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ENHANCING PRODUCTIVITY POTENTIAL OF SALINE SOIL THROUGH AGROFORESTRY SYSTEM USING SALINE IRRIGATION

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ABSTRACT

Establishing tree plantations on saline soil irrigated with saline ground waters may provide an economic use of abandoned lands, but a knowledge gap exists on potential of growing commercially important fast growing tree species under salt affected soils with saline irrigation and their impact on soil physico-chemical properties. The present study has been initiated to establish *Melia composita* and *Eucalyptus tereticornis* based agroforestry models and evaluate the performance of crops under trees and *vice versa* irrigated with the help of saline water irrigation. The treatments comprised of five tree and crop combinations viz., *Eucalyptus tereticornis* +crops, *Melia composita* +crops, Sole *Eucalyptus tereticornis*, Sole *Melia composita* and sole crops *i.e.* pearlmillet and mustard under open conditions. *Eucalyptus* and *Melia* tree species recorded 78% and 70% survival, respectively. Growth performance of the two tree species was recorded one year after transplanting. *Eucalyptus* attained higher plant height (269.36cm) as compared to *Melia* (223.38cm) whereas diameter at breast height (DBH) was more in *Melia* (4.46cm) as compared to *Eucalyptus* (3.15cm). Longest branches, crown spread and number of branches were higher in case of *Eucalyptus* as compared to *Melia*. In general, declining growth trend was observed with increase in soil salinity. Mustard was sown as intercrop in between *Melia* and *Eucalyptus* rows. Germination of mustard crop showed variable response depending upon level of salinity. Germination percentage varied from nil (EC_2 :7.28 dSm^{-1}) to 85.0 (EC_2 :2.40 dSm^{-1}) under *Eucalyptus* trees whereas it ranged from nil (EC_2 :7.29 dSm^{-1}) to 70.0 (EC_2 :2.40 dSm^{-1}) under *Melia* trees. The average germination under *Eucalyptus* and *Melia* plantation was 27.91% and 30.42%, respectively. Results on growth parameters is also reported in this paper.

Key words: Saline irrigation, *Melia, Eucalyptus*. Mustard, Salt.

Introduction

The forest and tree cover in India accounts for 24.16 per cent of the total geographical area (78.28 million ha) as against the national goal of 33% stated in National Forest Policy of 1988. Burgeoning population and degradation of land resources seems to be primarily responsible for constricted state of forest resources. To achieve the national target, there is a need to go for large scale plantations on all types of available lands. Agroforestry which combines agricultural crops and trees together on same piece of farmland has the potential in increasing the area under forests, improving productivity of degraded lands and improving the socio-economic condition of farmers. The agroforestry systems with technological interventions and incorporation of fast growing tree species (SRTs) has contributed significantly in land use diversification, natural resource management and other household requirements, thus, helping the economic transformation of farmers (Dhyani and Handa, 2013). India's first National Agroforestry Policy announced in the year 2014 emphasizes the need for plantation of agroforestry tree species on barren community land and other non-forest waste lands to provide opportunities of economic returns as well as contributing towards ecological benefits (GOI, 2014) In India, 6.73 m ha of land area is salt affected which is likely to almost treble to afflict 20 m ha by 2050 (Annual Report, 2012-13). Due to the adverse edaphic environment of salt affected soils, they are devoid of any vegetation and restrict the choice of arable crops to be grown. Conditions of salt affected soils *viz*., aridity, excess accumulation of salts, low-fertility, and poor quality irrigation, although hostile to tree species as well yet trees have comparatively higher tolerance limits than food crops. Moreover, the non-availability of good quality water further restricts the use of saline soil for arable cropping. Current exploitation of poor quality

Eucalyptus tereticornis and *Melia composita* based agroforestry system enhanced the productivity potential of saline soil irrigated with saline water.

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waters needs to be enhanced in space and time to bridge the water demand and supply gap in agriculture. The saline ground water which is unfit for irrigation could be used in cyclic or mixed mode with good quality water for raising forestry plantations (Mandal *et al.,* 2013). Establishing tree plantations on saline soil irrigated with saline ground waters may provide an economic use of abandoned lands. Keeping in view the above facts, the present study has been planned to assess performance potential of *Eucalyptus tereticornis* and *Melia azedarach*, two commercially important fast growing and short rotation tree species, for utilization of saline soil using saline irrigation.

Material and Methods

The experiment was initiated during August, 2014 at Central Soil Salinity Research Research Institute experimental farm, village Nain, Distt. Panipat (Haryana) of Indian Council of Agricultural Research. Quality planting stock of *Eucalyptus tereticornis* (clone 413) and *Melia composita* was procured from nursery of Haryana Forest Department. Planting of trees was done in pits of 120 cm depth and 30 cm diameter made with the help of specially designed tractor mounted augers using augerhole technique at a spacing of 4x3m (*Eucalyptus tereticornis*) and 6x3m (*Melia composita*). Planting was done with sub-surface planting-cum-furrow irrigation method. Pits were filled with mixture of original soil, sand and farmyard manure (2:1:1). 50g Diammonium phosphate was added in each pit. Chloropyriphos (0.1%) and Emisan-6 (0.05%) was applied at the time of planting. Irrigation was done with the help of saline water (EC_{iw} ranging from 2.75-4.0 dSm^{-1}) except initial 3-4 irrigations which were done using less saline water (EC_{iw} 1.1 dSm^{-1}). Mustard (variety CS 54) was sown as intercrop in between *Melia* and *Eucalyptus* rows and under open conditions with three replications.

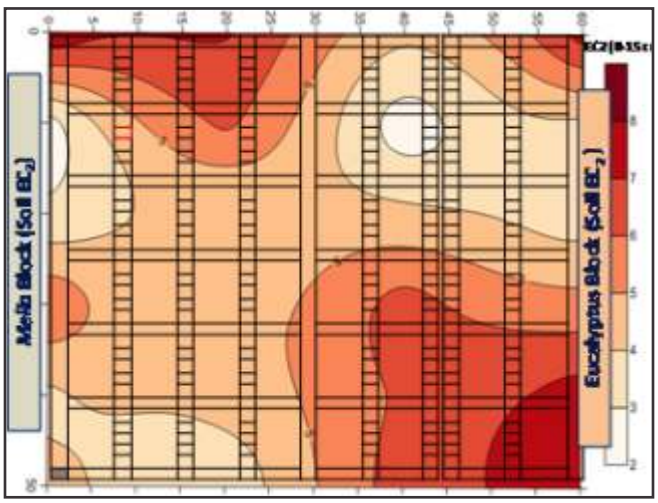

Fig. 1: Variability in soil salinity (dS/m) of study site.

Irrigation systems have been installed in the experiment to irrigate the trees and crops with water of different salinity levels. To know the initial electrical conductivity and pH of the experimental site, intensive soil sampling was done throughout the study site at various depths *i.e.* 0-15cm, 15-30cm, 30-60cm, 60-90cm and 90-120cm. In the month of March 2015, four observation wells, two each in *Eucalyptus* and *Melia* blocks, were installed upto 60cm depth in the experiment to monitor fluctuations in ground watertable depth and changes in water salinity temporally and spatially under both *Eucalyptus* and *Melia* blocks.

Results and Discussion

Study site

The study site faces the complex problem of soil salinity with hard $CaCO_3$ layer at varying depths, shallow water table combined with underground saline water. Electrical conductivity (EC_2) ranged from 2.40-7.90 dSm^{-1} (0-15cm), 1.90-5.90 dSm^{-1} (15-30cm), 1.60-6.10 dSm^{-1} (30-60cm), 1.20-5.60 dSm^{-1} (60-90cm) and 1.20-5.90 dSm^{-1} (90-120cm). Graphical presentation of the electrical conductivity of the whole experimental site shown in Fig. 1 which clearly shows that electrical conductivity varied greatly over the whole site experiencing high electrical conductivity with dark brown spots to low electrical conductivity with white spots. pH of the study site ranged from 7.91-8.96 (0-15cm), 6.65-8.99 (15-30cm), 7.94-8.95 (30-60cm), 7.88-9.25 (60-90cm) and 7.74-9.42 (90-

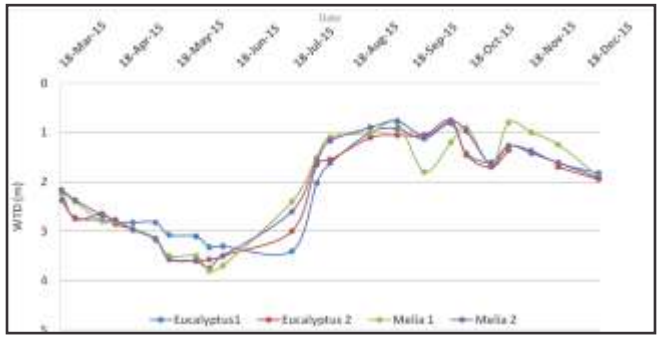

Fig. 2: (a) Ground water table depth under *Eucalyptus* and *Melia* blocks.

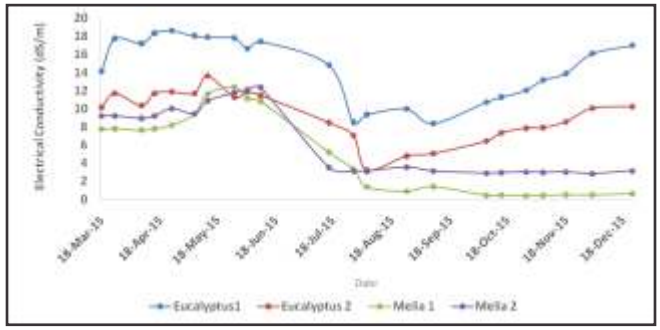

Fig. 2(b): Electrical conductivity of the ground water table under *Eucalyptus* and *Melia* blocks.

120cm). Ground watertable and ground water salinity recorded at periodic intervals in the year 2015 is given in fig. 2a and 2b. Ground water table was low during March to June whereas it was high during the period July to September. There were no significant differences in ground watertable depth under different tree species. Electrical conductivity of the ground water, however, had the reverse trend which was higher during March to June and low during the period July to September. Electrical conductivity of the ground water under *Eucalyptus* was higher as compared to under *Melia* block. This may be due the presence of more salts in the soil under *Eucalyptus* as compared to *Melia* which is evident in fig 1. In the month of of March, average groundwater table depth was 2.3 and 2.2m, respectively and corresponding groundwater salinity was 12,1 and 8.5dSm^{-1} in *Eucalyptus* and *Melia* fields, respectively.

Tree parameters

Eucalyptus and *Melia* tree species initially recorded 78% and 70% survival, respectively. Gap filling was done to complete the tree stand. Growth performance of the two tree species was recorded under different salinity levels. Mean performance of *Eucalyptus* and *Melia* plants one year after transplanting is given in table 1. *Eucalyptus* attained higher plant height (269.36cm) as compared to *Melia* (223.38cm) whereas diameter at breast height (DBH) was more in *Melia* (4.46cm) plants as compared to *Eucalyptus* (3.15cm). Longest branch, crown spread and number of branches were higher in case of *Eucalyptus* as compared to *Melia.* Growth performance of trees four months after transplanting is presented in fig. 3a and 3b. More than 40 native and exotic tree species of arid and semi-arid areas were evaluated by Tomar *et al.* (1998) for waterlogged saline soils upto 50 dS/m EC in root transmission zone of plants and *Prosopis juliflora, Acacia farnesiana* and *Parkinsonia aculeata* were found to be most promising species. *Acacia nilotica*, *A. tortilis*, *Casuarina gluaca*, *C. equisetifolia* and *C. obesa* could be grown with ECe varying from 10-25 ds/m. Singh and Yadav (1999) evaluated the performance of *Pongamia pinnata* at varying salinity levels and exchangeable sodium percentage in an alluvial silty clay loam soil and found that

Table 1: Mean performance of *Eucalyptus* and *Melia* one year after transplanting.

	Eucalyptus	*Melia*
Plant height (cm)	269.36	223.38
DBH (cm)	3.15	4.46
Longest brancg (cm)	72.53	59.41
Crown size (cm2)	130.59	110.63
Number of branches	56.37	36.26

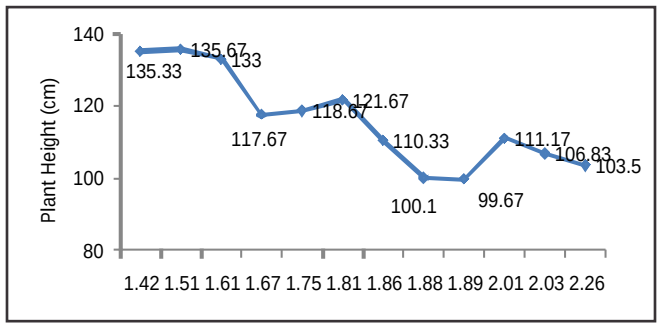

Fig. 3a: Effect of soil salinity (dS/m) on plant height of *Eucalyptus tereticornis*.

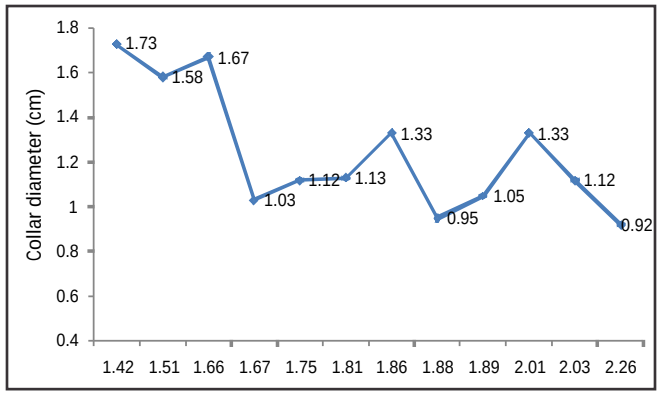

Fig. 3b: Effect of soil salinity (dS/m) on collar diameter of *Eucalyptus tereticornis*.

P. pinnata tolerated a fair degree of salinity upto 16dS/m ECe. *Acacia tortilis*, *Cassia siamea*, *Melia azedarach* and *Acacia farnesiana* were the highest performing tree species for their suitability on calcareous soil irrigated with saline water (Minhas *et al.,* 2008). In an experiment to evaluate the effect of irrigation frequency for saline waters for raising nursery of *Acacia nilotica*, decreasing irrigation interval to two days was observed to reduce salinity damages to some extent. *Acacia nilotica* was found to be moderately tolerant to salinity with an EC of 5.0 dS/m (Tomar *et al.*, 1997).

Crop parameters

Germination of mustard crop showed variable response depending upon level of salinity. Germination percentage varied from nil (EC_2 :7.28 dSm^{-1}) to 85.0 (EC_2 :2.40 dSm^{-1}) under *Eucalyptus* trees whereas it ranged from nil (EC_2 :7.29 dSm^{-1}) to 70.0 (EC_2 :2.40 dSm^{-1}) under *Melia* trees (Plate 1). The average germination under *Eucalyptus* and *Melia* plantation was 27.91% and 30.42%, respectively. Germination of mustard decreased with increase in soil salinity (Fig. 5). Under *Eucalyptus*, plant height, mean shoot length, number of pods and yield, in general decreased with increase in soil salinity. Plant height, number of primary branches, number of secondary branches, mean shoot length, number of pods and yield of

Plate 1: Mustard intercropped with Eucalyptus.

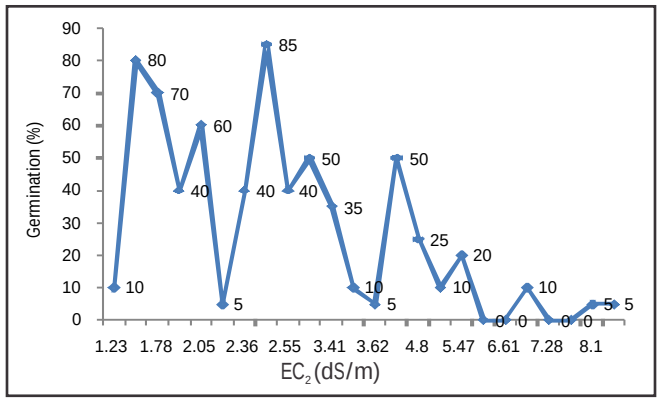

Fig. 5: Effect of soil salinity (dS/m) on germination percentage of mustard.

mustard ranged from 124.66-169.78cm, 5.44-7.23, 11.11-17.33, 30.67-68.33cm, 23.22-45.44 and 5.38-20.93 q/ha, respectively (Table 2). Under *Melia*, plant height, number of primary branches, number of secondary branches, mean shoot length, number of pods and yield of mustard ranged from 145.78-188.15cm, 5.04-6.38, 7.0-17.33, 49.44-61.67cm, 30.00-43.33 and 0.5-9.95 q/ha, respectively (Table 2). Average EC_2 in mustard under *Eucalyptus* and *Melia* was observed to be 4.72 dSm^{-1} and 3.59 dSm^{-1}, respectively. Dagar (2013) highlighted the importance of using saline water judiciously for raising agroforestry plantations. Tomar *et al.* (2003) evaluated nine forage grasses irrigated with saline water (EC 10 dS/m) and found that *Panicum laevifolium* and *P. maximum* were the most suitable species producing annually 3.43-4.23 tonnes /ha dry forage. In a separate study, dill (*Anethum graveleus*), taramira (*Eruca sativa*) and castor (*Ricinus communis*) could produce 931, 965 and 3535 kg seeds per ha, respectively when provided with three irrigations of saline water of 10dS/m electric conductivity (Tomar *et al.*, 2010). Clusterbean and barley were successfully between rows of fruit trees with one or two saline irrigations. Mesquite (*P. juliflora*) and kallar grass (*Leptochloa fusca*) based silvo-pastoral model was found most promising for firewood and forage production

Table 2: Yield parameters of mustard under different salinity levels in *Eucalyptus* block.

Average EC_2	Plant height (cm)	Number of primary branches	Number of secondary branches	Mean shoot length (cm)	Number of pods	Yield (q/ha)
2.36	168.82	6.63	11.70	67.34	37.78	18.30
3.52	162.44	5.44	11.11	58.89	35.45	9.13
4.57	174.55	7.11	16.33	53.22	45.44	16.90
6.54	138.00	7.23	17.33	34.11	31.44	20.93
6.59	124.66	6.89	11.34	30.67	23.22	5.38
Mean=4.72	153.70	6.66	13.56	48.85	34.67	14.13
Range (2.36-6.79)	124.66-174.55	5.44-7.23	11.11-17.33	30.67-68.33	23.22-45.44	5.38-20.93

Table 3: Yield parameters of mustard under different salinity levels in *Melia* block.

Average EC_2	Plant height (cm)	Number of primary branches	Number of secondary branches	Mean shoot length (cm)	Number of pods	Yield (q/ha)
2.37	184.55	6.38	15.22	49.44	33.33	8.28
2.50	188.15	5.93	17.33	54.55	38.89	11.10
2.79	183.00	5.93	14.78	61.67	43.33	9.43
3.65	164.89	5.71	15.89	59.45	31.00	9.95
4.95	161.44	5.04	10.38	50.67	30.00	6.90
5.26	145.78	5.73	7.00	56.78	37.33	0.50
Mean=3.59	171.30	5.79	13.43	55.43	35.65	7.70
Range (2.37-5.26)	145.78-188.15	5.04-6.38	7.0-17.33	49.44-61.67	30.00-43.33	0.5-9.95

and also for soil amelioration for highly alkali soil (Singh *et al.,* 1993*;* Singh and Dagar, 1998). *L. fusca* grown with *P. juliflora* produced 46.5 tonnes per ha green forage in 15 cuttings over 50 months period whereas *P. juliflora* produced 160 tonnes per ha air dried firewood on 6 years, when planted at 2 m x 2 m spacing (Singh *et al.,* 1995).

Conclusion

In saline soils with saline water irrigation, *Eucalyptus* recorded higher plant height as compared to *Melia* whereas diameter at breast height was more in *Melia* as compared to *Eucalyptus*. In general, declining growth trend was observed of both the tree species with increase in soil salinity. Germination of mustard sown as intercrop varied from 0 - 85 per cent depending upon level of salinity under the trees. Plant height, mean shoot length, number of pods and yield of mustard showed decreasing trend with increase in soil salinity.

लवणीय सिंचाई का उपयोग करके कृषि वानिकी प्रणाली के जरिए लवणीय मृदा की उत्पादकता क्षमता को बढ़ाना

राकेश के. गर्ग, आर.के. यादव, परवीन्दर शेरान, अश्वनी कुमार, भाष्कर नरजरी, एम.डी. मीना एवं डी.के. शर्मा

सारांश

लवणीय भू जल से सींचित लवणीय मृदा में वृक्ष रोपणों की स्थापना परित्यक्त भूमियों के आर्थिक उपयोग उपलब्ध करा सकती है किन्तु लवणीय सिंचाई के साथ लवण प्रभावित मृदाओं के तहत व्यापारिक रूप से महत्वपूर्ण तेज वृद्धि करने वाली वृक्ष प्रजातियों को उगाने की क्षमता और मृदा भौतिक–रासायनिक गुणों पर इनके प्रभाव में एक जानकारी अन्तराल विद्यमान है। *मीलिया कम्पोजिटा* और *यूकेलिप्टस टेरेटिकॉर्निस* आधारित कृषिवानिकी मॉडलों की स्थापना और वृक्षों एवं इसके विपरीत लवणीय जल सिंचाई की सहायता के साथ सिंचित के अन्तर्गत फसलों के प्रदर्शन का मूल्यांकन करने के लिए वर्तमान अध्ययन शुरू किया गया। पाँच वृक्ष एवं फसल संयोजनों, यथा–*यूकेलिप्टस टेरेटिकार्निस*+फसलें, *मीलिया कम्पोजिटा*+फसलें, एकल *यूकेलिप्टस टेरेटिकॉर्निस*, एकल *मीलिया कम्पोजिटा* एवं एकल फसलें, यथा – खुली अवस्था के तहत बाजरा और सरसों को मिलाकर उपचार था। *यूकेलिप्टस* एवं *मीलिया* वृक्ष प्रजातियों ने क्रमशः 78% और 70% उत्तरजीविता को अभिलिखित किया। प्रतिरोपण के एक साल बाद दो वृक्ष प्रजातियों का वृद्धि प्रदर्शन अभिलिखित किया। *मीलिया* (223.38 से.मी.) की तुलना में *यूकेलिप्टस* ने उच्च पादप ऊँचाई (269.36 से.मी.) प्राप्त की जबकि वक्षोच्चता पर व्यास *यूकेलिप्टस* (3.15 से.मी.) की तुलना में *मीलिया* (4.46 से.मी.) में ज्यादा था। *मीलिया* की तुलना में *यूकेलिप्टस* के मामले में लम्बी शाखाएं, छत्र फैलाव एवं शाखाओं की संख्या उच्च थी। सामान्यतः मृदा लवणता में वृद्धि के साथ ह्रासमान वृद्धि रुझान देखा गया। मीलिया और *यूकेलिप्टस* की पंक्तियों के बीच सरसों को बीच की फसल के रूप में बोया गया। सरसों फसल के अंकुरण ने परिवर्ती अनुक्रिया दिखाई, जो लवणता के स्तर पर निर्भर है। *यूकेलिप्टस* वृक्षों के तहत अंकुरण प्रतिशतता शून्य (EC_2 : 7-28 dSm^{-1}) से 85.0 (EC_2 : 2-40 dSm^{-1}) तक थी जबकि *मीलिया* वृक्षों के तहत यह शून्य (EC_2 : 7-29 dSm^{-1}) से 70.0 (EC_2 : 2-40 dSm^{-1}) तक थी। *यूकेलिप्टस* एवं *मीलिया* रोपणों के तहत औसत अंकुरण क्रमशः 27. 91% और 30.42% था। इस शोधपत्र में वृद्धि पैरामीटरों पर परिणामों को भी सूचित किया गया है।

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