GROWING *SESBANIA ACULEATA* AS A WOODY RAW MATERIAL FOR MEDIUM DENSITY FIBERBOARD (MDF) – THE PAKISTAN EXPERIENCE

Hashim Md Noor, Ahmad Zuhaidi Yahya, Zaki Abdullah and Mohd Nor Yusof
Forest Research Institute Malaysia (FRIM), Kepong, 52109 Selangor
hashimn@frim.gov.my
&
Salim Ayob
Al-Noor MDF, Noor Jahania, Taluka Moro District, Naushahro Feroz, Sindh, Pakistan

Abstract

Diminishing supply of wood for the board industry in Pakistan has prompted an MDF company (Al NOOR MDF) to utilise locally abundant agricultural residues, such as wheat straw, rice husk, bagass, cotton stalks, etc., in combination with woody materials obtained from longer rotation plantation tree species (e.g. poplar, mango, eucalypt etc.). However, the quality of the board produced was inferior and below the product standard. In order to overcome this drawback, a leguminous tree species known as Sesbania (*Sesbania aculeata*) has been proposed to be used. After rigorous trials, the company was convinced that Sesbania is the right species capable of solving the raw material problem. Consequently, Al-Noor MDF has succeeded in convincing major landowners in Sindh to participate in the Sesbania planting, with a total area of 500 acres of farm land being established with this species. The company is planning to expand its MDF production line in the near future. This legume species is a fast growing tree that grows up to 8 m in height and can be harvested within 18-24 months after planting, yielding about 45-50 tons of stemwood per acre. It can be grown on various site conditions and tolerates poor, waterlogged and saline soils. As legume the species can fix nitrogen biologically through a symbiotic association with rhizobium bacteria, and enables it to thrive on nitrogen deficient soils. In August 2008, FRIM has been invited by Al-Noor MDF to visit some of the Sesbania plantations in Sindh and to formulate R&D programme to improve the productivity and quality of planted Sesbania, in view of increasing the raw material production. This paper highlights the cultivation techniques of Sesbania and the problems and challenges encountered during the establishment this lesser known woody species, as a profitable alternative crop, in Sindh, Pakistan.

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INTRODUCTION

Geographically, Pakistan lies between 24^{o} and 37^{o} N latitude and 61^{o} and 75^{o} E longitude. It is bordered by China in the north, Arabian Sea in the south, Iran in the west, Afghanistan in the north-west and India in the east. The land area of Pakistan is about 796,096 sq. km and an estimated population of 145 million, having a population density of 168 persons per sq. km. It is a federation of four provinces: NWFP (74,521 km^2), Punjab (205,344 km^2), Sindh (140,914 km^2), Balochistan (347,190 km^2), and FATA (Federally Administered Tribal Areas, 27,220 km^2), with its capital at Islamabad.

The Province of Sindh, with a total land area of 14.1 million ha is located between 23°40' to 28° 30'N and 66°40′ to 71°, 30 E. The region experiences a sub-tropical climate. Some 65% of the land area is rangeland and non-rice-based systems predominate (85–90%) in the cropping areas. Irrigated agriculture is important except in the Thar Desert, Cholistan and those areas inundated by the Indus River.

AGRICULTURAL SECTOR

Agriculture is the largest income generating sector in Pakistan, accounting for 35 to 40% of national income and employing more than 45% of total labour force. It provides food, feed and raw materials for industries such as textiles, sugar and several other small- and medium-scale industries (SMI). The major problems associated with agriculture are scarcity of water, floods, waterlogging, salinity, alkalinity, soil erosion, low yield per unit area and traditional cultivation methods (Government of Pakistan 1993).

In the early 1990s, irrigation from the Indus River and its tributaries constituted the world's largest contiguous irrigation system, capable of watering over 16 million hectares. The system includes three major storage reservoirs and numerous barrages, headworks, canals, and distribution channels. The total length of the canal system exceeds 58,000 kilometers; there are an additional 1.6 million kilometers of farm and field ditches.

The irrigation system represents a significant engineering achievement and provides water to the fields that account for 90 percent of agricultural production. Water management is based largely on objectives and operational procedures dating back many decades and is often inflexible and unsuitable to current needs for greater water use efficiency and high crop yields. Charges for water use is low and do not meet operational and maintenance costs. Partly, due to its low cost, water is often wasted by farmers.

The soils are mainly loams with texture varying from sandy to clay. Most of the farms are less than 5.0 ha in size; wheat, rice and maize are the main food crops and groundnuts, cotton, sugarcane, banana and melons the main cash crops (Government of Pakistan 1993, Rasheed 1999). The continuous expansion of the irrigation system over the past century significantly altered the hydrological balance of the Indus River basin. Water table is now found to be within about three meters of the surface in more than one-half the cropped area in Sindh and more than one-third the area in Punjab. In some locations, the water table is much closer to the surface. Cropping is seriously affected over a wide area by poor drainage—*waterlogging* - and by accumulated salts in the soil.

AGRICULTURAL CROPS

In Pakistan, 13 percent of the irrigated area is reportedly suffering from severe salinity problems in spite of the efforts made to provide drainage in irrigated areas. At country level, 6.3 million ha of area is affected with salinity (Muhammad 1996). These salt affected soils are causing potential reduction in crop yield. Salinity problems persist because of deficiencies in water policies and the low priority attached to the allocation of resources for the operation and maintenance of drainage facilities. In majority of the soils of plains in Pakistan, higher evapo-transpiration than the annual precipitation and limited leaching of salts resulting in build up of salts in the soil profile and their accumulation on the soil surface (Khan 1993, Muhammad 1983). Both irrigated and rainfed agriculture systems are practiced. The primary source of irrigation is from an extensive canal system (70%) with the remaining 30% from tube-wells and wells. The Indus River Basin provides most of the water for canal irrigation and is the largest contiguous irrigation system in the world. However, shortage of water is still prevailed in many parts of the country. Water shortage is the most serious for the provinces of Punjab and Sindh, where ground water is of hazardous quality and about 75-80% of extracted ground water is unsafe for irrigation without amendments (Ahmad 1993).

The major food crops growing in Pakistan are rice, sugarcane, wheat, gram, maize, accounting for 35.9% of agricultural value added crops. Wheat is by far the most important crop in Pakistan and is the staple food for the majority of the population. In 2005, Pakistan produced 21,591,400 metric tons of wheat, more than all of Africa (20,304,585 metric tons). Rice yields also have increased sharply since the 1960s following the introduction of new varieties. Nonetheless, the yield per hectare was around 1.5 tons. Pakistan has emphasized the production of rice in order to increase exports to the Middle East and therefore concentrates on the high-quality basmati variety, although other grades also are exported. Area under cotton crop has declined by 10.3%. Other important food grains are barley, millet, sorghum, corn, and barley. Corn, although a minor crop, gradually increased in area and production after independence, partly at the expense of other minor food grains. Chickpeas, onion, groundnut, mungbean, and lentil are the main non-grain food crop in area and production.

Cotton was the most important commercial crop. The area planted in cotton increased from 1.1 million hectares in 1950 to 2.1 million hectares in 1981 and 3.02 million hectares in 2005 (Ahmad 2007). Yields increased substantially in the 1980s, partly as a result of the use of pesticides and the introduction of a new high-yielding variety of seed. During the 2000-2005, cotton yields increased to above the world average (557 kg/ha). In order the meet the future agriculture requirement, Pakistan farmers need to change their crop varieties, with high yielding, drought and salt resistant with better nutrition value. Government should encourage the replacement of field crops with horticulture and fiber crops for export. Educating farmers in new technologies requires involvement of private sector in agriculture, education, extension and research activities.

SESBANIA SPECIES AS A NEW CROP

The diminishing supply of wood for the board industry in Pakistan has prompted an MDF company (Al NOOR MDF) to utilise agricultural residues, such as wheat straw, rice straw, cotton

stalks, etc., in combination with woody materials obtained from longer rotation plantation tree species (e.g. poplar, mango, eucalypt etc.). However, the quality of the board produced was rather inferior and below the industrial standard. In order to overcome this pressing problem, wood of a leguminous tree found wild in Punjab and known as Sesbania (*Sesbania aculeata*) has been proposed to be tested. After more than three years of trial, the company was convinced that Sesbania is the right species that capable of solving the raw material scarcity. Furthermore, Al-Noor MDF has succeeded in convincing major landowners in Sindh to participate in the Sesbania planting, with a total area of 500 acres of farming land established with this species at various growth stages.

Sesbania sesban is a legume tree belongs to family Fabaceae. It is short lived shrub that grows up to 8 m in height. Open grown trees tend toward spreading habits and producing numerous thick branches at wide branching angle. The stem can reach a diameter of up to 20 cm. The leaves are pinnately compound, 2-18 cm long with 6-27 pairs of linear and oblong leaflets (26 x 5 mm). The raceme has 2-20 flowers which are white, yellow or red in colour and having unpleasant scent. Flowering starts shortly after the onset of the rains. The species can flower twice in areas with two rainy seasons. Fruit or pod is sub-cylindrical, straight or slightly curved, 20-30 cm x 2-5 cm in size, pale yellow, contains 10-50 seeds. Seeds are olive green, brown and sometimes mottled. There are 55,000-80,000 seed per kilogram.

The species currently planted in Sindh province for MDF raw material is identified as *Sesbania aculeata* or *S. aegyptiaca*. However, it is believed that the Sesbania species is of mixed cultivated varieties/sub-species of *S. sesban,* including subspp. sesban (yellow), coccinea (red), and albiflora (white) . In the field, several varieties with green, red, and grey coloured bark have been planted by the farmers. It should be noted that the bark of young seedling is green but gradually change to straw colour with age. The variety with reddish bark seemed to have a slow growth rate, while the variety with grey bark has a more vigorous growth. The presence of several varieties is rather interesting from R&D point of view, as this will provide breeder sufficient material for tree improvement activity. In Southeast Asia region, *S. grandiflora* (locally known as Turi or Geti) is more common and usually grown for livestock fodder, and young shoots and flowers are relished as vegetable. In the near future, Turi should be proposed as new species for supplying woody raw material for wood composite industries in Malaysia.

ESTABLISHMENT TECHNIQUES

Sesbania cultivation in Sindh seems to apply planting techniques modified from other local agricultural crops such as cotton. This is logical, as it is much easier for farmers to practice cultivation method which is familiar to them, rather than to adopt a new one. Three cultivation methods have been to establish Sesbania plantation: ridge, drill and broadcast sowing. The ridge method is claimed to produce the best result and seems very suitable for high water table (waterlogged) areas. All the three methods can be used depending on soil, water and labour availability. In the second crop of Sesbania, farmer also used natural regenerated seedlings and coppices from stumps of the previouly felled trees. Different amount of seeds (seed rate) is used for each type of sowing methods: 3-4 kg/ac for ridge, 4-5 kg/ac for drill and 5-6 kg/ac for broadcast. The sowing can be done twice yearly, in February-March and August-September.

Fertilizers given during site preparation consists of 1 bag of DAP/acre and 1 bag of SOP/acre. After 4-6 weeks 1 bag of urea/acre is provided to the growing plants. Additional nutrients such as phosphorus and potassium and minor nutrients are needed to sustain high yielding trees such as Sesbania.

Irrigation is important in order to improve productivity of Sesbania in Sindh due to aridity of the local climate. For ridge cultivation, irrigation is provided within a week after sowing and will be resumed every two weeks until the plants reach age 12 months. For drill method, irrigation is started after the third week and every 15 days thereafter until age 12 months.

In broadcasting method, irrigation is initiated after 8-10 days for three consecutive months and then in every 15 days untill age 12 months. In the second year, irrigation will be given in every 20-30 days, depending on soil moisture and weather conditions, irrespective of cultivation methods used.

The nodulation of four legume tree species (*Calliandra calothyrsus, Gliricidia sepium, Leucaena leucocephala and S. sesban*), their symbiotic interactions with the native rhizobial populations, and some of the ecological indicators of rhizobial population dynamics have been examined by Bala *et al* (2003). It was discovered that rhizobial population sizes ranged from undetectable numbers to 3.16×10^4 cells per gram of soil, depending on the host species. *S. sesban* was the most specific for both nodulation and symbiotic effectiveness. Symbiotic effectiveness did not bear any close association with specific soil parameters, but rhizobial numbers were highly correlated with soil acidity, particle size and exchangeable bases.

PESTS AND DISEASES

As a new alternative crop in Sindh, Sesbania was reported to have very few incidences of pest and disease. Larvae of *Azygophelps scalaris* was reported to bore through stem of Sesbania trees, causing them to snap. We have observed an irrigated plantation having a die-back problem. Small clumps of trees withered and died mysteriously. The external symptom was commonly associated with root problems. Even though termites were found in roots of recently dead tree (after excavation), the termites are not the primary cause of tree death, but more likely of a secondary invader. As most of the dead trees have gnawing injury on the bark caused by unknown animal, the trees could have been affected by a bacterial disease. In deed, a disease caused by bacteria *Xanthomonas Sesbaniae* has been reported to affect stem and leaves of Sesbania elsewhere.

CROP HARVESTING

Planted Sesbania trees reach felling size after 15-18 months. The trees will have an average of 6 inches (15 cm) diameter at the base and 2 inches (5 cm) top diameter. The average height is about 25 feet. Once harvested, the trees will be cut into 6 feet poles for easy handling and transportation to the mill. The yield is between 40 and 55 tons per acre, depending on site and age of harvesting. Sesbania wood is suitable for manufacturing medium density fiberboard (MDF) due to its uniform whitish colour. Another of advantage of Sesbania wood is that debarking of logs is not required, unlike other hardwoods. Al Noor factory is currently using Sesbania wood for MDF boards in mixture with other species of hardwood at various proportions, depending on the thickness of the boards to be manufactured. Due to its low wood density, pure Sesbania wood is suitable for production of thin boards. Currently, the mill is still accepting smaller size poles, as to encourage farmers and land owners to plant Sesbania. It is known that undersized pole tends to be wasted during wood processing.

DISCUSSION

Planting Material Improvement

Instead of seeds, Sesbania can also be established using bare-rooted seedlings. Potted seedling may not be feasible for this crop as it is more complicated to produce and maintained. It is expected that better quality trees can be established using less amount of seeds. However, seeds have to be sown in germination beds and placed near the planting site. The seedlings will have higher survival rate and can be planted at proper spacing. Maintenance activities such as weeding, fertilizer application, pruning and thinning can be conducted more effectively to enhance plantation growth and productivity. Moreover, tree inspection, seed collection, and harvesting could be greatly facilitated.

The improvement of planting material begins with seed collection. Good phenotype of mother trees can be easily identified and marked in selected populations. The seeds collected from the resultant seed stands and seedling seed orchard can be supplied to farmers to establish new plantings. Farmers should be encouraged to use only seeds that are certified to ensure better growth and yield of Sesbania plantations.

Sowing Method

Currently there is very high amount of seeds is used during sowing in the field, probably due to low germination rate. Seeds amount up to 6 kg per acre have been used. A kilogram of seeds contains between 50,000 to 80,000 seeds, depending on seed size. Thus, a minimum amount of 300,000 seeds have been sown per acre to produce about 5,000 – 8,000 plants. This indicates that more than 90% of the seeds are wasted. If good quality seeds were used, the amount of seed required per acre can be reduced substantially.

Due to impermeable hard seed coat, seeds of Sesbania need to be treated prior to sowing. Immersion in water for 24 hours at room temperature before sowing will soften the seed coat and improve germination rate of the seeds. Use of commercial fungicides such as benomyl (Benlate) or chloroneb (Demosan) can reduce mortality due to damping-off disease that is prevalent under high soil moisture condition. Fresh seeds should be used instead of stored seeds. If stored in container at 4° C, viability of the seeds can be retained for more than 3-5 years. Method of sowing should be based on the planting site condition. In waterlogged areas, it is better to adopt ridge planting method. In drier areas both broadcasting and drilling methods are suitable. To enhance high nodulation success, the seeds can be inoculated with suitable rhizobium strains.

Water Management

In arid and semi-arid climate as in Sindh where rainfall is very low, water conservation is important as the rate water loss due to evapo-transpiration processes are very high. In fact, the most fundamental constraint in Pakistan agriculture, in general, is water availability. Thus, an efficient use of irrigation water must be given a high priority.

Waterlogging and salinization of soils are common problems associated with surface irrigation. Irrigation-induced salinity can arise as a result of the use of irrigation water, irrigation of saline soils, and rising levels of saline groundwater combined with inadequate leaching. When surface

water or groundwater containing mineral salts is used for irrigating crops, salts are carried out into the root zone. In the process of evapotranspiration, the salt is left behind in the soil, since the amount taken up by plants and removed at harvest is small.

Since Sesbania can withstand dry and waterlogged conditions, to a certain degree, water management is critical to sustain plantation productivity. Both the extreme conditions can adversely affecting wood productivity of the trees. Excess water under waterlogged condition have negative effects on height, leaf, and root growth, induce leaf senescense and abscission (yellowing and shedding of leaves), and causing root rot and infection by *Phytophthora* fungi. Poor soil aeration can also predispose trees to infection by secondary fungi and insect infestation.

Stand Density Management

Stand density reflects how much a site is being utilized and the intensity of competition between trees for the site's resources (i.e., water, light, nutrients, and space). At higher densities, the growth rates of individual trees decelerate as there are more trees competing for the site's limited resources. Density of Sesbania trees in a plantation is resulted from germination success and seedling survival. The number of trees will decline progressively in time due to mortality as a result of shading and competition. To meet the management objective of a plantation, adequacy of its stocking (number of trees per acre) need to be maintained. Hence, plantations are often referred to as understocked, fully stocked, or overstocked, depending on site occupancy.

Full site occupancy is reached quickly if stand density is high and the spatial distribution of trees is uniform. Site occupation and merchantable biomass decline in response to decreasing of stand density. Any clumping of stems will reduce the stand productivity. In contrast, low density stands produce less volume initially because there are too few trees to exploit the available growing space. A specific target stand density can be obtained at early stage/age by means of right initial espacement or thinning. The silvicultural benefits for both practices, in terms of diameter growth, are due to creation sufficient growing space for residual trees. High regeneration density followed by thinning provides unique silvicultural advantages over initial wide spacing because of the opportunity to select the best trees in the stand.

Stand density management affect various links in the value recovery chain, including both tree and wood quality, harvesting and milling costs, product value and financial return. The optimal combination of stocking density and harvest age varies widely with management regime and targeted products. The landowners need to consider the impact of good silviculture regime on the quantity, quality and value at wood harvest for maximum return on investment.

For Sesbania plantations, two cutting options are recommended. The first harvesting option is to clear cut the plantation after age 18 months, as conventionally done at the moment. Pre-commercial thinning and pruning is done systematically to enhance the growth of the final crop trees. In the second felling option, there will be two cutting cycles. The first commercial cutting is made at age 12-14 months, where 50% of the trees are selectively felled by row. The remaining trees will be cut at age 20-24 months. With the second cutting option, farmer can sell their wood twice in a rotation and improves the cash flow.

Cropping with Fallow System

By practicing cropping with fallow system, agricultural field crops such as cotton and sugarcane can be alternated in time with Sesbania and site productivity can be greatly improved. Under the

fallow system the land will be rested for two years by establishing Sesbania on the land. Sesbania trees will enrich the site with nitrogen and other beneficial microflora during the fallow period. The root system of Sesbania helps in opening up the soil and acidifying the root environment, creating a better physico-chemical environment for microbial activity. Rao & Gill (2000) found that even after initial benefits of residual effects of Sesbania in the first two years, a steady supply of 31 kg N per ha per year was observed, due to non-symbiotic N_2 fixation of soil microbes. Once the Sesbania is harvested, the site can be prepared for field crop planting. The farmers not only benefited from the sale of Sesbania wood but also high yield of the following agricultural crop.

CONCLUSIONS

As a new crop, Sesbania is well received by the farmers in Sindh, mainly due to ease of establishment and maintenance, and favorable financial return. Farmers do not have to learn new technology in order to grow Sesbania, just to apply the cultivation techniques of other crops, with minor modification. The presence of MDF mill that willing to buy the wood of Sesbania also plays a pivotal role in the acceptance of the species among the landowners. However, the growth and yield of Sesbania plantations in Pakistan can be further improved through the use of good planting materials and application of correct silvicultural and management techniques during the establishment and maintenance of plantation.

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