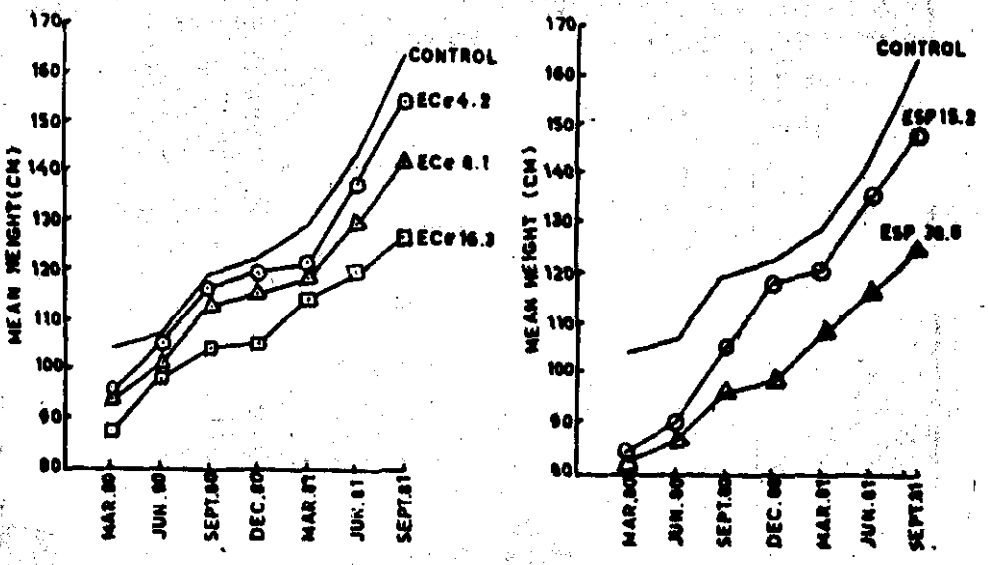
Average fresh and cationic ratios of Eucalyptus hybrid at varying ECe and ESP levels of soil

Treatments	Fresh weight (g)	Ratios		
		Na/K	Na/Ca	Na/Mg
ECe (m.mhos/cm)				
0.7 (cont.)	170.5	0.07	0.02	0.10
4.2	165.5	0.37	0.10	0.25
8.1	113.0	0.61	0.16	0.95
16.3	91.0	1.45	0.35	1.88
ESP				
1.1	170.5	0.07	0.02	0.10
15.2	93.7	1.31	0.20	1.19
30.6	67.0	1.62	0.51	1.38

progressively with increase in ECe or ESP, but the trend of increase in Na uptake was comparatively more abrupt in case of increasing ESP then ECe. The increase in sodium uptake showed a fair correlation with the marked reduction in height growth, girth, fresh and dry weight of *E. hybrid* . Taking Na^+ concentration as 100 in control, the increase was more pronounced at higher levels of ESP as compared to higher levels of ECe, being only about 10 times increase at ECe 16.3 m.mhos/cm as against about fifteen times increase at ESP 30.6.

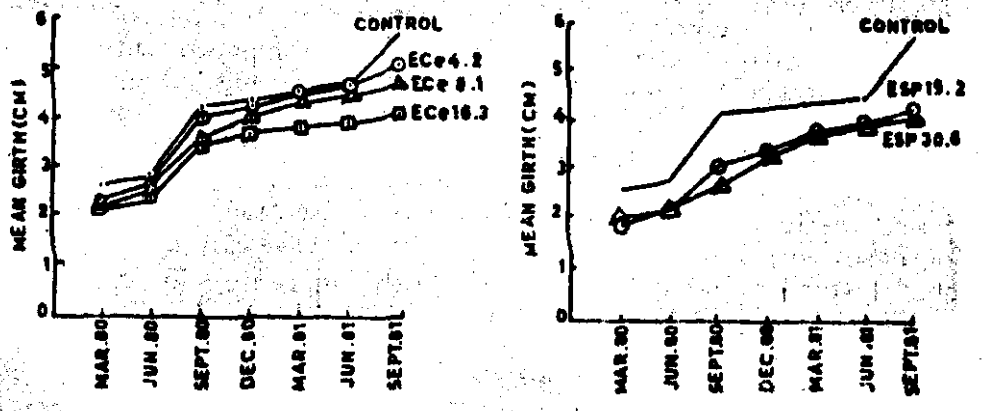
The uptake of calcium in plants showed a decreasing trend with increase in soil salinity and sodicity levels. About 41% decrease at ESP 30.6 and 42% decrease at ECe 16.3 m.mhos/cm was recorded as compared with the control. Relatively lower uptake of Ca^{++} under both saline and sodic soil conditions appeared to increase the adverse effect of sodium. Concentration of K^+ in plants did not have any definite relationship with increase in ESP. However, it exhibited about 46% decrease at ECe 16.3 m.mhos/cm. Likewise, the concentration of Mg^{++} in plants also did not show any definite relationship with increase in ECe or ESP levels, though about 13% more increase in Mg^{++} at ESP 30.6 as compared to its control

Fig. 1



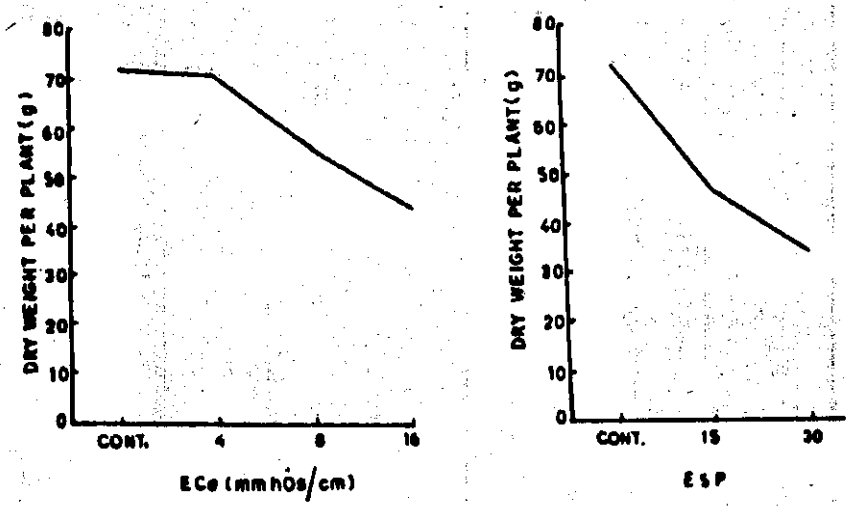
Mean height of *Eucalyptus hybrid* at varying Salinity and ESP levels

Fig. 2



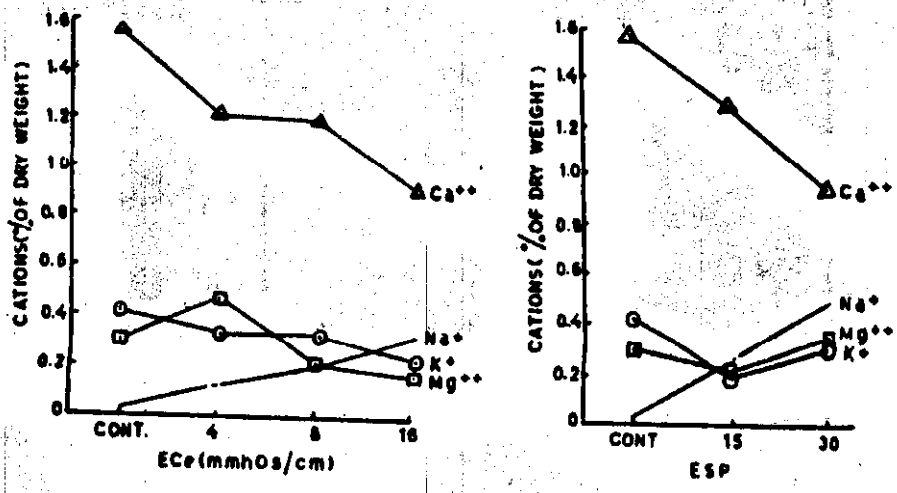
Mean girth at varying Salinity and ESP levels

Fig. 3



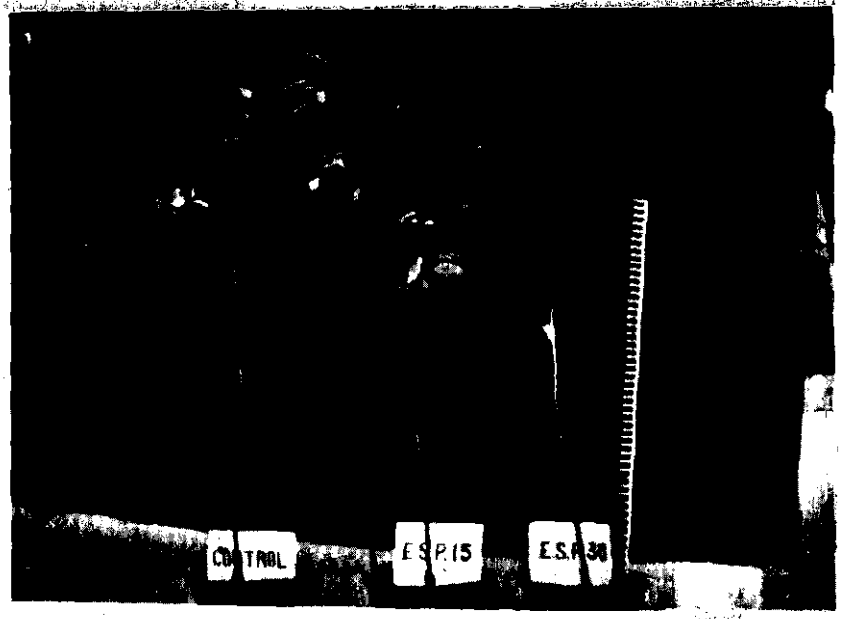
Dry weight per plant of *Eucalyptus hybrid* at varying Salinity and ESP levels

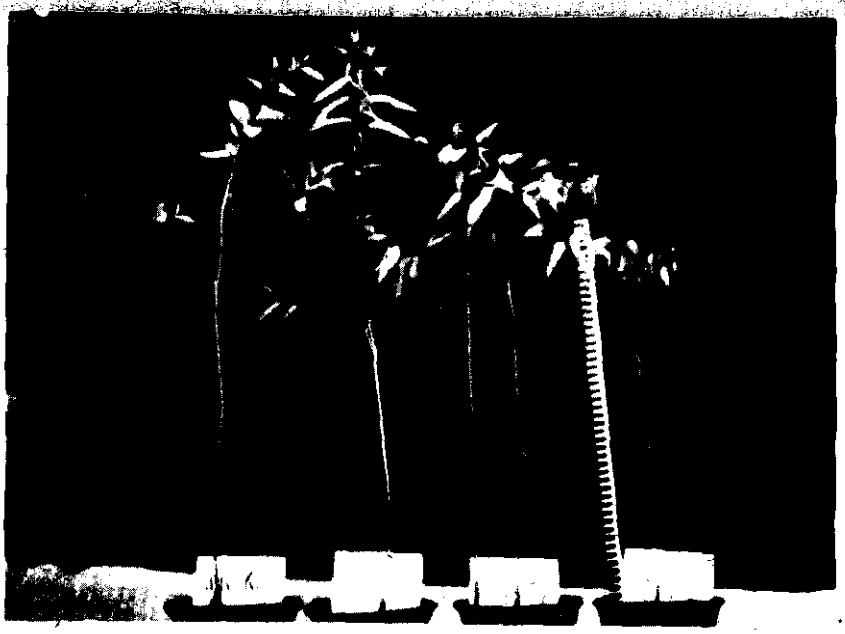
Fig. 4



Cationic concentration at varying Salinty and ESP levels

EUCALYPTUS HYBRID AT VARYING SALINITY AND ESP LEVELS





might have exercised adverse effect on plant growth. These data suggest that this forest species also shows differential uptake of cations under salt affected conditions like agricultual crops reported by Brown and Hayward (1956), Shalhevet and Bernstein (1968) and Heikal (1977). Owing to higher uptake of sodium Na/K, Na/Ca and Na/Mg ratios increased with increase in salinity or sodicity. Apparently, the increase in the values of these ratios depended more upon the increase of sodium content, rather then on the reduction in the content of calcium.

These results demonstrate that *Eucalyptus hybrid* offers a good possibility of being grown on moderately saline and sodic soils. There are vast stretches of salt affected lands in the Indo-Gangetic plains and elsewhere in the country. Some of these lands depending upon the degree of soil salinity and sodicity can be utilized for raising *Eucalyptus hybrid* plantations. The possibility is greater on road sides, canal banks, railway track, urban areas and village panchayat lands where cultivation of agricultural crops is not generally practicable due to obvious reasons, along with various forestry programmes like agri-silviculture, farm-forestry, social forestry, industrial plantations etc. In the areas where the soil conditions are more deteriorated, use of suitable amendment for effecting minimal soil improvement and appropriate planting technique for ensuring successful establishment will be necessary so as to avoid discouraging results of failure.

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Summary

Performance of Eucalyptus hybrid was evaluated under pot culture conditions at artificially created varying salinity (ECe) levels of 0.7, 4.2, 8.1, 16.3 and 32.5 m.mhos/cm and exchangeable sodium percentage (ESP) levels of 1.1, 15.2, 30.6, 61.4 and 88.7 in an alluvial silty clay loam soil by addition of different salts. Results revealed that Eucalyptus hybrid failed to grow above ECe 16.3 m.mhos/cm and ESP 30.6. Height, girth, fresh weight and dry weight of uprooted plants at the time of termination of experiment were found to decrease with increase in ECe or ESP. Uptake of Na^{+} by plants increased with increase in ECe or ESP levels, while the uptake of Ca^{++} decreased and Mg^{++} and K^{+} did not exhibit any definite relationship with increase in salinity or sodicity conditions. The values of Na/K, Na/Ca and Na/Mg ratios in the plant increased with increase in ECe or ESP. Relatively lower uptake of Ca^{++} appeared to increase the adverse effect of sodium in saline and sodic soils. Since the present experiments were conducted under pot culture conditions, further systematic field studies are suggested to confirm these observations.

मृदा लवणता और सोडिता के विभिन्न स्तरों पर संकर युकेलिप्टस द्वारा वृद्धि प्रतिचार और धनायन ग्रहण

के० सिंह व जे० एस० पी० यादव

सारांश

गमलों में उगाकर तथा चिकनी दुमट मिट्टी में विभिन्न लवण मिलाकर भिन्न-भिन्न लवणता स्तर 0.7, 4.2, 8.1, 16.3 और 22.5

एम म्हो / सेमी कृत्रिमता बनाकर तथा विनिमेय सोडियम प्रतिशत 1.1, 15.2, 30.6, 61.1 और 88.7 बनाते हुए संकर युकेलिप्टस की क्रियाशीलता का मूल्यांकन किया गया है। परिणामों ने दिखाया कि संकर युकेलिप्टस 16.5 एम म्हो / सेमी० से अधिक लवणता और 0.6 विनिमेय सोडियम प्रतिशत पर उग नहीं सका। संपरीक्षण पूरा होने पर उखाड़े गए पौधों की ऊंचाई, परिधि, ताजा भार और शुष्क भार, लवणता और विनिमेय सोडियम प्रतिशत बढ़ाने पर घटते पाए गए। लवणता का सोडियम प्रतिशत स्तर बढ़ने पर पौधों द्वारा सोडियम $^{+}$ उद्ग्रहण बढ़ा, किन्तु कैलसियम$^{++}$ उद्ग्रहण घटा, तथा मैगनीशियम$^{++}$ और पोटेसियम$^{+}$ का लवणता या सोडिता दशाओं में वृद्धि होने से कोई विशेष सम्बन्ध होता नहीं पाया गया। लवणता या सोडियम प्रतिशत बढ़ने पर पौधों में सोडियम / पोटाशियम, सोडियम / कैलसियम, सोडियम / मैगनीशियम X अनुपात की अर्हाएं बढ़ी। कैलसियम$^{++}$ के कम उद्ग्रहण से लवण और सोडा मृदाओं में सोडियम का कुप्रभाव बढ़ता प्रतीत हुआ। उपर्युक्त संपरीक्षण गमलों में ही किए गए हैं इसलिए इन पर्यावलोकनों को क्षेत्र परीक्षण कराकर पुष्ट करने का सुझाव भी दिया गया है।

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