

Profitable and sustainable farming of poplar for Indian farmers

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Poplar (Populus deltoides) has emerged as a flagship species for agroforestry in the Indo-Gangetic Plains of India, offering both economic and ecological benefits. Its fast growth, deciduous nature, and compatibility with rabi crops make it highly suitable for integration with traditional farming. Scientific nursery practices, Entire Transplants (ETP) selection, and improved planting techniques ensure high survival and productivity. Poplar-based agroforestry systems generate substantial income within short rotations while supporting diversified cropping. This article provides need-based, practical guidance covering the complete package of practices—from nursery establishment to harvest—supporting scientific cultivation and enhanced productivity for farmers and nursery practitioners.

Keywords: Agroforestry system, Carbon sequestration, Climate smart farming, Income

THE Indo-Gangetic Plains (IGP) of India, often referred to as the country's 'food bowl', produce nearly half of India's food grains, feeding around 40% of the population. Traditionally, rice-wheat cropping systems have dominated the region, covering more than half of its cultivated area. During the Green Revolution period (1960–70s), food production dramatically increased because of intensive farming practices such as heavy use of fertilisers, pesticides, irrigation, and high-yielding varieties. However, a toll on soil health, groundwater levels, and sustainability has taken. Fragmented landholdings, rising input costs, post-harvest losses, and the unpredictable impacts of climate change are further challenges, making it increasingly difficult for farmers to maintain productivity and profitability solely through conventional cropping.

Agroforestry has emerged as a practical and profitable

solution against these challenges. Agroforestry strengthens farm incomes and builds resilience by increasing crop yields by 5–15%, generating high net returns (₹5.55 lakh/ha in poplar-sugarcane-turmeric and ₹21.10 lakh/ha in Melia-banana systems), enhancing soil organic carbon from 0.62% under sole crops to 1.14% under poplar systems, and sequestering 13.7–27.2 t CO₂/ha/yr, directly supporting India's Nationally Determined Contribution (NDC) commitments. Poplar boundary plantations improved productivity, with the southern aspect yielding 6% higher sorghum biomass (30.36 t/ha) and 4% higher wheat yield, while temperate agroforestry systems have reported up to 16% higher wheat yield compared to open fields. It also plays a critical role in national wood security, supplying over 93% of domestic timber from Trees Outside Forests (TOF), meeting 65% of small timber, 70–80% of construction

wood, and nearly 60% of pulpwood demand, thereby reducing import dependence that reached USD 2.7 billion in 2023.

Among the variety of fast-growing and commercially important trees, poplar has emerged as a flagship species for agroforestry in Northern India. Farmers in Haryana, Punjab, Western Uttar Pradesh, and parts of Uttarakhand, Himachal Pradesh, Bihar, and West Bengal have embraced poplar due to its rapid growth, pruning tolerance, minimal interference with crops, and high economic returns within short rotation cycles of 6–8 years. The deciduous nature of poplar allows integration with *rabi* crops such as wheat, barley, mustard, and berseem without significant reduction in crop yield. Poplar-based agroforestry systems are highly versatile, cultivated in diverse planting geometries such as 5 × 4 m², 10 × 2 m², 4 × 4 m², 5 × 5 m², and 6 × 3 m², either as block plantations or along linear boundaries (2–5 m

away), to optimise land use and enhance biomass production.

Growth and agroforestry potential

Poplar is a tall deciduous tree, capable of reaching 30 m in height within a few years. Its rapid growth, and straight stem make it ideal for integration into agricultural landscapes without significantly interfering with crop production. One of the key advantages of poplar in India is its extended leafless period during winter, which can last up to four months. This feature allows farmers to intercrop cereals, pulses, vegetables, and fodder crops during the early and late parts of the year, optimising land use without compromising tree growth. Poplar can be planted along field borders, in rows within fields, or as shelterbelts.

Propagation

Poplar seedlings are raised through stem cuttings, and the planting of cuttings is to be completed between 15th January and 15th February. High-yielding clones such as G-48, Udai, W-22, W-32, W-39, S-7 C-15, and S-7C-8 have been developed for cultivation under specific soil and climatic conditions.

Poplar nursery method: Nursery beds are prepared according to irrigation facilities, and plough the soil to a depth of 30–35 cm. For each hectare, mix 1,000 quintals of well-decomposed farmyard manure with 125 kg of superphosphate (SSP), 50 kg of zinc sulfate, and 50 kg of muriate of potash (MoP) in the beds. Urea should be applied near the roots at 25 kg/ha after weeding in May–June and August, which helps seedlings grow tall and thick.

The most suitable cuttings are taken from one-year-old branches, but the soft upper one-third portion of the branch should not be used for cuttings. Prepare cuttings 20–25 cm long (with 4–5 buds) and about 2 cm thick. Plant the cuttings at a spacing of 45 cm × 45 cm. Before planting, make a 20–25 cm deep hole in the soil using a wooden stick, and place the cutting in the hole so that the uppermost bud remains above the soil. The planted cuttings should be properly cared for in the nursery



View of poplar cutting and nursery seedlings

for one year, including regular irrigation and protection.

Guidelines for selecting poplar ETPs (Entire transplants) to farmers

- Always purchase poplar seedlings/ETPs from state agricultural universities, government forest nurseries, or other certified agencies. This ensures the purity of the planting material, giving farmers a reliable investment.
- The best time to purchase seedlings is during September and October, as leaves are present on the plants. This helps in identifying pests, diseases, and overall plant health. By November, leaves fall, making it difficult to assess plant health.
- The ideal time for transplanting poplar seedlings is January–February. ETPs are generally lifted in late December and transplanted in early January.
- Avoid purchasing seedlings from nurseries where plants are infested with termites or stem-borer insects, as these cause leaves to dry and can affect growth. Avoid seedlings that

have frost damage on the upper surface due to cold weather.

- On arrival, seedlings should be placed horizontally in fresh water pits to prevent dehydration. Store for a minimum of three days in water; they can safely remain for 10–12 days before transplanting.
- While pruning seedlings, ensure they are not damaged and that they grow straight. Prune thick, long, or damaged roots while retaining all fine roots.
- At the time of planting, seedlings should be about one-year-old. Do not choose very tall seedlings, as they have a higher chance of mortality.

Planting technique

After one year in the nursery, poplar seedlings typically reach a height of 3–4 m, making them ready for field transplantation. Before planting, a pit of 1 m depth should be dug, and the excavated soil should be mixed with 5 kg Farmyard Manure (FYM) enriched with *Trichoderma* (prepared one month earlier), 200 g SSP, 25 g MOP and 25 g micronutrients (Zn, Fe, Cu, etc.).



Entire transplants (ETPs) of poplar

Prepare a solution by mixing 200 mL of chlorpyrifos 20% EC and 200 g of carbendazim 50% WP in 100 L of water, sufficient for treating about 100 seedlings. Seedlings should be placed upright in the pit, and the soil mixture should be filled gradually while gently compacting it with feet to avoid air pockets. After planting, the pits must be thoroughly irrigated to ensure proper soil-root contact. For ridge planting, maintain a distance of 3 m between seedlings. The orientation of the rows should preferably be north to south, allowing maximum sunlight penetration for intercropped crops.

During the first year, almost any crop can be grown alongside poplar. However, from the second year onwards, competition for water, sunlight, and nutrients increases. In the *kharif* season, shade-tolerant crops such as turmeric, ginger, and fodder crops like cowpea and sorghum are recommended. In the *rabi* season, poplar sheds its leaves, so intercropping has minimal negative impact on crop growth. When intercropping with poplar, it is advisable to increase the sowing rate of seeds by 25% to compensate for partial shading and resource competition.

Cultural practices

Once established, poplar plantation requires regular care, including weeding, pruning, and thinning. Manual or mechanical weeding twice in the first year reduces competition from grasses and herbs. Pruning helps develop a straight main stem, essential for high-quality timber. During the first year, lower portions of the stem may be debudded, and co-leader



Utilisation of tractor in poplar-based agroforestry system

branches removed, with further pruning carried out in winter to prevent stress during hot or rainy seasons. Thinning is typically done after three years to harvest pulpwood or to improve growth for future timber production.

Diseases and insect-pests

Poplar in northern India is vulnerable to several insect-pests and diseases that can affect growth and productivity. Key insect-pests include plantation defoliators, poplar stem-borer, nursery pests such as poplar shoot-borer, poplar leaf beetle, leopard butterfly, white grubs and termites. Poplars are also susceptible to over 143 fungal, bacterial, and viral pathogens affecting leaves, branches, boles, and roots, with stem-borer being a major threat in commercial plantations. Common preventive measures include regular monitoring of plantations, pruning infected branches, maintaining nursery hygiene, using insecticides like chlorpyrifos for stem and shoot-

borers, and adopting integrated pest management practices to minimise damage.

Harvesting and yield

Poplar is a short-rotation tree capable of yielding significant timber within six to eight years. On fertile sites, productivity may exceed 45 m³/ha/yr, which is considerably higher than the average productivity of natural Indian forests. The modern technologies and scientific management of poplar agroforestry produce average biomasses of around 50–60 Mg/ha. The wood is soft, straight, and versatile, suitable for plywood, veneer, pulp, matchwood, furniture, sports goods, and biomass for energy production. Farmers can earn up to ₹12 lakh/ha from the sale of wood after six years, translating to an average annual returns of around ₹2 lakh/ha. Intercropping with crops such as wheat or pulses further enhances profitability, providing benefit-cost ratios of up to 2.13:1 under favourable conditions.



Pit digging and planting of ETPs in field



Major leaf and stem diseases of poplar in nursery condition in Yamunanagar, Haryana

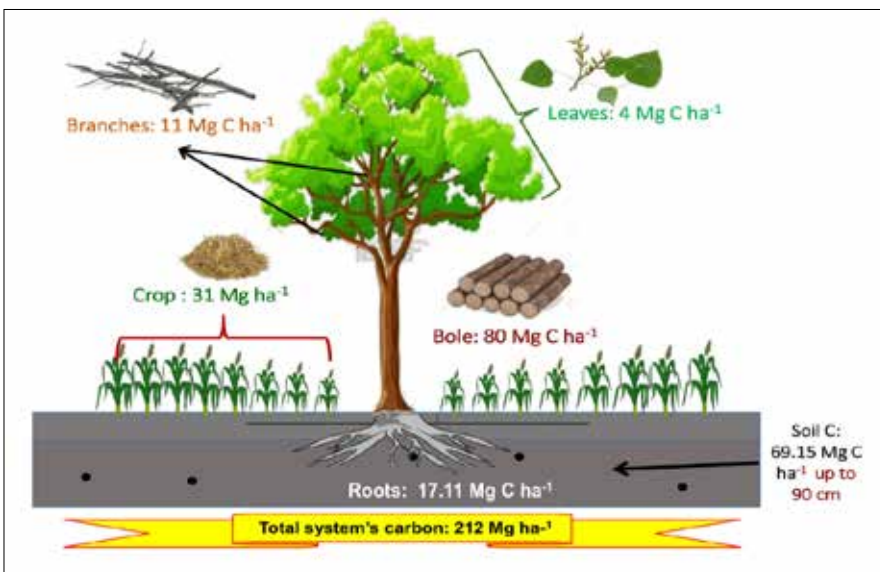
A. Leaf blight; B. Severe leaf and shoot blight;

C. Stem gall/canker like lesion on young stem; D. Stem canker with bark lesion

Environmental benefits and carbon sequestration potential

Poplar improves soil fertility through its leaf litter and root biomass. A well mature (6–8 years old) poplar-based agroforestry system can add 2.5–6.5 Mg/ha of leaf litter. This organic matter enriches the soil with essential nutrients, including nitrogen

(234.3 kg/ha), phosphorus (20.1 kg/ha), and potassium (241.3 kg/ha), and increases organic carbon content up to 0.77%. The biomass accumulation in poplar trees also contributes significantly to carbon sequestration. Eight-year-old plantations show total carbon storage ranging from 212 Mg C/ha. The highest carbon sequestration



Carbon sequestration potential of poplar based agroforestry in 8-years of growth

occurs in 5 m × 4 m spacing, at 14.09 Mg C/ha/yr, offering an average potential of around 10.7 Mg C/ha/yr. By capturing carbon in wood, leaves, and roots, poplar plantations support climate-smart farming and offer potential benefits in carbon credit markets.

Case study 1: Boosting prosperity through poplar based agroforestry system

In Haryana's semi-arid North-West, a study at Chaudhary Charan Singh Haryana Agricultural University, Hisar, showcases the economic prowess of poplar-based agroforestry, outshining traditional cropping systems. During 2008–2016, the research tested 10 m × 2 m spaced trees with sorghum–berseem intercropping at 500 trees/ha, yielding volume of 331 m³/ha with net returns of ₹1,191,241/ha, a net present value (NPV) at 12% discounting of 409,673 ₹/ha, a benefit-cost (B:C) ratio of 2.22:1, an internal rate of return (IRR) of 70%, a land equivalent ratio (LER) of 2.28 (reflecting 128% greater land use efficiency), and a land expectation value (LEV) of 2,242,372 ₹/ha. Comparatively, sole cropping lagged with a B:C ratio of 1:13.1, NPV of 45,880 ₹/ha, and LEV of 251,127 ₹/ha, underscoring agroforestry's potential to double farmers' income while enhancing soil health and sustainability.



Wheat intercropping under poplar agroforestry systems in Haryana

SUMMARY



Poplar-based agroforestry is a scientifically established and economically rewarding land-use system in northern India, presently covering about 263,000 ha. Its deciduous habit during the *rabi* season facilitates efficient intercropping with wheat, mustard, potato, mentha, fodder crops, and pulses, thereby improving overall land-use efficiency. With a short rotation of 6–8 years, it provides a mean annual increment of 20–25 m³/ha/yr in block. Empirical evidence from Haryana reports net returns of ₹1,191,241/ha, a B:C ratio of 2.22:1, and a LER of 2.28,

Case study 2: Enhancing fodder security through poplar-based alley cropping in semi-arid Haryana

Scarcity of green fodder remains a critical constraint to livestock-based farming in semi-arid regions. A three-year field experiment conducted at CCSHAU, Hisar evaluated poplar-based alley cropping systems integrated with sorghum-berseem (S-B) and cowpea-berseem (C-B) rotations under six spacings (3 m × 3 m, 4 m × 3 m, 5 m × 3 m, 6 m × 3 m, 7 m × 3 m and 8 m × 3 m). Results revealed that fodder yield improved significantly with wider row spacing. The maximum sorghum dry fodder yield under poplar was recorded at 8 m × 3 m spacing (20.95, 19.38 and 18.95 t/ha over three years), which was statistically comparable to sole cropping. Yield reductions due to tree competition ranged from 10–22% in the S-B system and 10–56% in the C-B system with increasing tree density. Conversely, soil organic carbon and available N, P and K were highest under closer spacing (3 m × 3 m), indicating improved soil fertility under denser plantations. The highest land equivalent ratio (2.86) was observed in the S-B rotation at 8 m × 3 m spacing, demonstrating 186% greater land-use efficiency over monocropping. Overall, the 8 m × 3 m poplar + sorghum-berseem system emerged as the most productive, resource-efficient and economically viable option for sustainable fodder production in semi-arid ecosystems.









clearly outperforming sole cropping systems. From an environmental perspective, mature plantations contribute total carbon storage reaching 212 Mg C/ha in eight years. Beyond profitability, these systems enhance soil fertility, recycle nutrients, and significant carbon sequestration, positioning poplar as a climate-smart, sustainable solution for resilient agriculture in northern India.

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Volume 1 & 2

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