Effect of salinity stress on growth performance of Citronella java

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Abstract: ***Salinity adversely reduces the overall productivity of plants. Out of 320 mha of land in India out 8.5 m ha is salt affected. Out of 15 agro climatic zones of India 8 are affected with salinity. Generally screening and cultivation of crops on the salt affected soil is the main approach. Slips of Citronella java were planted in pots containing loamy soil with control 5.0, 10, 15 and 20 d S/m concentration of salts of chloride, sulphate, and bicarbonate(6:3:1) of sodium and calcium(4:1) to see their salinity tolerance.Various concentrations of salt had a highly significant effect upon the survival percentage, plant height, number of branches, herb yield and dry matter yield. Number of leaves also varied significantly. However, leaf length and shoot moisture contents exhibited non-significant difference. The findings suggest that the test species are tolerant to moderate salinity and might be tried on saline soil to obtain some biomass.***

Keywords: Salinity stress, Citronella java, loamy soil, and medicinal plant

1. Introduction

India is endowed with a rich wealth of medicinal plants. Extension of the allopathic system of medicinal treatment in India has generated a commercial demand for pharmacopoeial drugs and their products in the country. Java Citronella(Cymbopogon winterianus Jowitt) an important aromatic grass belonging to the Poaceae family cultivated in parts of tropical and subtropical areas of Asia, Africa and America[1]. One of the important essential oils extracted from aromatic grass is citronella oil. This oil is used extensively as a source of important perfumery chemicals like citronellal, citronellal and geraniol, which finds its extensive use in soap, perfumery, cosmetic and flavoring industries throughout the world.

Soil salinity is a problem of global concern [2]. Some study [3, 4] estimated that terrestrial saline habitats constitute about 7% of the worlds land area i.e. ca. 7 million km^2. Plant growth in saline soils is suppressed by nonspecific osmotic effects, toxic solutes and sodicity [5, 6]. Most agricultural crops are sensitive to salinity [7,8].Salinity adversely reduces the overall productivity of plants including crops by inducing numerous abnormal morphological, physiological and biochemical changes that causes delayed germination, high seeding mortality, poor crop stand, stunted growth and lower yields[9-13]. These adverse effects of the salts are related to the decreased osmotic potential of the stressed root media but the extent of salt effect is altered by specific ions of the salt solution.

It appears that little information is available regarding the effect of salinity on the growth and productivity of medicinal plants. The present study is focussed to assess the tolerance of these medicinal plants towards salinity at their vegetative growth. The findings may help in utilizing saline habitats. The successful cultivation of medicinal plants will provide raw material to pharmacological companies and for local medicinal uses.

2. Experimental

2.1 Material and Methods

The soil for the experiment was collected from the upper layer (0-15 cm) of a cultivated field. The collected soil was air-dried, crushed and sieved through a 2 mm sieve and homogeneously mixed before subjecting to different treatment.

2.2 Characterization of soil

The soil was subjected to physico-chemical analysis. The physico-chemical properties of the experimental soil are given in table1. The results of mechanical analysis indicate that the soil used in greenhouse experiment was sandy loam in texture, alkaline in reaction, deficient in available nitrogen, phosphorus and moderate in potassium.

2.3 Experimental procedure

Response of the aromatic and medicinal plants to different levels of salinity was evaluated under pot culture conditions. For this purpose, experiments were conducted with varying levels of salinity.

2.4 Crop tolerance to salinity

In order to assess the range of soil status which can be tolerated by Citronella java, studies were carried out in earthen pots each filled with 10 kg soil. The different salinity levels, i.e., control, 5,10,15 and 20 dSm^{-1} were created artificially in a normal sandy loam soil by adding salts of chloride, sulphate and bicarbonate(6:3:1) of sodium and calcium(4:1). Different EC levels actually attained after equilibrium in the experiment were 0.7, 5.2, 10.1, 15.3 and 20.5dSm^{-1}. A polythene lining was provided inside the pots.

The basal doses of nitrogen (N), phosphorous (P_2O_5) and potassium (K_2O) were applied in each pot at the rate of 75 mg/kg, 30 mg/kg and 30 mg/kg through urea, single superphosphate and muriate of potash respectively at the time of planting sowing of each crop.

The 45 day old slips of Citronella java were planted in the pots. The pots were irrigated with deionised water for the establishment of seedling and further also when required.

The various growth observations viz. Plant height, number of branches and number of leaves per plant and dry matter yield of leaves were recorded in December and March. At harvest (in June), only the dry matter yields of roots, leaves and stem were recorded. Plant samples (leaf, stem and roots) were also collected at various growth stages.

3. Results and Discussion

The results of the present study as obtained for the various growth character, yield, quality and uptake of nutrients for the plant Citronella java are given below:

3.1 Relative salt tolerance of crops Plant height

The plant attained only a nominal height at first cutting. Thereafter, there was a steady rise. The rate of increase in the plant height was quite slow after second cutting. A further study of table 2 clearly shows that the effect of soil salinity on plant height was significant at various stages of growth. The higher levels of soil salinity were found to have an adverse effect on plant height of the crops. The height under salinity level of 5.0 dSm^{-1} was statistically on par with that in control (EC 0.7 dSm^{-1}).

3.2 Number of tillers per plant

The data on the number of tillers per plant at various cuttings are given in table 3. On an average, the number of tillers per plant increased and attained the maximum value at third cutting in all the treatments. It is clear from table 3 that the number of tillers per plant of Citronella java improved with lower level of soil salinity. However, this improvement was non-significant in both the crops. The higher levels of soil salinity tended to decrease the number of tillers per plant and the extent of reduction in number of tillers was more conspicuous at 20 dSm^{-1} salinity level. The extent of reductions in number of tillers in Citronella java at 20 dSm^{-1}salinity level at first, second and third cuttings were 28.6, 32.5 and 26.5 percent, respectively over control.

3.3 Herb Yield

The data on the effect of different soil salinity levels on herb yield of aromatic and medicinal crop is summarised in table 4. From the data it can be inferred the herb yield of crop decreased significantly with higher level of soil salinity. The corresponding decreases in herb yield of Citronella java with 20 dSm^{-1} EC level were 32.5, 31.6 and 19.9 percent. The higher EC levels (15 and 20 dSm^{-1}) also differed significantly with each other in respect of herb yields at all the cuttings. The herb yield of Citronella java was more or less constant up to salinity level of 5dSm^{-1} and was reduced thereafter. At the salinity level of 20 dm-1 the decrease in herb yield against control was 32.5, 31.0 and 19.9 percent at first, second and third cutting respectively.

3.4 Dry matter Yield

The data on the effect of different salinity levels on dry matter yield of plant is presented in table 5. A study of table 5 reveals that the higher EC level (15 and 20 dSm^{-1}) produced the lower yield over lower EC level and control. The extent of decrease in yield with 20 dSm^{-1} EC level was found to be 39.7, 35.4, 32.5 percent in plant at first, second and third cutting, respectively over control.

3.5 Relative salt tolerance of aromatic and medicinal plants

The plant Citronella java turned out to be the least tolerant as its herb yield was reduced considerably beyond EC 5.0 dSm^{-1} (Table 5). At higher EC values than 10.0 d Sm^{-1} the plant could not grow properly indicating that it may not be grown successfully in soils of medium to high salinity. Salinity up to a certain levels (5.0 EC in this case) seems to lead to osmotic adjustment that improves plant water balance which could result in an increase in the yield. At salinity beyond the optimum level, growth and development are affected because of water stress caused by osmotic inhibition[14] and influx of ions in large quantities leading to toxicity. Significant reductions in yield over control were observed at EC 15.0 and 20 d Sm^{-1}.Singh and Anwar [15] observed that java citronella can be grown without significant reduction in herb yield up to EC l of 11.5, 10.0 and 5.5 mmhos /cm respectively. At 7.5 EC while the herbs yield of citronella was reduced by 32 to 54% over control. Pal at al[16] studied the performance of Java citronella (Cymbopogon winterianus) irrigated with saline water ranging in EC 2.4 to 20 d Sm^{-1}. The herb production increased with EC 4 d Sm-1 of water as compared to control (EC 2.4) and beyond that remarkable reduction was noted.

Table 5 shows the effect of soil salinity on dry matter production of plant. The dry matter yield of the plant decreased considerably with increasing levels of soil salinity. The soil salinity at higher levels had an adverse effect on dry matter production. The effect of high salinity levels was harmful in case of growth characters. These salinity levels resulted in appreciably lower number of tillers than those by control treatment. The yield of the crop is the joint venture of its contributing characters such as plant height, number of branches, etc. All these attributes were adversely affected with high soil salinity levels and, therefore, this effect resulted in lower dry matter yield[17-20].

Accumulation of salts (Saline Soil) disturbs the physiological and metabolical activities of the plants [21]. It leads to an increase in the osmotic pressure in the soil solution, limits the absorption of water by plants and consequently retards their growth[22]. In many cases, the reduced soil osmotic potential induces a similar reduction in the leaf potential while its gradients remain unchanged. This phenomenon is known as osmotic adjustment[23] which results in an accumulation of inorganic and organic solutes in the plant sap. Osmotic adjustment is a primary mechanism affecting growth and production[24].

Excessive levels of salts may also alter the hormone balance of the plants and it may damage the plant cells and cytoplasmic organelles. It has been observed plants may tolerate total salinity within their tolerance limits, but change in the ionic nature of the solution of the same concentration may alter their tolerance limits[25]. The adverse effects of salinity on metabolic and enzymatic activity of the plants lead to decreased growth and finally yield.

In the present investigation, growth was measured in terms of plant height, number of leaves and number of branches per plant. These characters were increased continuously and almost linearly up to the harvest irrespective of treatment. During early growth period, the roots are not well established, thus, the initial weight of plant, number of tillers per plant were low. The height is closely related to the growth which is dependent on the osmotic pressure of the root medium, the growth depends on the maintenance of turgor while osmotic under adjustment might retard growth until additional absorbed solutes(salts) or synthesized solutes (organic compounds) affect the requisite adjustment. Hence, the reduction in height and growth may be retarded as a consequent of the requirement for osmotic adjustment[14]. Similar to height of plant, the number of tillers per plant was affected adversely with the salinity levels. The significant reduction in plant height with increasing levels of soil salinity (EC) is due to greater accumulation of salts in soil. This cause a reduction in the availability of water to plants resulting into stunted growth. The higher EC of soil decreased physiological availability of water to the plant. The normal cell division which is responsible for production of tiller gets hindered under the saline conditions. Increased salinity may reduce the tiller due to decrease in water potential of plant cell to the point that it or both of its components (osmotic potential and pressure potential) become limiting factor for plant growth.

4. Conclusion

There was a steady rise in plant height till harvest. The higher levels of soil salinity were found to have an adverse effect on plant height of the crop. The number of tillers per plant increased as the plant age was advanced. The higher salinity levels reduced levels reduced significantly the number of tillers over control. The number of tillers per plant increased irrespective of the treatments and reached the maximum level at first cutting. There was a significant reduction in the number of leaves from plant with higher salinity levels. The herb yield of the crop decreased significantly at higher salinity levels.

Table-1
Physico-Chemical properties of the experimental soil

Characteristics	Value
Sand	64.5
Silt	15.8
Clay	19.7
Textural Class	Sandy Loam
pH(1:25 soil water suspension)	8.0
EC(dSm-1)	0.16
Organic Carbon(gkg-1)	3.2
CaCO3(gkg-1)	5.0
Available N(mg kg-1)	65.0
Available P(mg kg-1)	4.5
Available K(mg kg-1)	90.0

Table-2
Effect of salinity levels on plant height (Cm) of Citronella java at various cuttings of the crop

Crop cutting	Salinity Levels (dSm-1)						S Em±	CD at 5%
	Control	5	10	15	20	Mean		
I	60.0	60.1	55.7	50.2	45.0	54.2	0.38	1.15
II	52.0	51.8	49.3	44.7	38.5	47.3	0.24	0.74
III	58.0	59.0	56.5	52.0	46.7	54.4	0.45	1.37

Table- 3
Effect of salinity levels on number of tillers per plant of Citronella java at various cuttings of the crop

Salinity Level (dSm-1)	Cuttings		
	I	II	III
Control	7.0	12.0	20.0
5	6.9	11.3	19.5
10	6.3	10.7	18.0
15	5.7	9.6	16.5
20	5.0	8.1	14.7
Mean	6.2	10.2	17.6
S Em ±	0.18	0.31	0.42
CD at 5%	0.55	0.95	1.37

Table-4
Effect of salinity levels on herb yield at various cuttings of the crop

Crop cutting	Control	Salinity Levels (dSm-1)					S Em±	CD at 5%
		5	10	15	20	Mean		
I	12.00	12.10	10.75	9.70	8.10	10.53	0.50	1.51
II	23.50	23.70	21.00	19.10	16.20	20.70	0.76	2.29
III	29.05	28.15	26.26	24.07	22.45	25.80	0.79	2.38

Table-5
Effect of salinity levels on dry matter yield (g/pot) of the crops at various cuttings

Crop cutting	Control	Salinity Levels (dSm-1)					S Em±	CD at 5%
		5	10	15	20	Mean		
I	3.75	3.78	3.18	2.95	2.26	3.18	0.17	0.53
II	8.15	8.20	7.36	5.88	5.26	6.97	0.24	0.74
III	10.01	10.04	8.72	7.81	6.75	8.67	0.27	0.83

References

[1] Shasany, A.K., Lal, R.K., Darokar, M.P., Patra, N.K., Garg, A., Kumar, S., Khanuja, S.P.S., Genet. Resour. Crop Evol., 47: 553–559 (2000).
[2] Choudri, G. N.,*Ecology*, 49(3), 465-471(1993).
[3] Dudal, R.and F. M. Purnell, *Reclam. Reveg. Res.* 5, 1-9(1984).
[4] Yensen, N. P. ,*Arid Land Newsletter* 27, 3-9 (1988).
[5] Maas, E. V., In Lieth, H. and Al Masoom, A. (Ed.), Kluwer Publishers, Netherlands(1993).

[6] Wang, W. B. Vincour and A. Altman ,*Planta* 218(1), 1-14(2003).
[7] Hofmann, G. J. and M. C. Shannon. ,*Reclam. Rev. Res*. 5, 211-225(1986).
[8] Vijayvargiya, S. and Kumar, A., Germany Lap, Lambert Academic Publishers. 170 pp. (2011)
[9] Z. Muhammad and F.Hussain, Pak. J. Bot., 42(1), 303(2010).
[10] T.A.Essa, Journal of Agronomy and Crop Science, 188(2), 86(2002).
[11] J.K. Mensah, P.A. Akomeah, B. Ikhajiaghe and E.O. Ekpekurede, African Journal of Biotechnology, 5(20), 1973(2006).
[12] R.Farhoudi and F.Sharifzadah, Indian J. Crop Science, 1(1-2), 74 (2006).
[13] H.Gut and R.Ahmed, Pak. J. Bot., 39(4), 1161(2007).
[14] L. Bernstein and H.E. Hayward, Annu. Rev. Plant Physiol., 9,25(1958).
[15] D.V. Singh and M. Anwar, J.Ind. Soc. Soil Sci., 33, 362(1985).
[16] B.Pal, K.K.Singh, S.P.S.Jadaun and A.S.Parmar, Indian Perf., 33(3), 196 (1989).
[17] B.S. Indulkar and S.D. More, Current Agriculture, 10, 81(1984).
[18] B.Pal, D.Kumar, S.P.S. Jadaun and A.S. Parmar, New Botanist, 15(2-3), 157(1988).
[19] S.P.S. Jadaun, Studies on Salt tolerance of polmarosa and extent of salt accumulation in soils, Ph.D. Thesis, Agra University, Agra(1988).
[20] A.Prasad, D.D. Patra, M. Anwar and D.V. Singh, J.Indian Soc. Soil Sci., 45, 537(1997).
[21] L. Bernstein and H.E. Hayward, Physiology of salt tolerance, Annu, Rev. Plant Physiol., 9,25(1958).
[22] E.V. Mass and G.J. Hoffman, J.Irrigation and Drainage Division, 103, 115(1977).
[23] L. Bernstein, Plant Anal. Fert. Probl., 4,25(1964).
[24] L. Bernstein, Ann. Rev. Phytopathology, 13,295(1975).
[25] E.V. Mass amd G.J. Hoffman, J.Irrigation and Drainage Division, 103, 105(1977).