Eucalypt Planting on Salt-Affected and Waterlogged Soils in Pakistan

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Abstract

Eucalypts have become popular in Pakistan in the past two decades. They are grown in small compact blocks, or single or multiple linear rows along the field boundaries or watercourses. Estimates of standing volumes and area of eucalypts vary but include a total volume grown on farm lands of about 0.36 million m^3 and of 245,000 ha of plantations in 2000. These figures will now have increased. Most wood produced in Pakistan is used as fuel, but 25% of *Eucalyptus* production is used for industry. Growing eucalypts on salt-affected and waterlogged abandoned lands has not been tested in a scientific and systematic way, but using these wastelands could generate income for farmers. This paper reports results of planting eucalypts on saline and waterlogged land with variables including different plant spacing, timing and planting techniques. The trees were irrigated with brackish groundwater. The unreplicated experiment cum demonstration area covered 29 ha in the Fordwah Eastern Sadqia South region of Punjab. Highest survival (78%) was achieved with September planting, while maximum growth was in trees planted in March. Trees spaced at 2.25 × 2.25 m had the best growth. Planting eucalypts in the middle and bottom of the ridge was quite encouraging under saline and waterlogged land and gave a survival rate of 96%. It was concluded that eucalypts can be fairly successful under degraded soil and water resources with post-monsoon planting superior to spring planting. The trees lowered the water table and served as effective an bio-drainage intervention in waterlogged areas.

Agriculture plays a pivotal role in the economy of Pakistan but is confronted with problems of waterlogging and salinity, which result in reduced agricultural production. It is estimated that over 6.3 million ha of prime land has been taken out of production since the current extensive irrigation system was introduced, due to this menace. Much of this land lies barren or produces very little for farmers. Bio-saline technology shows that by growing salt-tolerant trees such as *Eucalyptus camaldulensis*, and crops and grasses, this poor quality land can produce good income for farmers (see e.g. Marcar and Khanna (1997)). Perhaps more importantly, it can also help to protect their good agricultural land from such problems in the future. Planting of trees, especially eucalypts, can play a positive role in the improvement of socioeconomic conditions of the farming community. The current forest resources of Pakistan as compared with Asia and world are shown in Table 1.

The Status of Eucalypts in Pakistan

Eucalypts are planted on farmlands in social and farm forestry programs and as the promising tree species for afforestation and reclamation of waterlogged and saline areas in the plains of Punjab and Sindh provinces. They are grown either in the form of small compact blocks, or single or multiple linear rows along field boundaries.

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Turnbull, J.W., ed., Eucalypts in Asia. Proceedings of an international conference held in Zhanjiang, Guangdong, People's Republic of China, 7–11 April 2003.
ACIAR Proceedings No. 111.
(printed version published in 2003)

According to the Forestry Sector Master Plan, the total volume of eucalypts grown on farmlands is 0.36 million m^3 (FSMP 1992). Another estimate was 0.57 and 0.16 million m^3 in Punjab and North West Frontier Province, respectively (Amjad 1991). This volume has since increased due to growth and planting programs. Eucalypts are exotic in Pakistan with few known uses. Farmers find eucalypts difficult to market because of strong competition from traditional farm trees with established uses. A marketing survey in the districts of Attock, Gujrat, Jhelum, Sargodha and D.I. Khan confirmed that most eucalypt tree farmers suffer from marketing constraints (Suleman and Shah 1995) and this is influencing farm resource management decisions in these areas. It was projected that, in 2000, there would be 245,000 ha of eucalypts in Pakistan, with 10% in the public sector and the balance in the private sector (Pandey 1998).

Farmers could be assisted and even motivated to plant more eucalypts if industrial uses of these species could be developed within Pakistan, or there was an export market. The present industrial base in the country is not strong enough to absorb expected supplies. In view of the scattered plantings, a feasible alternative could be to produce, on-farm with mobile chippers, eucalypt chips for export.

Projected forest planting areas, including *Eucalyptus*, in Pakistan at year 2000 are shown in Table 2.

About 90% of Pakistan's wood production is used as fuel, and almost 80% of households use wood for cooking. Most industrial roundwood is used for sawn timber. Imported wood pulp is mixed with local non-wood fibre pulp to produce paper. Pakistan also imports small quantities of logs, sawn timber, panels and paper. It is estimated that 207,000 t of short-fibre pulp (equivalent to 675,000 m^3 of *Eucalyptus*) and 130,400 t of long-fibre wood pulp would be required annually to produce all paper and paperboard products consumed in Pakistan (Ayaz and Qureshi 2000). Consumption of all grades of paper and paperboard is estimated to increase by 2.9% a year from 1998 to 2018. These estimates are based on 1997 trade data (FAO 2000) and conversions factors in Haynes (1990). Thus, the maximum potential use of *Eucalyptus* for pulp production would increase from 675,000 m^3 in 1998 to 1.9 million m^3 in 2018. A plantation area of 40,000 ha would be required to sustain production of 675,000 m^3, assuming an average yield of 17 m^3 $ha^{-1}yr^{-1}$. However, organisation of buying and collecting are crucial factors for a pulp industry, especially since the eucalypts are grown on so many individual farms.

Table 1. Forest resources of Pakistan, Asia and the world.

	Land area	Forest cover 2000	Forest cover change 1990–2000		Distribution of land cover/use (1990)		
					Forest	Other wooded land	Other land
	('000 ha)	('000 ha)	('000 ha yr^{-1})	(% yr^{-1})	(%)	(%)	(%)
Pakistan	77,088	2,361	39	1.84	3.1	1.4	95.8
Asia	3.084,124	547,791	–287	–0.05	17.8	4.6	78.3
World	13,139,618	3,869,453	–9319	–0.24	29.4	11.2	58.6

Source: <http://www.fao.org/forestry/fo/country> Forestry information system (FIRS) country profile.

Table 2. Projected plantation areas in Pakistan by genera in 2000.

Generic groups	Area		Industrial	Non-industrial
	(000 ha)	(%)	(%)	(%)
Acacia spp.	196	20	75	100
Dalbergia sp.	196	20	25	25
Eucalyptus spp.	245	25	10	75
Other broadleaved spp.	249	30		90

Source: Pandey (1998).

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Pakistan could be a potential source of woodchips for export to East Asian countries. The main economic factor in the export of *Eucalyptus* woodchips from Pakistan is the cost of chip production and the marketing margin. Suleman and Ayaz (1995) discussed the economic feasibility of *Eucalyptus* chip exports. They noted the need to: 1) create a market demand for the *Eucalyptus* grown on farmlands in Pakistan; 2) improve socioeconomic conditions in the eucalypt growing area through better returns on the wood; and 3) provide motivation to the farmers to practise agroforestry and social forestry for the increased production of timber for fuels, industry and environmental improvement. Cost–benefit analysis suggests the negative marketing margin for manufacture of export *Eucalyptus* chips in Pakistan is due to higher transportation costs, lack of integration in the utilisation of eucalypts and absence of economies of scale in chip production. These three elements significantly hamper Pakistan's international competitiveness in *Eucalyptus* chip exports.

Growing eucalypts on salt-affected and waterlogged abandoned lands has not been tested in a scientific and systematic way, but using these wastelands could generate income for farmers. With this aim, *E. camaldulensis* was planted on saline and waterlogged land in Pakistan from 1998–99 to 2001–2002.

Research Methods

Variables tested included different plant spacings, timings and planting techniques. The trees were irrigated with brackish groundwater. An unreplicated experiment cum demonstration with an area of about 29 ha was laid out in Fordwah Eastern Sadiqia South region of Punjab. Data recorded were baseline soil analysis for texture and salinity/sodicity. Periodic water quality analysis and monitoring of soil salinity/sodicity, tree survival, girth and height, rainfall and water table fluctuation were carried out.

Planting months were February, March and April (spring) and August, September and October (post-monsoon). Spacings were 2 × 2 m, 2.25 × 2.25 m, 2.5 × 2.5 m, and 2.75 × 2.75 m giving plant densities of 2500 ha^{-1}, 1975 ha^{-1}, 1600 ha^{-1}, and 1322 ha^{-1}. Planting techniques included planting on top of the ridge, in the middle of the ridge, on the bottom of the ridge and in flat/basin soil (conventional).

The soil is a light textured, freely draining, loam to sandy loam. Chemical analysis in the 0–30 cm profile showed the soil profile was highly saline–sodic. Soil reaction was invariably alkaline (pH 8.5–8.9) with sodium adsorption ration in the range of 55–100 $(mmol_c\ L^{-1})^{0.5}$ and electrical conductivity (EC_e) 48–71 dS m^{-1}. Drainage water used for irrigation had SAR in the range of 14.0–16.4 $(mmol_c\ L^{-1})^{0.5}$ and EC_e 5.1–6.7 dS m^{-1}.

Results and Discussion

Tree survival

The data presented in Table 3 show impact of planting time on survival percentage in June 2002. September planting had 78% survival, which was significantly higher than other planting times. March and April planting survival was inferior to September but superior to February, August and October planting survival.

Table 3. Impact of planting time on tree survival.

Planting month	No. of trees planted	Percent survival
February	7457	23
March	7469	66
April	7755	57
August	4716	40
September	7507	78
October	7949	45

Survival at different spacings was in the range 49–58% but this may not be significant and may be due to variations in the site's soil salinity and sodicity.

Tree growth

Planting time had some influence on increase in tree height and girth (Table 4). Maximum mean tree height of 5.81 m was observed in March, with a mean of 5.60 m in April plantings. Trees planted in August had the minimum tree height of 3.79 m. In the case of February plantings, perhaps it was not just the time of planting that determined tree height: soil salinity/sodicity may have been more important. Examination of soil analysis data gives maximum salinity/sodicity values in February -planted fields.

The ranking of mean tree girth corresponded to the rankings for height growth. Mean maximum plant girth was in the March and April plantings: 8.11 cm and 7.95 cm, respectively. The smallest stem girth

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growth was in August and February plantings: 4.96 cm and 5.24 cm, respectively.

Trees planted at 2.25 × 2.25 m spacings had the greatest height growth (4.79 m) and those planted at 2.00 × 2.00 m were the shortest (4.31 m) (Table 5). It is difficult to say if this difference is significant or due to site differences. Like height growth, maximum mean girth was in spacing 2.25 × 2.25 m, followed by S_4S_3 and S_1 (Table 5).

Effect of different planting techniques on tree survival

Survival of the 224 seedlings in each of the four treatments was: (i) top of ridge, 85%; (ii) middle of ridge, 96%; (iii) bottom of ridge, 96%; and (iv) flat/basin soil, 92%. Survival of plants on the top of the ridge appeared marginally poorer than in the other positions.

Effect of trees on the water table

Land occupied by the plantation had a relatively deeper watertable in its interior than at its perimeter or the outer peripheral area, due to intensive extraction of groundwater and evapotranspiration by trees.

Conclusions

The area under *Eucalyptus* in Pakistan is increasing and currently comprises 25% of plantation area. There will be more planting if the various uses of eucalypt wood are popularised. There is also the potential to save foreign exchange by producing paper pulp from eucalypts. Plantations on salt-affected wasteland are an option to provide economic returns to farmers. The following conclusions were drawn from this trial.

1. *Eucalyptus camaldulensis* grew fairly successfully on salt-affected abandoned land when irrigated with drainage water.
2. Extremely hot and dry weather, coupled with shortage of irrigation water, may result in significant plant failure. Post-monsoon planting (September) appeared to result in better tree survival than spring planting, while there was little effect of tree spacing on survival.

Table 4. Impact of planting time on tree height and girth.

Planting month	Tree height		Tree girth	
	Mean height (m)	Increase over August planting (%)	Mean girth (cm)	Increase over August planting (%)
August	3.37	–	4.96	–
September	4.25	+26	5.60	+13
October	4.39	+30	6.29	+27
February	3.79	+12	5.24	+6
March	5.81	+72	8.11	+64
April	5.60	+66	7.95	+60

Table 5. Impact of initial spacing on tree growth.

Spacing	Tree height		Tree girth	
	Mean (m)	Percent increase over (S_1)	Mean (cm)	Percent increase over (S_1)
2.00 × 2.00 m (S_1)	4.31	–	5.84	–
2.25 × 2.25 m (S_2)	4.97	15	7.21	23
2.50 × 2.50 m (S_3)	4.40	2	6.15	5
2.75 × 2.75 m (S_4)	4.46	3	6.40	10

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3. Tree growth, and therefore wood production, after 4 years was considerably higher in pre-monsoon planting (March–April).
4. Land occupied by the plantation had a relatively deeper watertable in the interior than the perimeter or the outer peripheral area due to intensive extraction of groundwater and evapotranspiration by trees.

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ACIAR Proceedings No. 111.
(printed version published in 2003)