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Effect of *Eucalyptus* densities on fodder yield of winter crops in saline soils

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ABSTRACT

An experiment was conducted under irrigated condition during 1984–91 to find out optimum tree density of *Eucalyptus* for higher biomass production at New Delhi. Nine planting geometries consisting of 0.5 m × 1.0 m, 0.75 m × 1.0 m, 0.5 m × 1.5 m, 1.0 m × 1.0 m, 0.5 m × 2.0 m, 0.75 m × 1.5 m, 0.75 m × 2.0 m, 1.0 m × 1.5 m and 1.0 m × 2.0 m were randomized and studied in 3 replications. After 63 months of plantations (December 1989), oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.s.l.) Egyptian clover or berseem (*Trifolium alexandrinum* L.) and turnip [*Brassica rapa* (L.) Thell. emend. Metzger] crops were introduced as intercrops between the row spacings during the winter season 1989–90 and repeated in the next season of 1990–91 along with 1 pure crop treatment (without tree association). The tree populations during this period were 17,083; 10,138; 9,652; 7,222; 7,847; 6,944; 5,347; 4,789 and 3,958 trees/ha. After 78 months of plantations (March 1991), among all tree densities combinations, 3,958 trees/ha interspaced at 1.0 m × 2.0 m attained the maximum shoot height (16.33 m) and girth at breast height (28.37 cm). Combined fresh and dry biomass of intercrops was also significantly higher when intercropped under same tree density and were respectively 27.29 and 4.45 tonnes/ha in 1989–90 and 27.70 and 4.48 tonnes/ha in 1990–91. While 38.07 and 6.02 tonnes/ha in 1989–90 and 38.47 and 5.98 tonnes/ha fresh and dry biomass yields respectively were given by these crops when grown as pure crops. Barley crop outyielded all other 3 crops significantly in respect of fresh as well as in dry biomass accumulation during both the years. The trend was found in order of barley > oats > berseem > turnip.

An estimate geographical area of more than 2.5% (8 million ha) in India is affected with problem of root-zone salinity. Although, the public, private, voluntary and other agencies are taking every care on the reclamation of these lands, the area is expanding due to creation of new irrigation sources (canal etc.) and also the practice of increased application of chemical fertilizers. Besides, there is increasing demand for food, fuel, fibre, fodder etc. due to expanding human and domestic animal populations. Considering this, there is very little possibility to allot more area under tree and fodder crops. Thus to increase the production potential on per unit area basis, one of the alternatives before us to accommodate trees and arable crops association under agroforestry system, which is a viable alternative land-use system. This prevents further land degradation and also it leads to sustainability of degraded lands (Thind and Dhillon, 1994). Agroforestry which involves adding woody plants with annual or perennial crops or livestock, increases the biophysical or socio-economic productivity of

Table 1. Effect of *Eucalyptus* trees densities on its growth (lengh and girth of shoot)

Treatment	*Eucalyptus* trees (after 78 months)	
	Shoot length (m)	Shoot girth (cm)
Plant density		
P_1	12.46	13.39
P_2	13.68	17.21
P_3	13.52	16.18
P_4	15.51	21.90
P_5	14.44	19.36
P_6	15.06	20.78
P_7	15.60	23.99
P_8	15.77	25.83
P_9	16.33	28.37
P_{10}		
CD (P = 0.05)	0.754	2.078

Details of plant densities are given under Materials and Methods

an agriculture enterprise (Bentley, 1985). Research findings show that agroforestry can also improve the fertility and productivity of poor soils. As boundry plantations of *Eucalyputs* improve the fertility status of adjoining fields, an experiment was designated to determine the effects of *Eucalyputs* and its tree densities on oats (*Avena sativa* L.), barley (*Hordeun vulgare* L. s. l.), Egyptian clover or berseem (*Trifolium alexandrinum* L.) and turnip [*Brassica rapa* (L.) Thell. emend. Metzger].

MATERIALS AND METHODS

The field experiment on *Eucalyptus hybrid* was initially laid out at the research farm, New Dehi, during 1984—1991 in randomized block design. The treatments comprised 9 combinations of tree geometry, viz. 0.5 m × 1.0 m (P_1), 0.75 m × 1.0 m (P_2), 0.5 m × 1.5 m (P_3), 1.0 m × 1.0 m (P_4), 0.5 m × 2.0 m (P_5), 0.75 m × 1.5 m (P_6), 0.75 m × 2.0 m (P_7), 1.0 m × 1.5 m (P_8) and 1.0 m × 2.0 m (P_9), respectively consisting of 20,000, 13,333, 13,333, 10,000, 10,000, 8,888, 6,666, 6,666 and 5,000 trees/ha. The soil was sandy loam in texture and was medium in organic carbon, nitrogen, phosphorus and potassium with saline reaction (pH 8.1). A dose of 60 g urea per pit was mixed up in the soil before planting the seedlings. The cultural practices adopted during the period were as per the standard method followed by Mathur *et al.* (1984).

After 63 months of plantation (December 1989), oats, barley, berseem and turnip crops were introduced as annual intercrops between the rows of various *Eucalyptus* treatments (P_1 to P_9). An additional sole crop treatment (P_{10}) of all 4 crops was included with the same plant geometries. Split-plot design was adopted and replicated 3 times. The management practices to the intercrops were adopted as per the recommendations. The varieties grown were barley, oats, berseem and turnip were 'DL 454', 'PO 3', 'Vardan' and 'PT WG' respectively. A recommended dose 80 kg N and 50 kg P_2O_5/ha was applied for oats, barley and turnip, while 30 kg N and 80 kg P_2O_5/ha was applied for berseem.

Interception of solar radiation on crop canopy was recorded at 50 and 75 days after sowing during the years of experimentation. Light intensity was measured 3 times a day, i.e. 0930, 1330 and 1630 hr at 5 places of each treatment in lux units and finally computed as mega-joule (MJ) by using the formula 10,000 luxes = 3.47 MJ/m²/day (Table 4).

After 78 months of *Eucalyplus* plantation (March 1991), the survival of population was 17,083, 10,138, 9,552, 7,222, 7,847, 6,944, 5,347, 4,789 and 3,958 trees/ha under treatment P_1 to P_9, respectively. Shoot length (m) and shoot girth (cm) at breast

Table 2. Interaction effect of *Eucalyptus* tree densities × intercrops on fresh biomass production (tonnes/ha) of intercrops

Tree density	1989–90					1990–91				
	Oats	Barley	Berseem	Turnip	Average	Oats	Barley	Berseem	Turnip	Average
P_1	13.75	14.36	4.32	0	8.11	13.60	14.63	6.40	0	8.67
P_2	17.64	18.22	6.33	0	10.55	17.24	18.00	8.30	0	10.90
P_3	19.60	20.62	12.48	0	13.11	18.92	19.86	14.50	0	13.33
P_4	21.94	22.95	18.00	0	15.74	20.78	21.80	20.30	2.60	16.31
P_5	23.56	24.66	20.40	4.37	18.25	22.62	23.75	22.43	6.30	18.28
P_6	26.22	27.44	25.40	6.00	21.27	25.44	26.35	26.10	10.20	22.02
P_7	28.00	29.32	32.53	9.20	24.76	27.21	28.43	36.50	13.97	26.55
P_8	27.98	28.84	30.93	9.00	24.19	27.16	28.50	34.40	13.80	25.97
P_9	31.14	32.66	34.12	11.23	27.29	30.28	30.90	36.40	13.99	27.70
P_{10}	38.18	40.30	40.92	33.10	38.07	37.75	39.6	43.50	33.50	38.47
Average	24.80	25.91	22.55	7.29	24.11		25.20	24.82	9.35	
CD (P = 0.05)										
Tree densities	1.10					0.95				
Intercrops	0.58					0.54				
Tree densities × intercrops	1.83					1.70				

Details of plant densities are given under Material and Methods

Table 3. Interaction effect of *Eucalyptus* tree densities × intercrops on dry biomass production (tonnes/ha)

Tree density	1989–90					1990–91				
	Oats	Barley	Berseem	Turnip	Average	Oats	Barley	Berseem	Turnip	Average
P_1	2.27	2.62	0.57	0	1.37	2.24	2.62	0.83	0	1.42
P_2	2.90	3.40	0.84	0	1.79	2.90	3.32	1.80	0	1.83
P_3	3.25	3.86	1.59	0	2.18	3.12	3.66	1.86	0	2.16
P_4	3.64	4.26	2.42	0	2.58	3.44	4.02	2.65	031	2.61
P_5	3.96	4.64	2.64	0.54	2.94	3.74	4.34	2.96	0.80	2.95
P_6	4.12	4.84	3.31	0.78	3.26	4.21	2.91	3.38	1.37	2.97
P_7	4.72	5.52	4.24	1.20	3.92	4.46	5.22	4.74	1.96	4.10
P_8	4.70	5.50	4.80	1.19	3.87	4.50	5.26	4.80	1.85	4.02
P_9	5.20	6.14	4.76	1.70	4.45	4.55	5.72	4.75	1.97	4.48
P_{10}	6.40	7.50	5.36	4.80	6.02	6.18	7.24	5.58	4.92	5.98
Average	4.12	4.82	2.98	1.02		3.97	4.43	3.23	1.32	
CD (P = 0.05)										
Tree densities	0.05	0.06								
Intercrops	0.07	0.04								
Tree densities × intercrops	0.21	0.12								

Details of plant densities are given under Materials and Methods height of representative *Eucalyptus* trees/plot were measured by measuring tap. Biomass accumulation of each crop was recorded 90 days after sowing except berseem. Biomass yield of berseem was recorded at 50, 70 and 90 days after sowing. The data of *Eucalyptus* biometric observations were analysed by using the procedure of statistical analysis of randomized block design, whereas the data of crops were analysed by following the procedure of split-plot design.

RESULTS AND DISCUSSION

Growth parameters such as tree height and girth at breast height were affected by various planting geometry treatments (Table 1). The highest tree density P_1 (17,083 trees/ha) at closer spacing of 0.5 m × 1.0 m restricted its growth in terms of height (12.46 m) and girth (13.39 cm) of shoot compared with remaining tree densities, while maximum height (16.33 m) and girth (28.37 cm) were recorded under the lowest tree density (3,958 trees/ha) at spacing of 1.0 m × 2.0 m. This might be due to sufficient availability of space, light, nutrients and soil moisture as compared with higher tree densities. The findings confirm the result of Krishnaswami *et al.* (1982).

Signficantly higher fresh biomass of (27.29 and 27.70 tonnes/ha respectively) was accumulated by all the crops when intercropped under lowest tree density (3,958 trees/ha) during 1989–90 and 1990–91

Table 4. Interception of solar radiation by crops as influenced by tree densities of *Eucalyptus* and intercrops

Treatment	Interception (%)			
	1989–90		1990–91	
	50 days*	75 days*	50 days*	75 days*
Planting geometry of Eucalyptus				
P_1 (17,083 trees/ha)	30.31 (2.27)**	28.94 (1.79)	30.03 (2.48)	28.21 (1.88)
P_2 (10,138 trees/ha)	34.12 (2.56)	32.68 (2.02)	33.89 (2.80)	32.54 (2.17)
P_3 (9,652 trees/ha)	35.10 (2.63)	33.41 (2.06)	34.38 (2.84)	33.85 (2.25)
P_4 (7,222 trees/ha)	35.99 (2.70)	34.95 (2.16)	36.19 (2.99)	35.81 (2.38)
P_5 (7,847 trees/ha)	37.56 (2.82)	35.93 (2.22)	37.90 (3.13)	36.63 (2.44)
P_6 (6,944 trees/ha)	38.84 (2.91)	38.10 (2.35)	39.68 (3.28)	38.59 (2.57)
P_7 (5,347 trees/ha)	41.85 (3.14)	42.00 (2.60)	42.70 (3.61)	42.12 (2.81)
P_8 (4,789 trees/ha)	41.73 (3.13)	41.85 (2.59)	43.19 (3.59)	43.31 (2.88)
P_9 (3,958 trees/ha)	46.15 (3.46)	45.93 (2.84)	48.93 (4.04)	46 07 (3.07)
P_{10} (sole crops)	100.00 (7.50)	100.00 (6.18)	100.00 (8.16)	100.00 (6.66)
Intercrop				
I_1 (oats)	44.12 (3.31)	43.50 (2.69)	44.79 (3.70)	43.69 (2.91)
I_2 (barley)	44.13 (3.31)	43.25 (2.67)	44.70 (3.69)	43.72 (2.91)
I_3 (berseem)	44.08 (3.30)	43.35 (2 68)	44.68 (3.68)	43.70 (2.89)
I_4 (turnip)	44.16 (3.32)	43.38 (2.68)	44.80 (3.70)	43.73 (2.92)

*Days after sowing

Figures in parentheses are actual solar radiation (MJ/m^2/day) under interception (%)

compared with the recorded biomass yields under other 8 tree densities. However, the highest biomass (38.07 and 38.47 tonnes/ha respectively) were accumulated when grown as pure crops. Almost, similar trend was discernible for dry-biomass accumulation during both the years. It indicated that the higher tree density had more supressing effect on crop, viz. reduced solar radiation on crop canopy and lower availability of nutrients. Similar results were reported by Del Moral and Muller (1969) and Hazra (1990).

Amongst the intercrops, barley outyielded in respect of fresh and dry biomass yields during both the years (Tables 2, 3). Turnip was most affected crop by *Eucalyptus* tree densities. The trend of biomass accumulation was in order of barley > oats > berseem > turnip. The impact of the adverse effects on biomass yields, especially in the case of turnip was due to higher extent of shade affect under closer plantation of *Eucalyptus* trees (Table 4). The crop canopies grown as intercrops under tree plantations could get only 28.21 to 48.93% solar radiation of the intercepted solar radiation by crop canopies grown as pure crops. Reduction in solar radiaton on intercrops was reflected due to vicinity of *Eucalyptus* tree densities. This study re-established the findings reported by Sharma (1987).

REFERENCES

Bandyopadhyay, S. K. 1988. Solar radiation interception, soil, water and nitrogen use in sorghum based intercropping system with legumes. *Indian Journal Agronomy* 33 (1) : 31–36.

Bentley, W. R. 1985. Agroforestry—a strategy for research and action in India. Discussion paper series No. 17, Ford Foundation, Delhi.

Del Moral, R. and Muller, C. H. 1969. Fog drip : A mechanism of toxin transport from *Eucalyptus globulus*. *Bulletin, Torrey Botanical Club* 96 : 467–475.

Hazra, C. R. 1990. Forage from agro-based production systems in Bundelkhand Region. (In) : *Proceeding of IS WES and R. C.*, held at Dehra Dun during 9–13 October, pp. 437–445.

Krishnaswami, S., Rai, R. S. V. and Srinivasan, V. M. 1982. Sampling growth of *Eucalyptus tereticornis* under various edapho-climatic region of T. N. *Indian Journal of Forestry* 5 (7) : 21–25.

Mathur, R. S., Sharma, K. K. and Ansari, M. Y. 1984. Economics of *Eucalyptus* plantations under agroforestry. *Indian Forestry* 110 : 171–201.

Sharma, K. K. 1987. Effect of trees on agricultural crops. Institutional Seminar, Forest Research Institute, Dehra Dun.

Thind, H. S. and Dhillon, M. N. 1994. Degraded lands of Punjab and their development through agroforestry. (In) *Agroforestry Systems for Degraded Lands*. I. pp. 3–12. Singh, Punjab, Pathak, P. S. and Roy, M. M. Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.