Poplar agroforestry in India

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Accepted 21 June 1996

Abstract

The development of poplar agroforestry and associated research in India is reviewed. The model of agroforestry development involving a partnership between farmers, the private sector and the government is worthy of further investigation for application in other areas of India and to other countries. A number of suggestions are given for further research in the context of optimising the system for resource-poor farmers. These include changes in tree and crop varieties, tree spacing, and utilisation of small diameter logs, and other poplar products.

Keywords: Agroforestry; Poplar; India; Intercropping

1. Introduction

There is currently considerable interest worldwide in the potential for trees on farms to increase income in a manner that maintains or enhances the diversity of species. In economic terms it can be important that the trees have the potential to produce a variety of products with a large local and international market. Poplar fits into this category in many areas including Europe, North America, India and China. The range of industrial products include matchwood, packing materials, pallets, plywood and pulp.

Resource-poor farmers find poplar useful if it enhances the yield or quality of the understorey crops and or supplies products such as fodder, firewood and materials for house construction.

Deciduous trees have considerable potential for integration into agroforestry as they tend to use growth resources for only part of the year, thus allowing resource use by adjacent or understorey pasture or crops to take place with minimal interference. By selecting appropriate species in terms of this temporal partitioning, it is possible to enhance ecological combining ability as manifested by yield advantage. Some of these yield advantages can be considerable (Newman, 1986, 1987, 1990) and if managed correctly can enhance overall profitability (Newman et al., 1991a,b). The incorporation of trees into arable systems can lead to considerable changes in species diversity above and below ground. One recent study has shown this for poplar in terms of soil fauna (Park et al., 1994).

This study was carried out in order to identify key variables in the design of successful silvoarable systems in agronomic and silvicultural terms and to assess poplar agroforestry as a tool for socioeconomic development in poorer areas. Suggestions for further research were also developed. The study consisted of a CAB TREECD literature review from 1939 to 1992 supplemented by CAB abstracts from
1993 to October 1994. This was complemented by three field tours to India between 1993 and 1995.

2. Poplars and agroforestry in India

There are six species of poplar native to India: Populus ciliata, Populus euphratica, Populus laurifolia, Populus alba, Populus gambelii and Populus glauca (Mathur and Sharma, 1983). All are located in the north of the country.

Improved fast growing poplars were introduced as early as the 1950s and have only shown good growth performance above latitude 28 degrees North (ICFRE, 1982).

Many varieties have been tried in India, but the most successful have been clones of Populus deltoides or Populus euramericana. Full accounts of site x variety trials are given in ICFRE (1982), ICFRE (1992), Mathur and Sharma (1983), Chaturverdi (1982), and Tewari (1993). Yield tables are presented in Chaturverdi (1982) and Tewari (1993).

Poplar agroforestry can now be found in many states in India (Fig. 1). These include Uttar Pradesh, Punjab, Haryana, Jammu and Kashmir, Himachel Pradesh and Arunachal Pradesh.

The introduced clones have a considerable leafless period in India that can last up to 4 months. Depending on variety they will shed leaves during November to December and will not come into full leaf until April or May. This gives considerable scope for intercropping with a wide range of arable, vegetable, spice, and fodder crops.

P. deltoides is very productive in terms of leaf production producing 2.5 tonnes ha⁻¹ dry matter at 594 stems ha⁻¹ in Year 3 increasing to nearly 9 tonnes from 400 stems at 11 years (Kaul et al., 1983). The nitrogen contribution to the soil from this could be as much as 43 kg in Year 3 rising to 102 kg in Year 11 (Kaul et al., 1983). Improvements in soil structure and chemical properties under poplar are also possible (Singh et al., 1989).

Poplar has been used extensively as fodder for sheep goats and other livestock in the past.

3. The role of the private sector

A major force behind the expansion of poplar agroforestry in Northern India was a partnership arrangement between a private match producing company, Wimco Ltd., farmers, and financial institutions (Piare-Lal and Lal, 1991, AFC, 1993). In simple terms, the company markets a package to farmers targeted on the basis of land suitability. This package includes the supply of appropriate planting stock (2–3 m rooted sets of P. deltoides clones such as G3, G48, D121, S7CB, S7C15, and S7C20) and advice on pit planting (5 m × 4 m or 6 m × 6 m), irrigation, pruning and management including intercrop procedures. Wimco then gives a buy back price for the final crop for a given size and quality. The package is financed through long-term bank loans with a guaranteed refinance underwritten by the govt agency known as the National Bank for Agriculture and Rural Development or NABARD. Wimco assists in the administration and validation of the loans. The scheme is attractive to farmers as it gives them access to credit that can be used on any aspect of improving the farm business. Initially normal cropping can occur between the trees with a long-term crop such as sugarcane or successional crops such as

Fig. 1. Map of India showing location of poplar-growing states of Uttar Pradesh (UP), Punjab (P), Haryana (H), Jammu and Kashmir (JK), Himachel Pradesh (HP) and Arunachal Pradesh (AP). The southern limit of natural distribution (28 degrees North latitude) is also shown as a dashed line.
wheat (a winter or rabi crop) followed by a kharif (summer) crop such as maize. When trees approach canopy closure more shade-tolerant crops such as ginger, turmeric, fodder, or leaf vegetable have to be used.

4. Extent of the practice

Bhalla (1988) stated that 5.1 million trees were planted between 1979 and 1988 under the Wimco scheme. Assuming a planting of \(4 \times 5\) m\(^2\) and no mortality this gives an area of 10,200 ha planted. Jones and Lal (1989) stated that the Wimco trees when planted had achieved an MAI of 20 m\(^3\) ha\(^{-1}\) year\(^{-1}\), after 8 years with a rotation expected of 12–15 years. The trees were planted in blocks or on field boundaries at 4 m within the row. The Wimco scheme by this time had involved some 5000 farmers. The total number of trees planted by 1991 in the three states of Punjab, Haryana, and Uttar Pradesh had amounted to over 11 million giving a plantation area of over 22,000 ha. (AFC, 1993). Targets set by the company and others if met could lead to an estimated extent of 40,000 ha by 1995.

5. Performance of poplar agroforestry and research needs

Chandra (1986) gives an excellent account of the economics involved in establishing poplar agroforestry. He shows discounted costs of Rs 41,503 (12% over 8 years) against benefits of Rs 77,336. (1 US$ = 34.5 Rs, May 1996). Kapur and Dogra (1989) have shown how poplar agroforestry may meet the needs of both industry and the rural communities in the Punjab in terms of product diversity.

Nearly all studies of net present value of poplar agroforestry show improvements over poplar monoculture. A study by Mathur and Sharma (1983) showed that at 12% interest on an 8 year rotation agroforestry net present values of Rs 7325 as opposed to Rs 3208 for poplar monoculture on forest land. Few studies have looked at optimising tree density or had sufficient agriculture controls under the same level of management as the intercrops in order to assess the efficacy of agroforestry compared to agriculture alone. Some of the few studies that met this criterion are presented in Table 1. The highest yield of faba beans was obtained under the lowest tree density (Dhukia et al., 1989). Spice crops can give considerably higher yields than monocultures if intercropped (Jaswal et al., 1993). Sharma and Singh (1992) carried out one of the few studies on bund planting.

The net present value of the system could be enhanced if there is a good demand for small diameter timber. Chaturverdi (1992), suggested a system based upon a rotation of 4 years at conventional spacing.

Singh et al. (1989) show that the intercropping of aromatic plants such as Mentha spp. and Cymbopogon spp. had no effect on poplar growth. They

<table>
<thead>
<tr>
<th>Spacing in metres</th>
<th>Tree age in years (height m, DBH cm)</th>
<th>Understorey crop</th>
<th>Understorey performance (% of monoculture control yield)</th>
<th>Economic or other performance</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 × 2</td>
<td>5</td>
<td>Faba beans</td>
<td>7.39 t ha(^{-1}) fodder yield 1.36 t ha(^{-1}) dry matter yield</td>
<td>Dhukia et al., 1989</td>
<td></td>
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<tr>
<td>4 × 4</td>
<td>5</td>
<td>Faba beans</td>
<td>12.67 t ha(^{-1}) fodder yield 2.08 t ha(^{-1}) dry matter yield</td>
<td>Dhukia et al., 1989</td>
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<tr>
<td>6 × 6</td>
<td>5</td>
<td>Faba beans</td>
<td>14.89 t ha(^{-1}) fodder yield 2.58 t ha(^{-1}) dry matter yield</td>
<td>Dhukia et al., 1989</td>
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</tr>
<tr>
<td>5 × 5</td>
<td>5 (13.8, 13.7)</td>
<td>Ginger</td>
<td>183%</td>
<td>53% PAR</td>
<td>Jaswal et al., 1993</td>
</tr>
<tr>
<td>5 × 4</td>
<td>5 (13.8, 13.7)</td>
<td>Ginger</td>
<td>196%</td>
<td>46% PAR</td>
<td>Jaswal et al., 1993</td>
</tr>
<tr>
<td>5 × 3</td>
<td>5 (13.8, 13.7)</td>
<td>Ginger</td>
<td>122%</td>
<td>38% PAR</td>
<td>Jaswal et al., 1993</td>
</tr>
<tr>
<td>5 × 5</td>
<td>5 (13.8, 13.7)</td>
<td>Turmeric</td>
<td>145%</td>
<td>53% PAR</td>
<td>Jaswal et al., 1993</td>
</tr>
<tr>
<td>5 × 4</td>
<td>5 (13.8, 13.7)</td>
<td>Turmeric</td>
<td>119%</td>
<td>46% PAR</td>
<td>Jaswal et al., 1993</td>
</tr>
<tr>
<td>5 × 3</td>
<td>5 (13.8, 13.7)</td>
<td>Turmeric</td>
<td>95%</td>
<td>38% PAR</td>
<td>Jaswal et al., 1993</td>
</tr>
</tbody>
</table>
also showed that the oil yield of *Cymbopogon* spp. was constant over the first 3 years of intercropping in G3 *P. deltoides* at 5 m × 4 m.

There is considerable variation between clones in the phenology and density of leafing. In an experiment carried out in the nursery by Wimco reported by Tewari (1993), a number of intercrops were tested between rows of *P. deltoides* G3, F48 and D121 planted 1 m × 0.4 m². For black and green gram the yield under D121 was 61% and 44% of that under G3, respectively. There is considerable scope for optimising the agroforestry system by choosing poplar clones with a shorter leaf area duration per unit wood production.

The yield of high value intercrops and ultimately the returns from the whole system can be optimised by changing the spatial arrangement of the trees. Wider spacing between rows will allow greater flexibility in intercropping for a longer period. This can be carried out without reducing tree density if within row spacing is reduced. Mishra and Gupta (1993) have generated relevant data for the assessment of possible crown interference problems.

Selecting for shade tolerance (physiological adaptation) and shade avoidance (phenological adaptation) in short season crops is also possible and particularly worthwhile in high value intercrops such as the medicinals studied by Jha et al. (1991) and aromatics (Kamla-Singh et al., 1985, Kamla-Singh et al., 1988, Kamla-Singh et al., 1990.)

Singh et al. (1993) showed that wheat yield under poplar can be improved by choosing appropriate varieties.

Ploughing to reduce the growth of fine roots is vital if interference from the trees is to be reduced. Poplar if not intercropped is a surface rooting species capable of producing very dense root mats in the first 30 cm of soil (Sighal et al., 1990).

Boundary planting on bunds and in other areas if irrigated is very attractive to farmers with small fields as it is possible to produce more trees in this way than by using row intercropping (see Chaturverdi (1982) and ICFRE (1992)). Spatial studies on understorey yields adjacent to line planting are essential if the design of these systems is to be improved. A useful sampling approach using perpendicular transects has been carried out by Sharma and Singh (1992).

### 6. Conclusions and further research

The Wimco model of agroforestry involving govt. supported loans for the purchase of tree crops could be applied to many countries. It has resulted in large areas of land under agroforestry with a concomitant increase in farm incomes and employment from other poplar-using industry. The scheme shows promise for many other tree crop systems in India where the trees have an industrial as well as local market. In Central India bamboo agroforestry may be one suitable candidate.

There is considerable potential for developing the Wimco poplar agroforestry model towards the needs of poorer farmers by changing the attributes of the trees and their spatial arrangement to favor the extent and yield of the understorey crop and to develop markets for smaller diameter timber. These recommendations are listed below.

Selection and breeding programs could extend the southern limit of poplar production and increase tree productivity relative to leaf area duration.

Establishment methods using 1-m cuttings from trees pruned in adjacent farms could reduce costs compared to the use of entire transplants.

Increased spacing between rows with compensating decreases in within rows could improve the performance of an understorey as could the selection of more shade-tolerant species and varieties.

The use of bund or boundary planting should be studied and the effect of aspect investigated. This method is particularly relevant to farmers with small fields.

Small-scale local industry using small diameter logs and or prunings could be encouraged and developed in strategic areas by appropriate research and government assistance.

### References


