
THE POTENTIALS AND LIMITATIONS OF AGROFORESTRY FOR IMPROVING LIVESTOCK PRODUCTION AND SOIL FERTILITY IN POTHWAR

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ABSTRACT

Drawing upon a wealth of research information available for the pothwar area the potential and limitations of agroforestry for improving animal production and soil fertility are discussed. Agroforestry is reputed to incorporate essential components of sustainability and self-sufficiency into some agricultural systems. Evidence is given that agroforestry, by providing shade in pastoral systems, thereby reduces heat stress in livestock and increases animal performance and overall productivity. A wide range of agroforestry trees provide forage with high crude protein and low fibre contents, making them a source of home-grown and cheaply available supplement for poor quality roughage feedstuffs such as cereal crop residues. Evidence is presented that browsing on such trees improves feed intake, animal performance and overall utilization efficiency of poor quality roughage.

Due to the inherent low soil fertility of major areas of the pothwar and to the rapidly increasing population pressures, systems of agricultural production that combine the use of leguminous shrubs and trees to recycle nutrients of importance are discussed. Evidence is given that several agroforestry technologies, can improve fertility and sustain crop yields.

INTRODUCTION

Agricultural production in Pothwar involves an integration of crop and livestock

production. Logically this involves pasture and forage production on the lands which are marginal for cropping, and crop production on higher potential land. Cultivation of agricultural crops in an intimate combination with trees and other woody vegetation has been practiced in the area for a very long time. The importance of tree cover for ecological and economic sustainability of food production has been discerned since early times. What is now termed as 'agroforestry', is integrated cultivation of woody perennial, crops and animals on the same unit of land, in some form of spatial mixture and temporal sequence. Agroforestry is an activity that can enhance the production of both the crop and livestock subsystems. It can incorporate essential components of sustainability and self-sufficiency into the whole agricultural system. This can be achieved by providing multiple products such as fuelwood and charcoal, timber for construction, food, medicine, tan stuffs, dyes, shade and shelter, by prevention of soil erosion and increase in soil fertility and provision of forage for livestock. This review will attempt to highlight the potential and limitations of agroforestry in improving soil fertility and livestock production in the Pothwar areas to do this effectively, the experiences of the research together with available information from elsewhere are used.

POTHWAR PLATEAU

This is large plain area spread over 130 kilometers north-south, by 192 kilometers east west, lying north of Salt Range and between the

Jhelum and Indus rivers. The parent material of the tract is loess with few ridges and troughs scattered in the area. The soil of the area is mainly medium textured with a fair proportion of clayey soils. There is great variations in soil depth, slope and susceptibility to erosion.

According to Punjab Barani Commission Report (1976), out of the total area of 1.82 m.h., only 0.61 m.h. are cultivated whereas, the remaining land is used for rough grazing. About two third of the cultivated area is moderately good agricultural land and remaining 1/3 is poor agricultural land. The average annual rainfall varies from 1500 mm at the south-east corner and drops to 375 mm or less in the south-west. Monsoon rains are dominant in the east.

Out of total area 0.67 m.h. receives rainfall of more than 750 mm, 0.84 m.h. between 375-750 mm and approximately 0.26 m.h. get rainfall less than 375 mm. The winter minimum temperature drop below freezing point some time. The incidence of frost occur but is not uniform.

PROBLEMS OF POTHWAR AREA

The important problems of the area can be broadly classified into physical, biological and soil. The physical problems include constraints related to poor management and use of available land and water resources of the area. Low and erratic rainfall, erosion hazard and inadequate soil depth are the main limitations adversely affecting and potential of the cultivated area. These limitations are severe in case of poor agricultural land as compared to those in moderate agricultural land. They are more severe in 1.21 m.h. of uncultivated area which restricts to its use.

The major problems of the Pothwar area are outlined as under:

- Climate is highly variable, Rainfall and at times, temperature are unfavourable for vigorous and continuous plant growth.
- Soils are often infertile and suffer from widespread deficiencies of nitrogen and phosphorus and sometimes other major and trace nutrients.
- Soil erosion is widespread because rainfall intensity is high, and soils are often poorly structured and hence highly erodible. Erosion of the top fertile soil in the cultivated area is common.
- Formation and deepening of gullies; The Punjab Barani Commission has reported (1976) that about 5000 hectare of different types of cultivated land is eaten away by erosion every year.
- Loss of surface run-off: According to an estimate by PARC (1980), about 50 percent of the total rainfall is lost from agricultural lands due to surface run-off.
- Poor management and conservation of rain water.
- Ineffective and uneconomical use of gullied lands (60 percent of the total area) being used for grazing.
- Siltation of water reservoirs and nullah-beds.
- Forage for the grazing animals is generally of low quality, particularly during the long dry seasons

Farmers are often poorly educated and, in some regards, relatively unsophisticated.

Processes by which trees maintain or improve soils Processes which augment additions to the soil:

Soil Fertility Situation in Pothwar

Generally, soil are poor and low in inherent fertility due to the poor nature of parent material. Pressure on land resulting from an increasing human and livestock population has resulted in longer cropping and shorter fallow periods because soils are not given time to regain their fertility, there is a general decline in crop yields, which has made the traditional methods of restoring fertility either inappropriate or unsustainable.

Importance of Agroforestry

Nutrient pumping is cited as one of the potential benefits of trees in agroforestry systems; trees have deep root systems which absorb nutrients from the subsoil and deposit them in or on the surface soil via above and below ground biomass production, decomposition of pruning of leaves and branches, or indirectly through the deposition from manure of browsing livestock (Nair 1984; Young 1989). This assumes that the translocation of nutrients to superficial soil horizons by trees can increase the amount of nutrients available to shallow-rooted vegetation and crops and improve overall productivity of the agricultural system.

Small-scale farmers who, until the present days, relied on subsidized inorganic fertilizers to produce crops could make use of agroforestry technology for soil improvement which have shown potential in overcoming low soil fertility and increasing crop yield with reduced or no inorganic fertilizer input.

- * maintenance or increase of soil organic matter through carbon fixation in photosynthesis and its transfer via litter and root decay.
- * nitrogen fixation by some leguminous and a few non-leguminous trees.
- * nutrient uptake: the taking up of nutrients released by rock weathering in deeper layers of the soil.
- * atmospheric input: the provision by trees of favorable conditions for input of nutrients by rainfall and dust, including via throughfall and stemflow
- * exudation of growth-promoting substances by the rhizosphere.

Processes which reduce losses from the soil:

- * protection from erosion and thereby from loss of organic matter and nutrients
- * nutrient retrieval: trapping and recycling nutrients which would otherwise be lost by leaching including through the action of mycorrhizal systems associated with tree roots and through root exudation.

Processes which affect soil physical conditions:

- * maintenance or improvement of soil physical properties (structure, porosity, moisture retention capacity and permeability) through a combination of maintenance of organic matter and effects of roots.
- * modification of extremes of soil temperature through a combination of shading by canopy and litter cover.
- * breaking up of compact or indurated layers by roots.

Processes which affect soil chemical conditions:

- * reduction of acidity, through addition of bases in tree litter
- * reduction of salinity or sodicity.

Soil biological processes and effects:

- * production of a range of different qualities of plant litter through supply of a mixture of woody and herbaceous material, including root residues
- * effects upon soil fauna
- * transfer or assimilate between root systems

Properties that make a tree or shrub suitable for soil-fertility maintenance or improvement are:

- * a high above-ground biomass production
- * a high rate of nitrogen fixation
- * a dense network of fine roots, either with abundant feeder roots of a capacity for mycorrhizal association.
- * the existence of some deep roots
- * a moderate to high balanced, nutrient content in the foliage.
- * an appreciable nutrient content in the root system
- * either rapid litter decay, where nutrient release is desired, or a moderate rate of litter decay, where soil cover for protection against erosion is desired
- * absence of toxic substances in the foliage or root exudates
- * for soil reclamation or restoration, a capacity to grow on poor soils

After screening the species to suit the agro-climatic conditions, the principal of right species at right site should be adhered to.

COMMONLY USED AGROFORESTRY SYSTEMS AND PRACTICES IN POTHWAR

Following broad categories of agroforestry systems and practices are generally recognized.

Agrosilviculture

Trees and agricultural crops

Silvipastoral

Trees, pasture and animals

Agrosilvipastoral

Trees, crops, pasture and animals

Sustained production of food, fodder, fuelwood etc, is the important function of all agroforestry systems. Protective functions may include soil and moisture conservation, soil improvement or shade for crops, animals and man. All agroforestry systems have both productive and protective functions and based on the relative dominance of one of these two roles, a system can be termed as a productive or protective one.

Agrosilviculture Systems

Some examples of common agrosilviculture systems and practices followed in pothwar area are described below.

Multipurpose trees on farmlands

Fruit trees and other multipurpose fast growing trees are planted scattered on the agricultural lands. As an example, *Acacia nilotica*, *Albizzia lebbek*, *Tamarix aphylla*, *Melia azedarach*, *Zizyphus mauritiana*, *Dalbergia sissoo*,

Eucalyptus camaldulensis, *Cordia dichotoma* are the common tree species found on the farmlands in the area.

Shelterbelts and Windbreaks

Shelterbelts and windbreaks around some farmlands are established. Trees in the form of windbreak and/shelterbelts can reduce the damage to crops and orchards, caused by the effects of extremes temperatures, cold, hot and desiccating winds, and sand storms. Reducing evaporation, ameliorating the microclimate, protecting the crops against storms, providing shade, shelter and tree products to the people and their livestock. Fast growing tree like *Tamarix aphylla*, *Eucalyptus camaldulensis*, *Acacia nilotica* var. *Cupressiformis* etc, are grown for this and other purposes (e.g. fuelwood, timber) in this area.

Block Plantations

Some progressive farmers having large piece of land under their control have established block plantations of *Acacia nilotica*, *Eucalyptus camaldulensis* for commercial purposes usually on the lands which are marginal for cropping. In areas where land is not fit for agriculture or where block plantations can not be established due to some or the other reasons natural vegetation is retained and protected for production of firewood and for grazing of animals.

Silvipastoral Systems

These systems are generally practiced, primarily for increased supply of green fodder, especially in the dry season. Fast growing leguminous and other fodder trees and shrubs are grown on croplands and pastures as protein banks. Commonly grown species are *Albizzia*

lebbek, Cordia dichotoma, Zizyphus mauritiana, Acacia nilotica, Melia azedarach etc.

Agrosilvipastoral Systems

These system include "Homegardens" in which trees are usually planted near the homesteads mainly for shade both for man and livestock. In addition to this trees grown provide fuelwood, fodder, fruit, timber. Tree planted in homegardens generally include *Zizyphus mauritiana, Cordia dichotoma, Melia azedrach, Citrus* spp., Guava etc.

Constraints in Promoting Agroforestry

The important implications in adopting agroforestry systems are:

Land tenure systems

The land tenure system has evolved over a period of more than a century and a half under the influence of changing social and political circumstances. From the legal point of view, three broad categories of land tenure systems can be distinguished. These are; Landlord system, Peasant proprietorship system and the so-called Riyatwari system.

As result of the different land tenure systems, three classes of people have emerged viz. non-cultivating owners; cultivating owners; and non-owner cultivators. The non-cultivating owners are usually the land lords. They often live in the big cities, leaving the management of their land to their agents. The agents of the landlord select the tenants to cultivate the land. With the modern machinery and technology available, the landlord's interest in the productivity of land has grown and they have started reinvesting in land. Their tenants,

however, keep on living a miserable and poverty stricken life, just managing to survive.

The cultivating owners constitute the progressive farmer class. The land and the produce from the land both belong to them. They are most willing to adopt the modern technology to increase the production of their farms.

The class of non-owner cultivators is composed of tenants who have nothing at stake in the productivity of land as the land and the product which they till, does not belong to them.

Fragmentation of farms

Fragmentation of farms into two or more separated holdings. Fragmentation is a result of social laws of inheritance and acquisition through marriage. Fragmentation inhibits the efficiency of farming operations. Fragmented land holdings are contra-productive and a hurdle in implementing agroforestry programs.

The implications of the land tenure system for agroforestry are quite clear. About 3/4th of the farmers who own subsistence holdings, lack the means for participating in the programme. They cannot afford to spare land for growing trees. Especially, the subsistence tenant farmers who have to share produce with the owner cannot be expected to show any interest in the plantation programme. Usually the trees belong to the owners and not to the cultivators. So it would be rather optimistic to expect a favorable response from this class of farmers.

The medium farmers who own land in excess of the subsistence holding, have the means to participate in the programme, but a

lot of effort would be needed to convince and motivate them to invest in trees which obviously take a long time to mature.

The landlords have enough land and water to spare for tree growing. They are now reasonably convinced of the economic returns from trees and their demand for planting stock is increasing.

Economics of MPTS

There are many useful species which can be incorporated in agroforestry systems to boost the income of the farmers. However, neither the data on economics of such species nor the silvicultural practices to optimize the production, are available in the field. Even with some stray data, farmers are not motivated to take initiative to plant those species because of the weak market outlets in rural areas which are disorganized and controlled by exploiting middlemen.

Marketing Infrastructure

Very little work has been done so far to handle the forestry produce, generated by the farmers. Although there is shortage of fuelwood in the country, farmers producing fuelwood are not able to sell it at remunerative prices. Due to the bulky nature, markets far away from the production sites, middleman at several intermediate level of distribution, fuel wood growers are exploited.

Infrastructure to support Agroforestry

Selection of superior germplasm, availability of good quality seedlings, whenever necessary technical advisory services are presently lacking or not sufficient to support the agroforestry in the field.

Protection from Stray Animals

In most of the Pothwar tract farmers let their livestock graze free after the crops are harvested. Under such conditions maintaining the saplings during the first few years, is difficult and expensive.

Livestock Production in Pothwar

Pothwar has broadly two types of livestock production. The first involves extensive use of land, i.e. low human and livestock density. This type of system is common in the agropastoral and pastoral areas, where rainfall pattern preclude reliable cropping and limit the support capacity of land for both people and live stock.

The other system of livestock production, also extensive, exists in the higher potential areas along with mixed farming systems where overall land use is intensified, increasing population pressure. In this system the livestock sub-sector is used to increase the overall output of land through exploitation of the synergism between cropping and livestock sub-sectors through soil nutrient enhancement from livestock and improved soil tillage through animal traction. However, while overall land use becomes more intensified, livestock management and feeding strategies remain extensive. Livestock continue to rely on natural pastures, plus crop residues for dry season feed; external feed inputs are applied strategically to increase productivity at certain times. For instance, in milking animals and to improve the work output of traction oxen, supplementary feed is provided when demands for tillage and transport are high i.e. early in the crop growing season and during or after crop harvests and also in milking animals.

Benefits of trees for livestock

Shade

In traditional livestock production systems, animals crowd the shade of trees during hot sunny weather and some trees in pastoral systems are browsed (Cameron et al. 1991). It is reported from work in the Australian tropics that high temperatures can induce conception failure, abortion in pregnant ewes and reduced lamb birth weight (Roberts 1984).

Young calves, and pregnant and lactating cows are more susceptible to heat stress than other cattle, but all classes of animals grazing for a greater part of the day made greater weight gains in paddocks with shade than those without (Daly 1984). Shade significantly increased milk yield of dairy cows from 17.2 to 19.2 kg/cow/day in Australian tropics (Davidson et al. 1988).

Leguminous and non-leguminous trees for browse

Historically, the use of leguminous and non-leguminous fodder trees in the Pothwar tract has been confined to lopping of the species for feeding of the livestock during the drought season. Many species have value in this role; *Zizyphus mauritiana*, *Acacia nilotica*, *Acacia modesta*, *Tecomella undulata*, *Albizia lebbek*, *Chordia dichotoma*, *Ficus religiosa* etc. Major fodder trees and shrub species are shown in Table 1. A majority probably have high nutritive values as suggested by the data in Table 2. Among the exotic species *Leucaena leucocephala* is becoming gradually popular. Use of leguminous trees and shrubs is particularly appropriate where feed is carried to the tethered animals, a common practice in the area during the crop growing season.

Table 1. Dry matter (g/kg) and chemical composition (g/kg DM) of local browse (leaves and tender stem)

Species	As % of Dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P
<i>Acacia nilotica</i>	-	12.9	11.3	6.4	12.6	56.8	1.14	0.18
<i>Acacia modesta</i>	42.5	10.4	28.7	8.2	-	46.4	-	-
<i>Acacia senegal</i>	88.4	18.2	11.2	8.4	6.7	55.5	1.32	0.14
<i>Albizia lebbek</i>	31.7	22.0	26.5	7.0	10.0	34.5	1.84	0.20
<i>Bauhinia variegata</i>	35.9	18.5	10.5	10.0	9.0	52.0	1.73	0.16
<i>Cordia dichotoma</i>	36.8	10.1	19.2	16.5	7.4	46.8	2.53	0.18
<i>Ficus religiosa</i>	50.5	11.7	26.1	15.3	2.9	44.0	3.69	0.27
<i>Grewia optiva</i>	-	16.4	16.6	14.9	8.4	43.7	3.57	0.25
<i>L. leucocephala</i>	31.6	27.8	10.4	3.5	3.2	55.1	0.54	0.29
<i>Melia azedarach</i>	30.1	21.8	11.6	10.8	8.8	47.0	2.31	0.22
<i>Moringa oleifera</i>	-	15.6	17.9	13.4	4.4	48.7	3.22	0.27
<i>Morus alba</i>	-	15.0	15.3	14.3	7.4	48.0	2.42	0.24
<i>Syzygium cuminii</i>	37.1	7.9	20.7	7.0	2.6	61.8	1.38	0.12
<i>Zizyphus jujuba</i>	-	8.6	30.1	10.8	1.7	48.8	2.16	0.23
<i>Zizyphus nummularia</i>	-	1.5	33.8	6.2	1.6	46.9	1.90	0.31

Table 2. Nitrogen-fixing trees and shrubs legumes for forage (by family, genera and species

Mimossoideae	No. species	Papilionoid eae	No. species	Caesalpinoideae	No. species
<i>Acacia</i>	4	<i>Sesbania</i>	3	<i>Bauhinia</i>	2
<i>Albizzia</i>	2	<i>Cajanus</i>	1	<i>Parkinsonia</i>	1
<i>Leucaena</i>	1	<i>Pongamia</i>	1	<i>Erythrina</i>	1
<i>Pithecolobium</i>	1	<i>Butea</i>	1	<i>Cassia</i>	1
<i>Prosopis</i>	3	<i>Gleditschia</i>	1		

CONCLUSION

There is great potential of agroforestry for improving livestock production and soil fertility in pothwar area. But there is a great need to substantially increase multipurpose fast growing trees and shrubs on the farmlands. This can only be done through involvement of farming community as no substantial increase in the tree wealth of the country can be expected if planting remain confined to the government lands only. The farming community should be made to realize through various means that trees are essential for the preservation, protection and production of not only the crops and livestock but also the land itself.

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