Global Applications of Fast-Growing Trees in Agroforestry Systems

Elizabeth R. Rogers[1], Ryan A. Vinhal[1], Ronald S. Zalesny Jr.[1],
Jan Weger[2], Joris Van Acker[3], Sanjeev Chauhan[4],
Ian McIvor[5], Pierluigi Paris[6,7], Niels Thevs[8,9]

[1] USDA Forest Service, Northern Research Station, Rhinelander, Wisconsin, USA
[2] Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Pruhonice, Czech Republic
[3] Ghent University, Laboratory of Wood Technology, Ghent, Belgium
[4] Dr. YSP University of Horticulture and Forestry, Nauni, Solan (HP), India
[5] The New Zealand Institute for Plant and Food Research Limited, Palmerston North, New Zealand
[6] Italian National Research Council, Institute of Agro-Environmental and Forest Biology IBAF, Rome, Italy
[7] Italian National Research Council, Research Institute on Terrestrial Ecosystems IRET, Rome, Italy
[8] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Germany
[9] World Agroforestry, Central Asia Office, Bishkek, Kyrgyzstan

IPC
INTERNATIONAL
POPLAR
COMMISSION

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Short Rotation Coppice Combined with Poultry Breeding and Homegardening

June 2023: WP-ENV: #5A

Overview

A small-scale agroforestry system consisting of fast-growing trees (FGTs) and a poultry brood was established gradually from 1999 to 2004 for self-provision of woodchips, vegetables, and eggs/meat in the Czech Republic. The 0.6-ha system is the result of a partnership between a family farmer and the Silva Tarouca Research Institute and is divided into four parts: 1) a clonal test of poplars and willows (36 genotypes; 10,000 stems ha^{-1}); 2) short rotation coppice (SRC) for firewood and woodchips using the top five poplar and willow clones; 3) a stoolbed for production of cuttings (i.e., planting material); and 4) a home garden for vegetable production.

Czech Republic

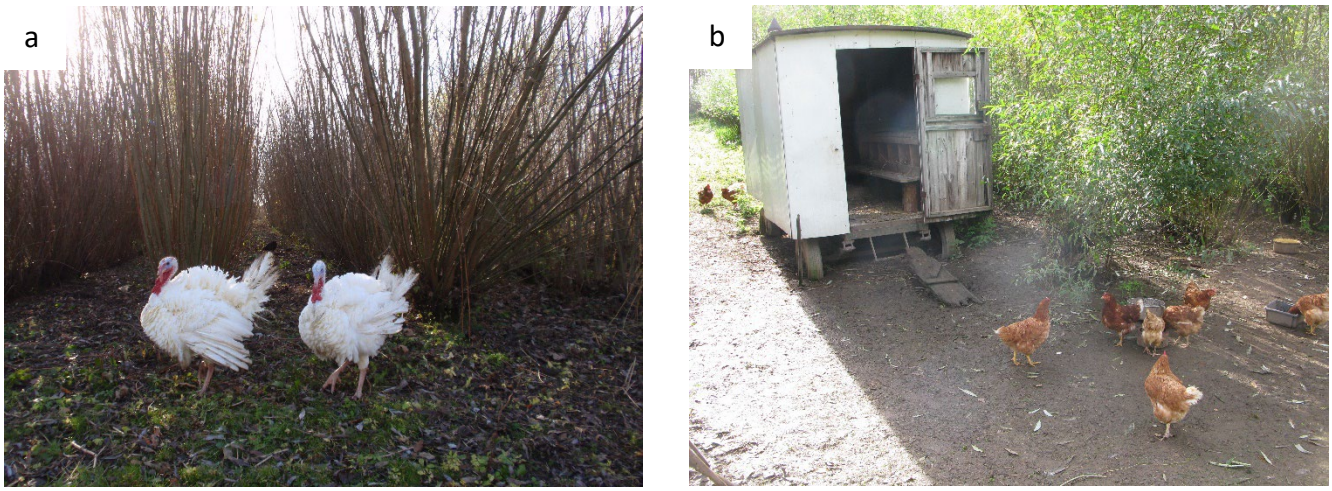


Figure 1. a) Turkeys and b) chickens raised in a short rotation coppice agroforestry system.

In 2004, the landowner started locating poultry close to the plantation, and she found that hens and chickens entered the plantation, not only to feed on insects and plants, but also to protect themselves against birds of prey (e.g., Eurasian sparrow hawk, *Accipiter nisus* L.). A typical poultry flock consists of 20 to 30 hens with one cock and several specimens of ducks, turkeys, and geese (Fig. 1a). Now, a henhouse with water and a feeder is located inside the plot (Fig. 1b). Poultry are fed with locally produced cereals and some commercial pellets *ad libitum*. The agroforestry system is fenced and is registered as SRC, which is suitable for direct payments under the European Union's Single Area Payment Scheme (EU SAPS).

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

After 17 years of agroforestry combining SRC with poultry, soil parameters in the topsoil (5 to 15 cm) exhibited positive trends for pH, phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) despite a lack of fertilization and tree biomass being removed throughout the course of five harvests (Fig. 2a). In addition, the closed canopy of the SRC improved poultry welfare by lowering temporal variations of air temperature and humidity, especially on hot days, and by providing shelter against birds of prey (Fig. 2b). As a result, combining poplar and willow SRC for biomass production with poultry breeding can be recommended for its integrated positive effects on soil, microclimate, poultry welfare, and adaptation/mitigation effects.

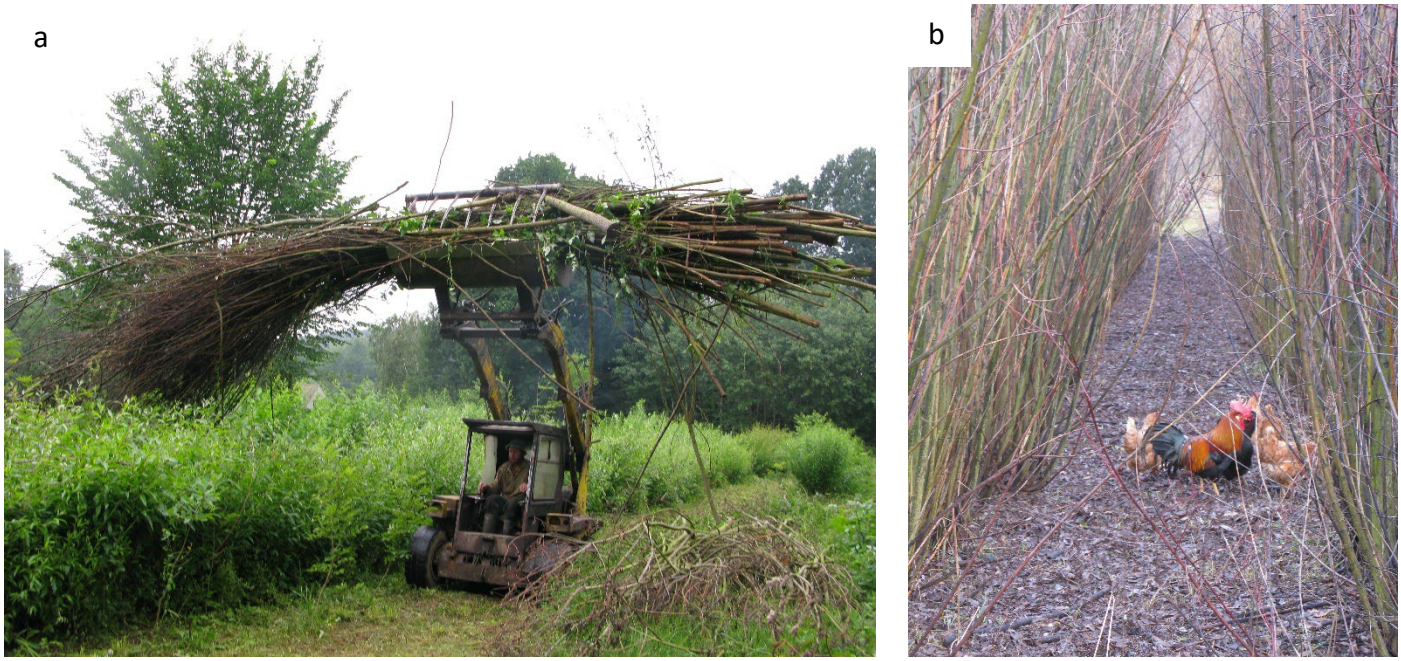


Figure 2. a) Harvesting of willows from a short rotation coppice agroforestry system, and b) free range chickens in an agroforestry willow plot.

Keywords: Poplar, willow, chickens, turkeys, poultry welfare, soil health, microclimate

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Jan Weger: weger@vukoz.cz

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; and Ron Zalesny, WP-ENV Chair

http://www.fao.org/forestry/ipc/en/

Highlight #5A

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

How Poplars and Willows Can Contribute to Improved Water Quality

June 2023: WP-ENV: #5B

Overview

New Zealand pastoral agriculture is very dependent on regular inputs of inorganic fertilizers and commonly implements practices that increase soil erosion (e.g., tillage, removal of groundcover). Farmlands, therefore, are important drivers of nonpoint source water pollution, contributing substantial amounts of sediment, phosphorus (P), and nitrogen (N) to New Zealand rivers and streams. Exacerbating this problem is streambank erosion which typically accounts for 50 to 90 percent of a stream's sediment and P load. Pastoral farmers are increasingly under legislative pressure to improve the quality of water moving from their farms into streams and rivers.

New Zealand

Figure 1. Poplars stabilizing a watercourse.

Poplars (*Populus* L.) and willows (*Salix* L.) are the bioengineering tools used by farmers in New Zealand to reduce sediment transfer and improve water quality. Both genera take up inorganic forms of P (from applied fertilizer or as mineralized P in the soil) and return P in organic forms at leaf fall and through root death. These trees do not store P but recycle it, since most P is used in the leaves. By reducing the rate of runoff and increasing infiltration, these trees reduce overland flow and loss of P into waterways (Fig. 1).

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

Poplars and willows provide other benefits to water quality, both through indirect and direct means. Indirectly, these plants provide shade and shelter to stock animals, which helps distribute animal excrement more widely as the animals disperse for shade and shelter, thereby leading to less-concentrated waste inputs into surface and groundwater. Poplars and willows improve water quality directly by terracing the land, which slows the runoff of sediment, P and N, and by shading and cooling stream water, which improves habitats for aquatic animals and recreational fishermen (Fig. 2a). Willows, particularly those established in riparian buffers, can also build up stream banks, leading to reduced, and even negative erosion rates over time (Fig. 2b). Overall, improvements in water quality are observed where pastoral slopes are planted with poplars and willows. These measures are improving the image of farmers as responsible environmentalists among the urban public in New Zealand and internationally.

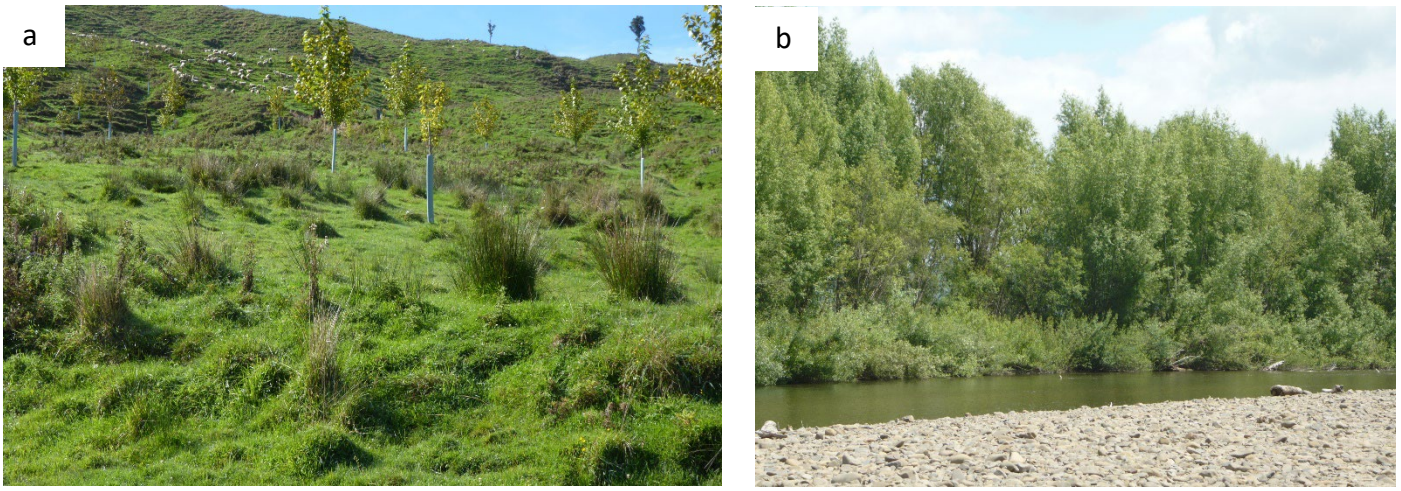


Figure 2. a) Hybrid poplars planted to stabilize a slope and intercept sediment before it reaches a stream, and b) willows protecting the banks of a stream.

Keywords: Erosion, agricultural pollution, streambank stabilization, water quality

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Ian McIvor: ian.mcivor@plantandfood.co.nz

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; and Ron Zalesny, WP-ENV Chair

http://www.fao.org/forestry/ipc/en/

Highlight #5B

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

The Benefits of Pollarding Poplars and Willows to Provide Stock Fodder

June 2023: WP-ENV: #5C

Overview

Poplars (*Populus* L.) and willows (*Salix* L.) are planted extensively in New Zealand pastoral hill country for soil stabilization, but serve other important functions that make them multipurpose trees. One such function that is particularly relevant for agroforestry systems is the ability of poplars and willows to serve as valuable sources of fodder for pastoral farmers.

New Zealand

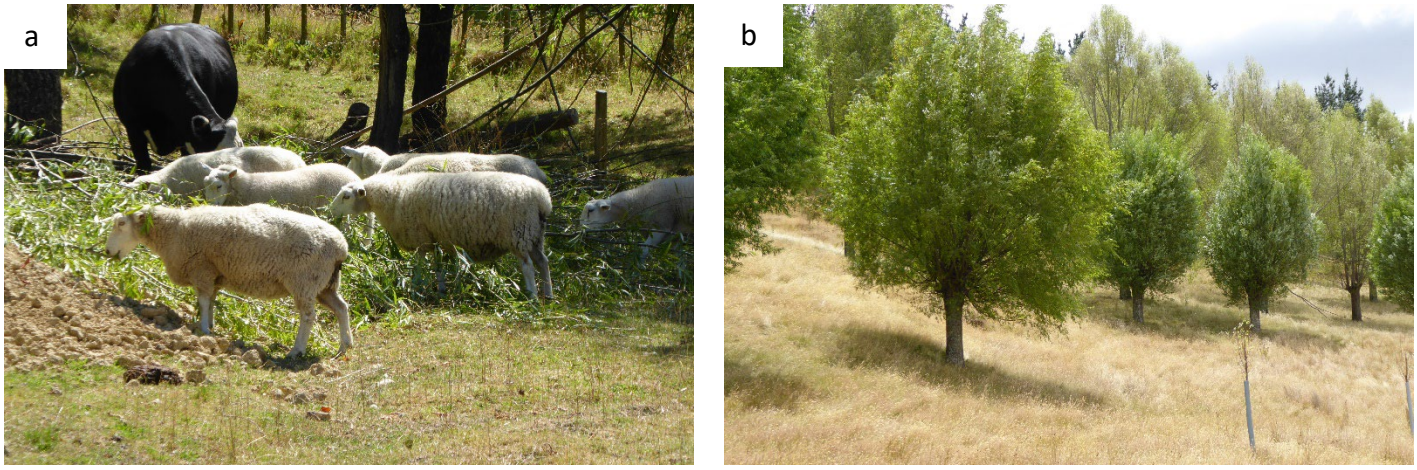


Figure 1. a) Cattle and sheep browsing on freshly cut willow fodder, and b) willows grown for fodder production.

Tree fodder utilization usually occurs during the summer and into autumn when pasture quality is the lowest and trees are in full leaf. Stock animals readily eat the leaves, small stems, and bark of both poplars and willows (Fig. 1). However, willows exhibit several characteristics that make them ideal as a source of fodder. First, while trees aged 5 to 10 years of both genera yield up to 22 kg dry matter of edible forage per tree, willows grow 4 to 5 times the number of new shoots and carry more edible fodder than poplars. Condensed tannins and higher levels of zinc and magnesium compared to typical pasture species are added stock health benefits of willow fodder. Willows are also easier than poplars to manage for harvesting fodder. Harvests for fodder occur every 3 to 4 years, with willow trees being reduced to a pollarded form.

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

Today, extension activities emphasize the multiple uses of these trees, promote their adoption, and provide information on management for fodder and safe harvesting practices. The intentional planting of poplars and willows for multiple purposes is increasing, with farmers planting a wider variety of clones, seeking information on fit-for-purpose clones, and attending to their management (Fig. 2).

Figure 2. Willows managed for fodder production.

Keywords: Pastoral farms, tree fodder, fodder nutrition, fodder production

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Ian McIvor: ian.mcivor@plantandfood.co.nz

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; and Ron Zalesny, WP-ENV Chair

http://www.fao.org/forestry/ipc/en/

Highlight #5C

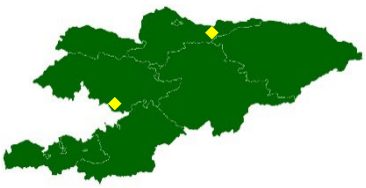
'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Crop Water Consumption of Whole-Tree Windbreak Systems

June 2023: WP-ENV: #5D

Overview

Central Asia is one of the world's largest dryland regions. Consisting of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, the countries of the region are forest-poor and import most of the wood resources demanded by their domestic markets. At the same time, agriculture in the region largely depends on irrigation, which has resulted in the overexploitation of Central Asian water resources; the desiccation of the Aral Sea is the most vivid outcome of water extraction for irrigation. With climate change, water resources available for irrigation are expected to decrease, while the occurrence of heat waves is expected to increase.



Kyrgyzstan

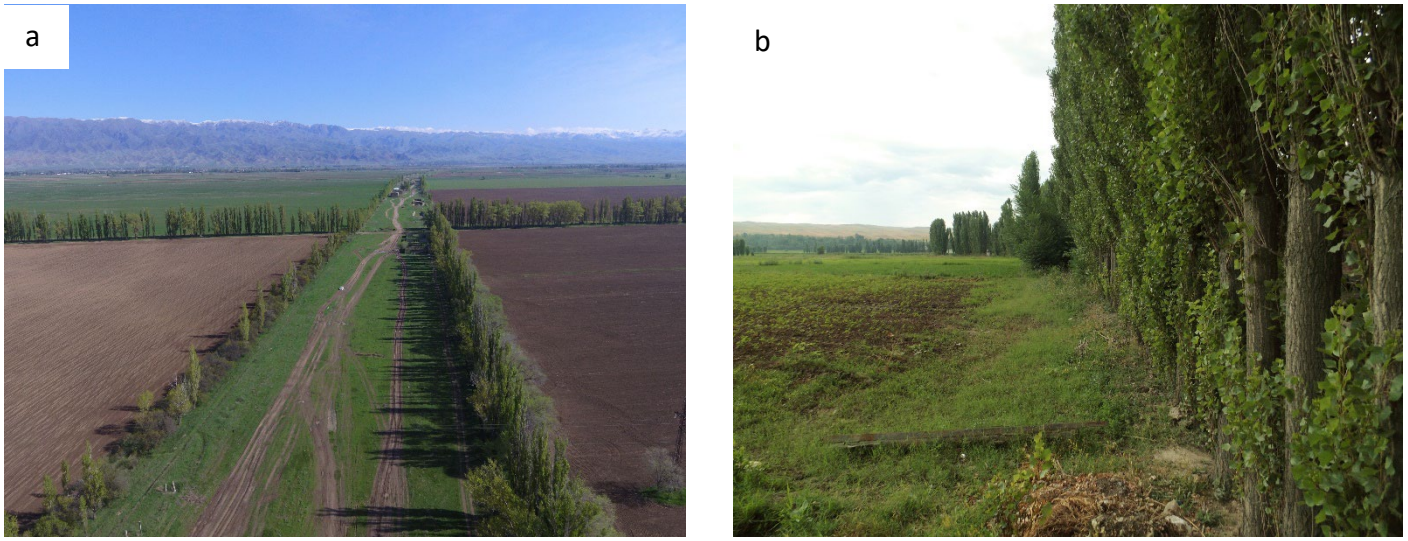


Figure 1. *Populus nigra* (local name Mirza Terek) tree windbreaks in: a) Chui Valley, Kyrgyzstan, and b) Chek Village, Bazarkorgon County, Kyrgyzstan.

Tree windbreaks composed of poplars (*Populus* L.) have long been implemented across Central Asia and are one option for reducing water consumption in irrigated agriculture and building resilience against climate change (Fig. 1). Tree windbreaks also provide wood resources, which make Central Asian countries less dependent on costly wood imports.

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

In a case study on Central Asian agroforestry practices, poplar windbreak systems attained greater overall water efficiency than crops without tree windbreaks. Specifically, the water consumption of cotton (*Gossypium* L.) combined with that of single tree lines from poplar windbreak systems (200 m between tree lines) was 777 mm per growing season, while cotton without tree windbreaks consumed 904 mm per growing season (Fig. 2). This study also assessed the growth rates of 30 poplar cultivars unknown to the region to identify varieties that could increase the yields of wood products from tree windbreaks. Most of the new cultivars tested, particularly *Populus deltoides* Bartr. ex Marsh. × *P. nigra* L. hybrids, grew 2 to 3 times faster than the locally adapted *P. nigra* cultivars. Further, their water consumption was in the same range as that of the locally adapted cultivars.

In conclusion, newly developed poplar cultivars offer potential to increase the yield of wood resources

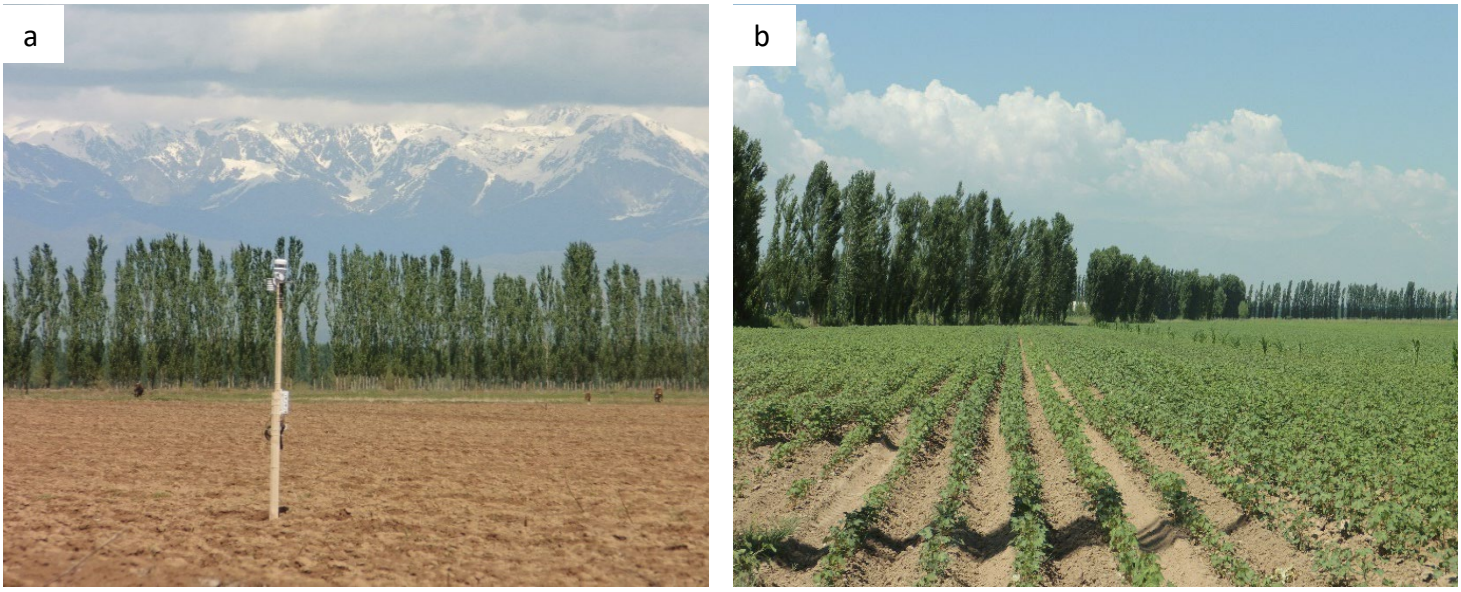


Figure 2. *P. nigra* (Mirza Terek) windbreak systems in Chek Village, Bazarkorgon County, Kyrgyzstan. The climate station in the foreground of a) was installed to record changes of the microclimate due to the windbreak for underplanted cotton seen in b).

to be harvested from tree windbreaks in Central Asia, while simultaneously helping to reduce water consumption of irrigated agriculture.

Keywords: Windbreak systems, water use, microclimate, cotton, *Populus*

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Niels Thevs: niels.thevs@giz.de

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; and Ron Zalesny, WP-ENV Chair

http://www.fao.org/forestry/ipc/en/

A SPECIAL IPC[1] WORKING PARTY ON COMMUNICATION AND OUTREACH (WP-ENV) HIGHLIGHT SERIES:

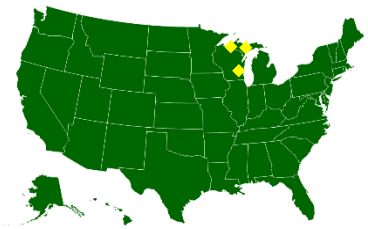
'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Ecosystem Services and Profitability of Agroforestry Phyto Buffers with Cover Crops and Endophytes

June 2023: WP-ENV: #5E

Overview

Industry and conventional agriculture have degraded the soils and waters of the Great Lakes region in the United States of America, which limits social, environmental, and economic progress. These impacts have led to subsequent losses of on-farm profits and, in many cases, a decrease in the quality of life for farmers, ranchers, and growers. There is a need for plant-based systems that enhance ecosystem services of degraded agricultural lands and waters.



United States of America

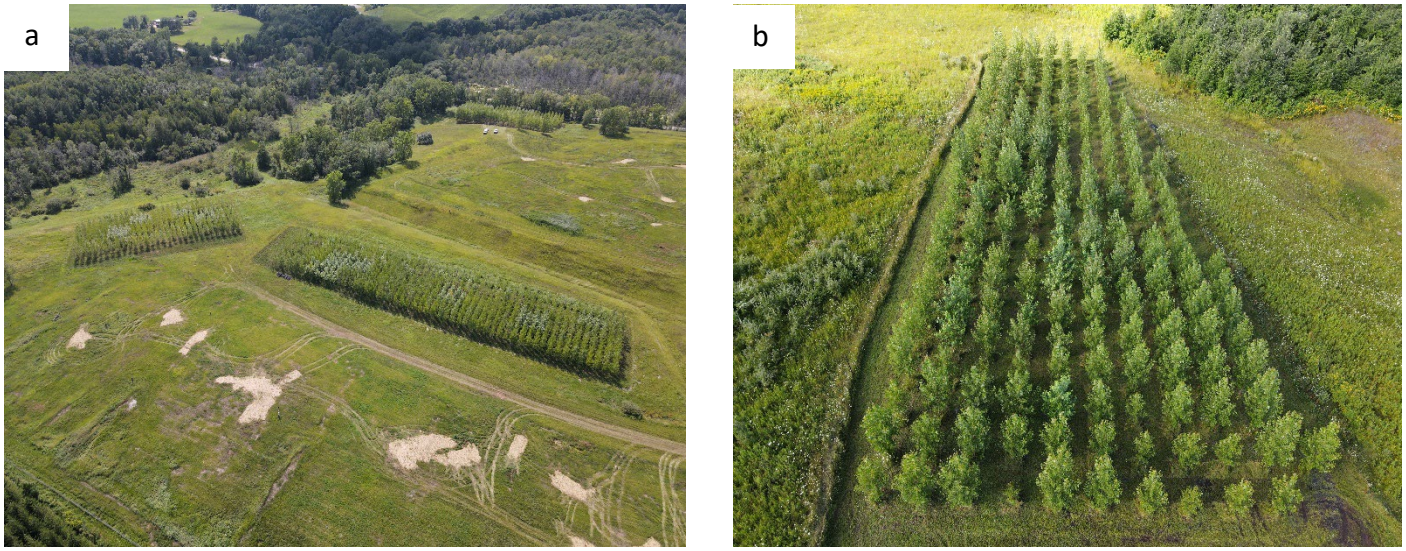


Figure 1. a) Ariel view of two agroforestry phytoremediation buffer systems established at a closed landfill in Wisconsin, USA, and b) close-up overhead view of a poplar agroforestry phytoremediation buffer system established at a closed landfill in Wisconsin, USA.

To address this problem, the Great Lakes Restoration Initiative (GLRI) was established in 2010. One of the GLRI's five main focus areas is Nonpoint Source Pollution Impacts on Nearshore Health, which specifically aims to mitigate pollution of the Great Lakes.

[1]**The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)**

Outcomes

With funding from the GLRI, a regional network of specialized poplar (*Populus* L.) and willow (*Salix* L.) phytotechnology installations was established from 2017 to 2019 on lands contaminated with inorganic and organic pollutants (Figs. 1 and 2). The main objective of the project is to reduce potentially contaminated runoff and subsurface water flow that can impact the ecosystem services on which agriculture depends.

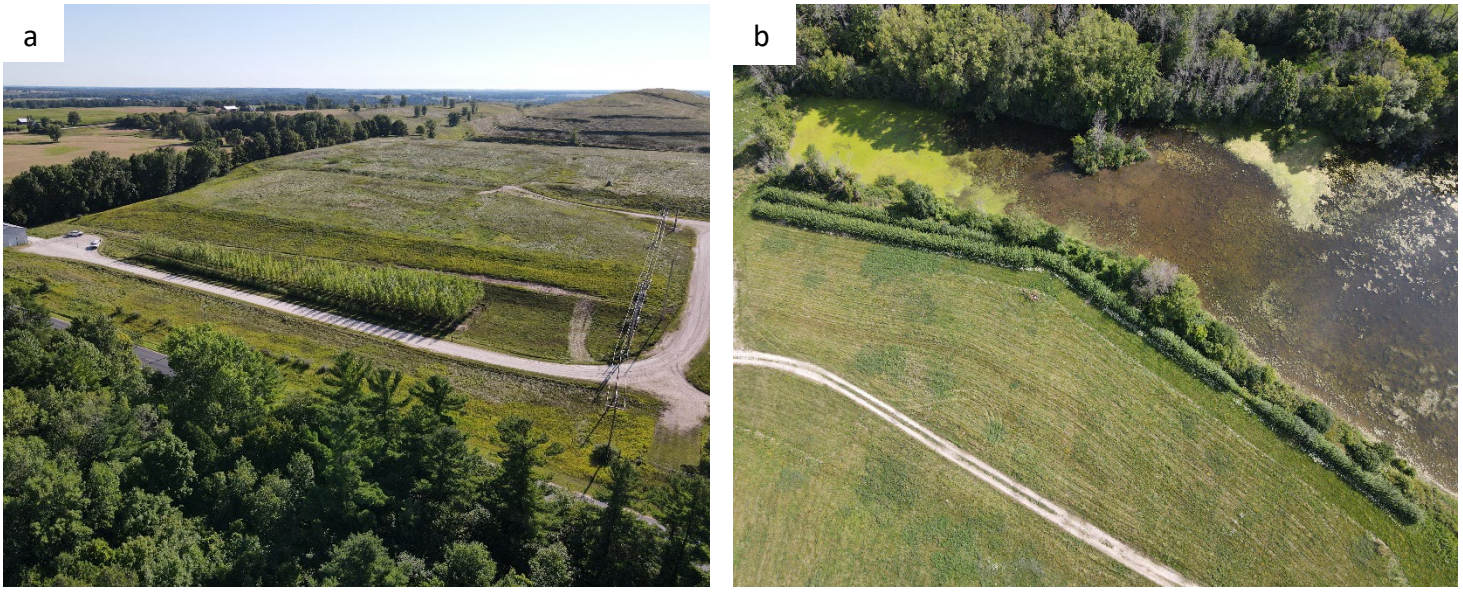


Figure 2. a) Agroforestry phytoremediation buffer system (trees in midground) established adjacent to a closed landfill (midground) and an active landfill (right, background), and b) willow agroforestry phytoremediation buffer system (densely planted trees, midground), established adjacent to a contaminated landfill leachate retention pond (upper midground).

Continuing efforts of this endeavor include the integration of cover crops and soil endophytes with existing trees to establish a replicated research and demonstration network of sixteen agroforestry phyto buffers in the Lake Michigan and Lake Superior watersheds. This project seeks to enhance quality of life, stewardship of ecosystem services, and profitability for regional growers. The efficacy of these systems for implementation in an agricultural setting will be measured specifically as they relate to: 1) reducing health risks from water and soil pollution by developing best management practices, 2) enhancing ecosystem services such as water quality and soil health along with carbon sequestration and biomass productivity of the trees, and 3) decreasing grower costs and increasing land productivity for bioenergy, biofuels, and bioproducts.

Keywords: Phytoremediation, phytotechnologies, *Populus*, *Salix*, cover crops, endophytes

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Ron Zalesny : Ronald.Zalesny@usda.gov

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; and Ron Zalesny, WP-ENV Chair

http://www.fao.org/forestry/ipc/en/

IPC
Highlight #5E

A SPECIAL IPC[1] WORKING PARTY ON COMMUNICATION AND OUTREACH (WP-COM) HIGHLIGHT SERIES:

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Tree Alley Cropping with Novel Hybrid Poplar Clones on Alluvial Soils of Southern Europe

June 2023: WP-ENV: #5F

Overview

The intercropping of crops with poplar trees for timber production was largely practiced in Southern Europe during the twentieth century until the late 1970s. This practice was then almost abandoned because tree canopy spraying for pest/disease control often hindered the management of intercrops. Nowadays, tree alley cropping is again studied for its important environmental and productive values for mitigating climate change and the environmental emergencies of modern agri-monoculture (Figs. 1 and 2).

Italy

Figure 1. *Populus* alley cropping systems in Italy.

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

In Europe, public institutions provide funding for the establishment of tree alley cropping. Particularly, in Italy, new poplar clones are now available that do not require canopy spraying: Maggiore Sostenibilità Ambientale (MSA) clones. A network of three experimental sites was recently established in Italy with the aim of optimizing the tree alley cropping system according to the criteria of modern agriculture. Research is currently in progress; however, the first experimental results of one site (10 ha) established in 2014 are very encouraging in terms of tree growth, intercrop yield, and financial profitability.

Figure 2. *Populus* alley cropping systems in Italy.

Tree rotations are expected to be 10 years. The key element for financial profitability is the final timber quality of the harvested trees. In the context of a modern market economy, the final timber produced should have very high standards for plywood transformation and should be able to fulfill the requirements of the furniture industry. Thus, trees that do not require canopy spraying, and that exhibit fast growth rates and produce high-quality timber, are essential for successful management of tree alley cropping in areas of Southern Europe with intensive agriculture.

Keywords: *Populus*, alley cropping, MSA clones, productivity

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Pierluigi Paris: pierluigi.paris@cnr.it

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; and Ron Zalesny, WP-ENV Chair

http://www.fao.org/forestry/ipc/en/

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Diversifying Traditional Crop Rotations Through On-Farm Planting of Short-Rotation Trees

June 2023: WP-ENV & WP-PRO: #5G

Overview

Environmental degradation due to natural resource exploitation, excessive withdrawal of mineral elements, and substantial application of agrochemicals, is a major consequence of the existing land management strategies in India. There is a need for investments in farming systems to diversify traditional crop rotations. Land managed to include trees and crops, with or without animals, is emerging as a diversification option for farmers. This method, known as agroforestry, is scientifically sound, practically feasible, economically viable, socially acceptable, and ecologically desirable.

India

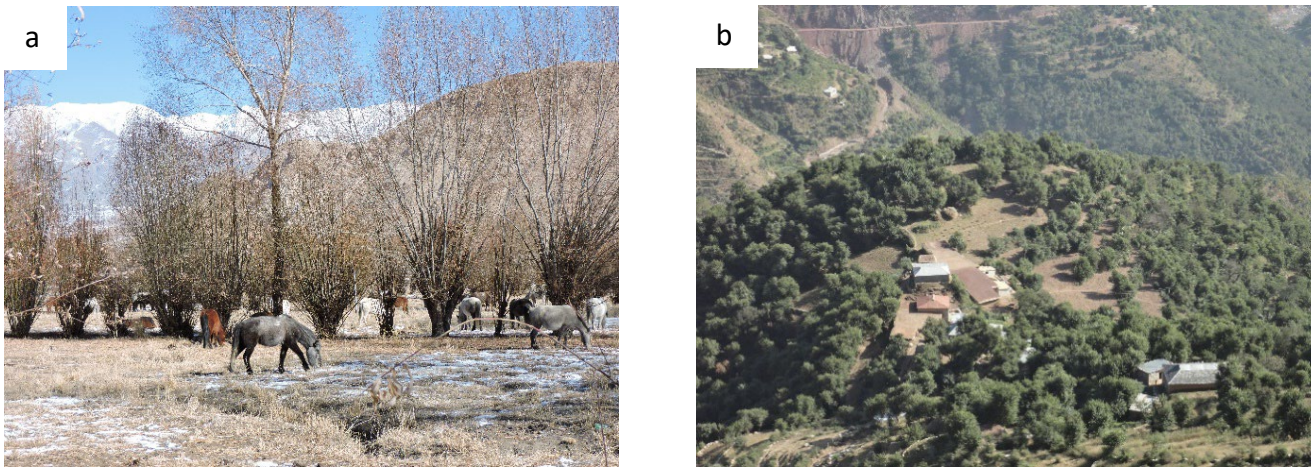


Figure 1. a) Willow-pasture model in the cold, arid region of Ladakh, India and b) a single species (*Grewia optiva* J.R. Drumm.) village fodder block.

Agroforestry is a sustainable alternative to existing land management systems that involve a limited number of crops (e.g., rice, wheat, sugarcane, cotton, vegetables, fruits) and are exhaustive of natural, financial, and human resources. At present, fast-growing trees such as *Populus deltoides* Bartr. ex Marsh., *Eucalyptus* spp., *Melia composita* Cav., *Leucaena leucocephala* (Lam.) de Wit, *Anthocephalaus cadamba* (Roxb.) Bosser, *Casuarina equisetifolia* L., *Gmelina arborea* Roxb., *Salix alba* L., *Ailanthus excelsa* Roxb., and *Tectona grandis* L.f., among other indigenous/exotic species, are meeting approximately 90 percent of domestic and industrial timber demands in India. These productive species indirectly conserve Indian forests by minimizing pressure on traditional forests for timber requirements (Fig. 1).

[1]**The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)**

Outcomes

Poplars and eucalypts have become the most preferred trees for farmlands in northwestern Indian states because of their fast growth and ability to meet industrial demands (e.g., plywood, paper, packaging). Both genera can be harvested within 4 to 6 years, thus creating a highly lucrative business, since a market for their timber is readily available.

Farmers have recently realized the benefits of growing *Melia composita*, *Leucaena leucocephala*, *Anthocephalaus cadamba*, *Casuarina equisetifolia*, *Gmelina arborea*, *Salix alba*, *Tectona grandis*, and bamboo within agroforestry systems. All these species can yield high economic returns if raised intentionally under agroforestry systems, where available solar energy, nutrients, and water are efficiently utilized, and environmental concerns are ameliorated (Fig. 2).

Figure 2. Fast-growing tree genera well-suited for use in Indian agroforestry systems.

Utilizing tree-based agroforestry systems may help India achieve a “green revolution.” The current political and administrative climate in the country is in favor of on-farm trees and may promote increased adoption of agroforestry. For instance, India has a well-defined National Agroforestry Policy which facilitates the adoption of on-farm trees. Further, new socioeconomic policies have brought forestry and agriculture closer than ever to meet the objectives of the United Nations Sustainable Development Goals.

Keywords: Crop diversification, Indian agroforestry, *Populus*, *Eucalyptus*, sustainable agriculture

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Sanjeev Chauhan: chauhanpau@rediffmail.com

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; Ron Zalesny, WP-ENV Chair; and Joris Van Acker, WP-PRO Chair

http://www.fao.org/forestry/ipc/en/

IPC

Highlight #5G

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Integrating Poplar in Rice-Wheat Farms

June 2023: WP-ENV & WP-PRO: #5H

Overview

The rice-wheat crop rotation is an important cropping system in most southeastern Asian countries because of its capability to ensure food security and provide means for livelihood. In India, the Green Revolution helped to increase the production of these two significant crops. However, over time, these crops heavily depleted the nutrient content of soils, contributed to the lowering of water tables, and increased the release of greenhouse gases into the atmosphere.

India

Diversification is perceived as the primary way to save the crumbling agricultural economy and the degraded environment of the original Green Revolution states in India. Agroforestry is a practical and feasible alternative land-use system that can enhance farm incomes and restore degraded natural resources, in addition to sequestering significant amounts of carbon.

Figure 1. a) Poplar boundary surrounding inter-cultivated rice, and b) employment generation through on-farm poplar cultivation.

Indian farmers have integrated fast-growing trees in agroforestry systems, which has been met with substantial market demand. Poplars are one type of fast-growing tree that has caught the attention of farmers due to their deciduous nature, slender crowns, fast growth, high market demand, and ease of cultivation (Fig. 1). Integrating poplars into agroforestry systems also permits the cultivation of agricultural crops, though there are environmental limitations for integrating poplars into wheat-rice paddy rotations. For example, while poplars are water-loving, they are sensitive to waterlogged conditions, and cannot survive in stagnant water. However, rice requires stagnant water for high productivity. Hence, poplar and rice are not a good combination, which has discouraged most small- and medium-farmers from integrating poplars into their farms.

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

Field observations have indicated that poplar-rice cultivation is possible if changes are made to cultivation methods (Fig. 2). For instance, growing poplars along boundaries rather than in blocks is a good option for integrating poplar with rice. A ratio of 1:3 block:boundary plantations of poplar facilitates the combination of poplar and rice. Studies have revealed that almost 64 percent of rice yield can be harvested when bordered by six-year-old poplar trees.

Figure 2. Major components of poplar-rice agroforestry systems in India.

Farmers can also plant poplars in blocks integrated with rice, provided the trees are grown on raised beds at wider row-to-row spacing that prevents poplar root systems from being immersed in stagnant water. Stagnant water not only negatively affects poplar root systems, but also causes the trees to tip over. Poplars can be integrated with rice within block plantations on raised beds at regular spacings, but only for an initial two years, with around 70 to 75 percent crop yield.

Direct seeding is the third option for cultivating rice in farms with poplar trees. This method requires 37 to 40 percent less water than transplanted rice. Direct seeding of rice is labor efficient, often yielding ± 5 to 6 percent yield versus transplanted rice.

Keywords: Indian agroforestry, poplar-rice cultivation, fast-growing trees

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Sanjeev Chauhan: chauhanpau@rediffmail.com

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; Ron Zalesny, WP-ENV Chair; and Joris Van Acker, WP-PRO Chair

http://www.fao.org/forestry/ipc/en/

IPC

Highlight #5H

'GLOBAL APPLICATIONS OF FAST-GROWING TREES IN AGROFORESTRY SYSTEMS'

Stabilizing Root Systems of Poplar Trees in Agroforestry Systems

June 2023: WP-ENV & WP-PRO: #5I

Overview

In agroforestry, food crops and timber trees are integrated on the same land area without compromising yield and/or degrading natural resources. In the northwestern states of India, poplars (*Populus deltoides* Bartr. ex Marsh.) have become favorite trees among agroforestry adopters. Poplars improve timber supply and provide additional income, including through employment of rural poor.

India

Though poplar trees have successfully been integrated into Indian farms (Fig. 1), their shallow root systems compete with inter-cultivated agricultural crops for nutrients and moisture. Poplars propagated through cuttings prominently develop adventitious root systems, but these roots tend to grow profusely in the upper soil horizon, thereby competing with agricultural crops, and leading to reduced crop yield.

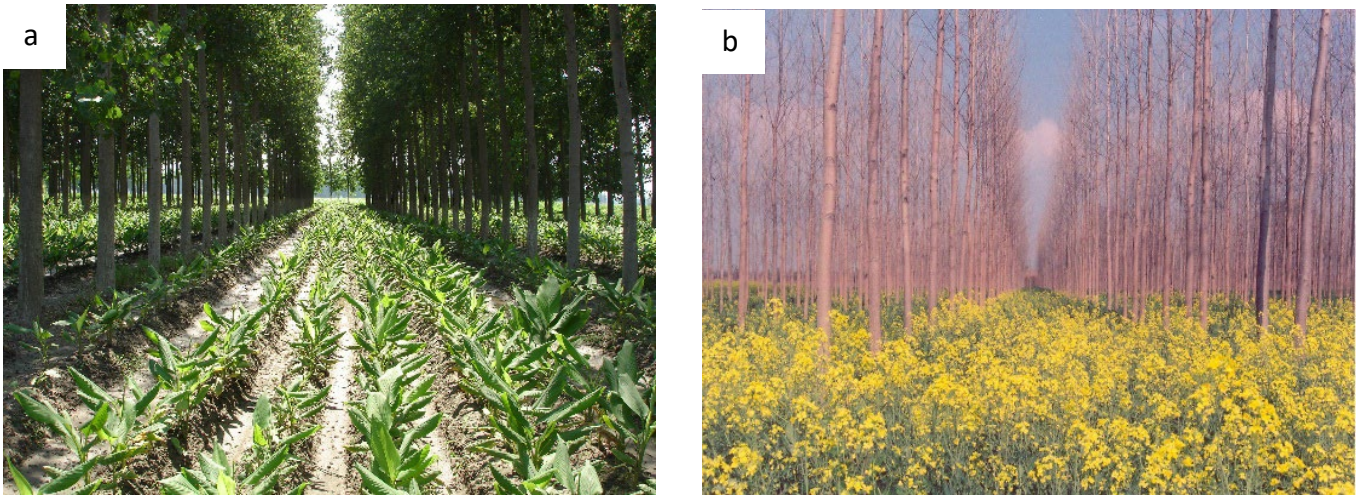


Figure 1. Remunerative poplar-based agroforestry models: a) poplar-turmeric model, and b) poplar-marigold model.

There is a need for methods to minimize root competition between poplars and annual crops in agroforestry systems. One option is to dig trenches on both sides of the tree rows, however, this limits mechanical cultivation and restricts total workable area in agroforestry plots. Another option is to implement polyethylene sheets on both sides of the tree rows, or around the trees at a distance of 1 m, to restrict tree roots from extending horizontally.

[1]The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

Outcomes

In field trials, 1 m^3 pits lined with polyethylene sheets led to the development of fibrous root systems, as compared to the thick roots produced in 1-m^3 pits without polyethylene lining (Fig. 2). During the first year, the polyethylene sheets prevented poplar roots from extending beyond the sheet lining. In pits with polyethylene sheets, fibrous roots were common, and the direction of root growth was restricted as they circled along the polyethylene sheet.

Figure 2. *Populus deltoides* root systems and the effects of polyethylene lining on *Populus* root architecture.

Plants with smaller-diameter roots tend to have greater physiological capacity for resource uptake and greater ability to respond to changes in their resource environment than those with larger-diameter roots. This results in enhanced growth and biomass production for plants with smaller-diameter roots. In light soils, poplars grown in 1-m^3 pits produced 53 percent more aboveground biomass than those grown in traditional auger holes (20-cm diameter and 1-m deep). However, growing poplar trees in 1-m^3 pits on light soils poses the risk of eventual uprooting of the trees. The shallow root system in these pits would not be able to support the trees against strong winds as the crowns get heavier.

A good knowledge of belowground interactions between trees and agricultural crops is needed to properly manage these components and maximize the benefits from tree-crop combinations. Studies on root architecture are also essential to guide farmers in selecting the correct method of planting to avoid competition with inter-cultivated crops. Inserting polyethylene sheets around planting pits plays a critical role in redirecting horizontal tree roots downward to source nutrients from lower soil horizons instead of top layers, thereby minimizing competition with inter-cultivated agricultural crops, and providing stability against strong winds for the poplar trees.

Keywords: *Populus*, root competition, root architecture, root management

For more information on the IPC please contact the **IPC Secretariat**:
IPC-Secretariat@fao.org **or Barb Thomas, WP-COM Chair:** bthomas@ualberta.ca

For more information on this case study please contact:
Sanjeev Chauhan: chauhanpau@rediffmail.com

This Case Study was edited by Liz Rogers, WP-ENV Co-Chair; Ryan Vinhal, WP-ENV Co-Chair; Jan Weger, WP-ENV Co-Chair; Ron Zalesny, WP-ENV Chair; and Joris Van Acker, WP-PRO Chair

http://www.fao.org/forestry/ipc/en/

IPC

Highlight #5l