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Evaluation of agroforestry tree species and irrigation methods in sodic soil

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Abstract : A field experiment was conducted during 1995-97 in sodic soil with four tree species viz., neem (*Azadirachta indica*. A.Juss), pungam (*Pongamia glabra*. L), casuarina (*Casuarina eqisetifolia*. JR and G. Forst) and subabal (*Leucaena leucocephala*. Lamk) in main plots and the irrigation methods, viz., drip, pitcher and surface basin in sub-plots. The intercrops viz., sorghum and sunflower were grown as rainfed and ploughed *in situ*. Among the four tree species subabul had recorded the highest mean growth rate in terms of collar diameter (17.43 cm) and the maximum biomass yield (4.840 kg/tree/year) followed by neem with the collar diameter 16.30 cm and the biomass 3.756 kg/tree/year. Among the irrigation methods drip irrigation had recorded the highest mean collar diameter (15.57 cm) and the biomass yield (3.971 kg/tree/ year) followed by the surface basin with collar diameter 15.52 cm and biomass yield 3.913 kg/tree/year. The pitcher method of irrigation had recorded the lowest collar diameter (14.72 cm) and the biomass yield of 2.812 kg/tree/year. Annually about 1460, 2431 and 3650 litres of water were applied through drip, pitcher and surface basin respectively. Water saving by drip over surface basin is 60% and 39.9% over pitcher method. Irrigation methods invariably reduced the sodic soil properties viz., pH, EC (ds/m), and sodium absorption ratio significantly over a period of two years. (*Key Words : Agroforestry, Neem, Subabul, Casuarina, Pungam, Collar diameter, Biomass, Drip, Pitcher, Basin Irrigation).*

In India, problem soil constitutes nearly 25 mha of which saline soil 5.5 mha. and alkaline soil 2.50 mha., which often may not be used for other arable crops. Better economic exploitation of these soils can be possible by tree cultivation (Tripathi and Hazra, 1996). The tree species with rapid growth, deep rooting, dense foliage production, good coppiceability, good green leaf manure value and ability to fix nitrogen can be integrated with crops for effective utilisation of waste lands. Naturally growing and resistant trees under alkaline or salt affected soil conditions like neem, pungam, subabul and casuarina etc., have been identified for each agroclimatic zones (Panjab singh, 1996). The surface irrigation is practised for all the crops from time immemorial in which not only water is wasted but creating water logging, salinity and alkality problems (Sivanappan, 1994). Plantation of salt loving trees like neem, pungam, subabul etc. with multipurpose value is more beneficial which can make the best use of the sodic soil environment (Tripathi and Hazra, 1996). Hence a study has been carried out to identify the agro-forestry tree species suitable for sodic soil as large areas are available under waste lands and also find out the suitable irrigation method with minimum saline water usage.

Materials and Methods

Field experiment was conducted during November 1995 to October 1997 at Anbil Dhamalingam Agricultural College and Research Institute, Tiruchirapalli, Tamil Nadu. The experiment was laid out in split plot design with four replications. The main plot treatment consisted of four tree species *viz.*, neem, casuarina, pungam and subabul each tried with two intercrops, sunflower and sorghum and as pure stand with no intercrop. Sub plots consisted of three irrigation methods *viz.*, drip, pitcher and surface basin. Pits of uniform size (1.5 x 1.5 x 1.5 ft.) were opened and filled with FYM, sand and redearth mixture. All the tree species were planted at an uniform spacing of 2 m in a row and the rows are formed at 4 m interval. The soil of the experimental field was sandy clay loam with soil pH of 8.9, EC of 1.9 ds/m and ESP 20. The initial nutrient status of the soil revealed that it was low in available nitrogen, medium in available phosphorus and potassium. The water used for irrigation is slightly sodic with a pH 9.2, EC 1.2 ds/m and RSC 12meq/1. All the trees were manured only with FYM @ 50 kg/pit applied through pit mixture. Intercrops were grown as rainfed during the first year of study for effective utilization of the interspace till the trees had establised. Though the mean annual rainfall of the study area is 940 mm, the annual rainfall received during the first year of study was 581 mm and during the second year the rain contributed 942 mm. Evaluation of tree species were done through growth and yield measurements as collar diameter

(at a height of 1 m and 2 m level) and air dry biomass yield after every lopping at quarterly intervals. The quantity of water used under each method of irrigation is measured and the percentage of water saving was compared.

Results and Discussion

Irrigation methods on collar diameter of tree species

In most cases drip method of irrigation has given better performance than surface and pitcher methods. Drip system of irrigation recorded maximum collar diameter in casuarina (21.1cm), neem (17.3cm) and 16.25 cm in pungam. In subabul the highest collar diameter of 24.25 cm is recorded under surface basin irrigation (Table 1). Overall there was no significant difference between irrigation methods tried, however there is saving of water in drip irrigation to a tune of 60 percent when compared to surface basin and 39.9 percent compared to pitcher method of irrigation. The maximum amount of water given to the crop in drip is about 4 litres/day/tree, whereas the water supplied through pitcher is 6.66 litres/day/tree. The water saving by pitcher irrigation over surface basin is 34.2 per cent (Table 3). This is in agreement with the findings of Sivanappan, 1994. The minimal saline water usage through drip system under sodic soil reduces the problems of salt accumulation and water logging thus encouraging successful tree farming in problem soils (Panab Singh, 1996 and Sivanappan, 1994).

Subabul has recorded the highest collar diameter and it is on par with neem and casuarina. Pungam has recorded the lowest collar diameter but it is statistically comparable with neem and casuarina.

Irrigation methods on biomass yield of tree species

Biomass production is significantly higher with drip and surface basin methods compared to pitcher irrigation. The maximum biomass yield of 3.971 kg/tree/year was recorded under drip irrigation followed by 3.913 kg/tree/year under surface basin method. The pitcher method of irrigation had recorded the lowest biomass of 2.812 kg/tree/year. In biomass production subabul has excelled all the other tree species, by recording the maximum biomass yield of 4.840 kg/tree/year and was followed by neem (3.756 kg/tree/year). Subabul is ever green, branchy, aggressive small tree, quick growing and high foliage producing with good fodder value when moisture is not a limiting factor (Whitesell, 1976) Debroy and Gill (1991) reported maximum fuel and fodder biomass of 7.91 and 1.85 q ha^{-1} by annual pruning from leucaena when grown at 10 x 2m spacing. Subabul is tolerant to salinity upto an electrical conductivity of 8 to 16 dSm^{-1}. Similarly neem tolerates upto an EC of 4 to 8 dSm^{-1}. (Tripathi and Hazra, 1996). The biomass production of casuarina and pungam was lower and comparable (Tabel 2).

Neem, casuarina and pungam have given higher biomass yield under drip followed by surface basin. By drip irrigation the aerial and below surface vegetative development was found to be more vigorous than when other irrigation methods were used. Subabul has given significantly higher biomass yield under surface basin irrigation; however it was found lodged while the trees grown under pitcher and drip method were erect.

Influence of intercrops on the growth and yield of tree species

The intercrops were grown as rainfed during the first year of study. The quantum of rainfall received during the growth of intercrops was not sufficient for supporting the economic harvest of intecrops, hence the intercrops grown in the alleys formed between the tree crops were ploughed *in situ*. Among the intercrops sorghum grown during the first year might have produced significant effect by way of contributing organic matter during the second year invariably for all the tree species. In some alleys sunflower might have also contributed the organic matter as evidenced through the increment in collar diameter and biomass yield of neem and subabul. Appreciable yield advantage were noticed through intercropping in the alleys (Korwar, 1984).

Irrigation methods on some sodic soil properties and salt dynamics

Irrespective of the irrigation methods there is a significant decrease in pH, EC, and SAR of the sodic soil under study, over the period of two years as shown in Table. 4.

The soil pH decreases an year after tree growth. The agro-forestry system improved the soil to the extent that pH of soil in the top 15 cm layer

Table 1. Effect of irrigation methods on growth (measured as collar diameter in cm) of tree species (Mean values at 1m and 2m height)

Treatment	Irrigation methods				Mean of tree species
	Drip	Pitcher	Surface basin	Mean	
Neem + Sunflower	17.30	16.35	13.40	15.68	
Neem + Sorghum	17.05	13.30	15.85	15.40	
Neem alone	16.25	17.60	19.50	17.78	16.29
Casuarina + Sunflower	13.50	10.95	11.90	12.12	
Casuarina + Sorghum	17.70	14.10	16.10	15.97	
Casuarina alone	21.10	15.90	11.75	16.25	14.78
Pungam + Sunflower	12.45	11.50	11.60	11.85	
Pungam + Sorghum	11.10	10.95	11.05	11.03	
Pungam alone	16.25	14.85	13.55	14.88	12.59
Subabul + Sunflower	16.55	19.10	24.25	19.97	
Subabul + Sorghum	14.50	16.10	17.40	16.00	
Subabul alone	13.20	15.95	19.90	16.35	17.44
Irrigation Mean	15.579	14.721	15.521		

	SE_d	CD(P=0.05)		SED	CD(P=0.05)
Tree species (M)	1.870	4.116	S at M	1.672	3.450
Irrigation methods (S)	0.483	0.996	M at S	2.315	4.986

Table 2. Effect of irrigation methods on total biomass yield (kg/tree/year) of tree species

Treatment	Irrigation methods				Tree mean
	Drip	Pitcher	Surface basin	Mean	
Neem + Sunflower	4.143	2.825	2.225	3.064	
Neem + Sorghum	4.550	2.875	4.050	3.825	
Neem alone	4.900	3.440	4.800	4.383	3.757
Mean	4.531	3.047	3.692		
Casuarina + Sunflower	3.050	1.917	2.933	2.783	
Casuarina + Sorghum	3.108	2.167	2.850	2.708	
Casuarina alone	3.100	1.575	3.117	2.614	2.702
Mean	3.086	1.886	2.967		
Pungam + Sunflower	4.225	1.908	2.200	2.778	
Pungam + Sorghum	3.125	1.975	3.025	2.708	
Pungam alone	4.100	2.925	2.842	3.289	2.925
Mean	3.817	2.269	2.689		
Subabul + Sunflower	3.475	3.550	4.817	3.947	
Subabul + Sorghum	5.325	6.100	8.100	6.508	
Subabul alone	3.900	2.475	5.550	3.975	4.840
Mean	4.233	4.042	4.550		
Irrigation Mean	3.971	2.812	3.913		

	SE_d	CD(P=0.05)		SED	CD(P=0.05)
Tree species (M)	0.135	0.29	S at M	0.230	0.474
Irrigation methods (S)	0.066	0.137	M at S	0.231	0.487

Table 3. Quantity of water saving under drip and pitcher irrigation methods

Irrigation method	Quantity of water (Litres/day/tree)	Total quantum of water applied (Litres/year)	Water saving (%)
Drip	4.0	1460	60.0 (over surface basin)
			39.9 (over pitcher)
Pitcher	6.66	2431	33.0 (over surface basin)
Surface basin	10	3650	-----

Table 4. Influence of irrigation methods on some sodic soil properties

Soil Property		Depth of soil layer (cm)	Drip (I_1)		Pitcher (I_2)		Surface basin (I_3)	
			Initial	After 2 years	Initial	After 2 years	Initial	After 2 years
pH	D1	0-15	8.8	8.6	8.8	8.7	8.8	8.5
	D2	15-30	8.9	8.7	8.9	8.8	8.9	8.8
	D3	30-60	9.0	8.9	9.0	8.9	9.0	8.8
	D4	60-90	9.2	9.1	9.1	9.0	9.2	9.1
EC (ds/m)	D1	0-15	1.92	1.53	1.90	1.78	1.90	1.60
	D2	15-30	1.82	1.50	1.82	1.60	1.92	1.55
	D3	30-60	1.80	1.53	1.80	1.72	1.78	1.68
	D4	60-90	1.73	1.45	1.73	1.78	1.73	1.52
ESP	D1	0-15	20	19	20	19	20	19
	D2	15-30	21	19	21	20	21	20
	D3	30-60	22	20	20	19	22	21
	D4	60-90	22	22	22	21	21	20
SAR	D1	0-15	18	17	18	18	18	17
	D2	15-30	19	18	19	19	19	18
	D3	30-60	20	19	20	19	20	19
	D4	60-90	20	20	20	20	20	19

	pH		EC		ESP		SAR	
	SE_d	CD P=(0.05)	SED	CD P=(0.05)	SED	CD P=(0.05)	SED	CD P=(0.05)
Irrigation methods (I)	0.050	0.104	0.22	0.47	0.38	0.79	0.28	0.58
Depth os soil layer (D)	0.057	0.118	0.07	0.15	1.39	2.89	0.44	0.92
Time (year) (T)	0.064	0.134	0.03	0.06	0.24	0.50	0.49	1.01
DxI	0.100	0.190	0.02	0.05	NS	NS	NS	NS

was significantly reduced from 8.8 to 8.5 under surface basin, 8.6 under drip and 8.7 under pitcher method of irrigation at the end of the study. This might be due to the ameliorative nature of the tree species and their leaf fallings, inter crop residues added to the soil through tiller ploughing and incorporation in the alleys. There exists a significant interaction between the depth of soil and irrigation methods. The rate of decrement is less as the depth advances which might be due to the native high soil pH in the subsoils with sodicity.

Salt dynamics study shows that, EC decreases from 1.9 to 1.53 ds/m after two years especially under drip in the top 0-15 cm soil layer which supports the findings of Dager and Singh (1993) and Singh *et al.*, (1993). Interaction between irrigation methods and soil shows that there is a significant reduction in EC as the depth of soil increases. Among the irrigation methods, drip irrigation had recorded significantly low EC values as compared to surface basin and pitcher methods. The minimal saline water usage through drip under sodic soil conditions might have minimized the problems of salt accumulation even if the sodic water is used as observed by panjab singh, 1996 and sivanappan, 1994 which favours to maintain low matric potential in the rhizospheres of treespecies.

Similarly, the exchangeable sodium percentage (ESP) of the soil decreased from 20 to 19 in the top layer but not significantly as the depth soil increases. The sodium absorption ratio (SAR) values decrease significantly at different soil depth irrespective of the irrigation methods at the end of two years. There is no significant interaction existing between irrigation methods and ESP or SAR values.

Among the irrigation methods drip irrigation performed better with an overall water saving upto 60 percentage. The drip system suits well to neem, pungam and casuarina with slightly saline water under sodic soil conditions. However, surface basin significantly enhanced the growth and yield of subabul when compared to other methods of irrigation.

Among the tree species subabul had recorded the highest growth and biomass yield followed by neem thereby proving their suitability under sodic soil conditions. Pungam and casuarina had registered higher growth and biomass production only under drip method of irrigation.

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