

Promotion of Underutilised Crops for Income Generation and Environmental Sustainability

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Abstract: Over 30% rural families in India live in poverty due to small holdings and low soil productivity. As many underutilised tree species are tolerant to harsh agro-climatic conditions, BAIF promoted agri-horti-forestry on degraded lands inhabited by tribals. Traditionally dependent on non-timber forest products, they selected tamarind (*Tamarindus indica*), jackfruit (*Artocarpus heterophyllus*), Indian gooseberry (*Emblica officinalis*) and ber (*Zizyphus mauritiana*), apart from mango and cashew for their livelihood. Oilseed trees like neem (*Azadirachta indica*), mahua (*Madhuca indica*) and jatropha (*Jatropha curcas*) were introduced on field borders, while the interspace was utilised for cultivating food crops. To ensure higher yield and superior quality of the produce, selection of elite germplasm, domestication through standardisation of cultivation practices and facilitation for supply of planting material are essential, apart from increasing the demand by exploring their uses, creating awareness among consumers and establishing a good distribution network. Intercrops like foodgrains, vegetables and medicinal herbs generated additional income and reduced risk in case of failure of underutilised crops. Introduction of underutilised crops on a small scale with local crops and expansion of their cultivation with the demand is recommended.

Key words: Underutilised fruits, oilseed trees, agri-horti-forestry, tribal rehabilitation.

1. Introduction

Out of the 0.27 million plant species on earth, over 17,000 species are found in India and 65 plant species have good demand in world trade, although about 9500 plant species have potential use in the pharmaceutical industry. However, most of these species are in a state of neglect, while a small number of them are under cultivation in their native tracts by the local communities for specific household uses. In spite of their well proven uses and economic returns over generations, such species are not being cultivated on a large scale, due to lack of awareness about the utility, economics and adaptability. Many of the underutilised species having survived under harsh agro-climatic conditions can be established on degraded lands, which are presently being underutilised either due to

poor soil fertility or moisture scarcity.

1.1 Indian Agriculture

In India, agriculture is the major source of livelihood for over 85% of the 650 million rural populations. However, over 60% of these families are not assured of food security due to small land holdings and low soil productivity. Out of 89.4 million land holders, over 75% families own less than 2 ha land, most of which are degraded, resulting in low crop productivity. Lack of irrigation facilities is another serious problem, responsible for lower crop yield. Only about 30% of the 147 million ha agricultural lands have assured irrigation and the remaining 100 million ha are dependent on rainfall for crop production. Out of this area, about 60 million ha are located in semiarid and arid regions, where the crop yield is significantly lower than the average national yields. Farmers deprived of irrigation facilities generally

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grow one crop during the year. As they hesitate to apply the requisite inputs, the crop yields are low and agriculture on such lands can provide employment for hardly two to three months in a year. Due to these problems of small holdings, underemployment and lower productivity, over 35% of the rural families are living in poverty with their annual income less than USD 500 per family [1].

1.2 Problems of Tribals

About 9% of the Indian population is represented by tribal communities, who have been traditionally living in the forests, collecting minor forest products for their livelihood. However, with the depletion of forest resources during the last 5-6 decades, the income of these families has been sharply declining and this has forced them to cultivate crops on degraded hilly terrains and to migrate seasonally to urban areas in search of employment. Distress migration has been affecting their quality of life, particularly, the health and education of their children. Considering the plight of these poor who are dependent on agriculture and deprived of employment opportunities, the Government of India has been focusing on promotion of special agricultural development packages to promote sustainable livelihood for these small holders [2].

1.3 Tribal Rehabilitation through Agri-Horti-Forestry

With a view to rehabilitate and provide sustainable livelihood to over 25,000 tribal families spread over 500 villages in the hilly terrains of the Western Ghats in the districts of Valsad, Navsari and Dangs in Gujarat State and Thane and Nashik districts of Maharashtra State, BAIF Development Research Foundation, a Civil Society Organisation committed to helping small farmers to earn their livelihood, promoted an agri-horti-forestry development programme in the early 1980's. This region receives a rainfall of over 2500 mm spread over a period of five months from June to October. However, due to shallow lateritic soils, undulating topography and lack of

ground water, the crop production is confined to the rainy season and these villages face serious crisis of drinking water for two to three months in summer. The temperature in these districts ranges from 40 °C in May to 8 °C in January.

Looking to the average size of the land holding, development of orchard on 0.4 ha land was promoted. Preference was given to fruit trees tolerant to drought, with short gestation, having local acceptance. Mango being popular in the region, participants selected it as the main crop. Subsequently, after carrying out multi-location performance studies, cashew was also introduced on a large scale. As the growers had to wait for four to five years before the mango and cashew trees started bearing fruits, it was necessary to introduce various income generation activities to sustain the livelihood during this gestation period and to discourage the participant families from migrating to cities. One such opportunity was to promote various food crops such as sorghum, pearl millet, finger millet, maize, green gram, horse gram and pigeon pea as intercrops between the fruit trees. This ensured food security and generated additional income. Establishment of fruit and forest nurseries and cultivation of seasonal vegetables and mushroom were also attractive. Live fencing of the orchards was promoted by using fodder, fuel, timber and minor fruit species to ensure protection from domestic and wild animals. Thus, the agri-horti-forestry system was designed taking into consideration the agro-ecological conditions and local needs. With good seeds, improved agricultural practices and water conservation measures, the crop yields went up by 50% to 100%, although about 20% land was covered under fruit plants. Encouraged by the success in increasing the crop yields, the participants cultivated vegetables, flowers and other cash crops and earned about Rs.12,000 to Rs.15,000 (USD1=Rs.40) annually, right from the first year. With gainful employment on their own farms, migration of women and children was almost discontinued. Subsequently, with the production of fruits, the net

annual income of these families increased to USD 800-1000 annually. With plenty of biomass generated on the farms, the local families stopped going to the forests to collect wood and fodder, which resulted in the regeneration of natural forests. This programme, which has demonstrated the conservation of ecosystem and biodiversity while providing sustainable livelihood, has now been recognised by the Government of India for wider replication [3].

As the income from fruits, vegetables and cash crops is higher than that from food crops, farmers prefer to grow such high value crops, although there is a risk of price fluctuation. However, it is extremely difficult for small farmers to compete with large farmers whose cost of production is significantly lower due to superior quality land and well established infrastructure. Therefore, there is good opportunity for small farmers to take up cultivation of new and underutilised crops which can be sold easily, while generating additional income. With small scale production, it is also easy to find good market for lesser known products. With this background, BAIF initiated the promotion of underutilised fruit crops through small farmers.

1.4 Potential Underutilised Trees in India

There are many tree species having significant economic uses, which are either under severe neglect or the cultivation is restricted to a small region. Realising the advantages of these species, serious attempts have been made during the last five decades to popularise the cultivation of underutilised plants by several international and national organisations. Among them, a few species have performed exceedingly well by competing even with traditionally grown local crops and have provided sustainable income to farmers. Many other species, in spite of their adaptability, economic potentials and initial acceptance, were ultimately rejected by farmers, while some others had problems of adaptability outside their native tracts. Among these species, trees bearing fruits and nuts are

more popular compared to the species providing non-timber forest produce and various forms of biomass. Some of the underutilised fruit trees which have gained prominence in recent years in India are tamarind (*Tamarindus indica*), custard apple (*Annona squamosa*), Pummelo (*Citrus grandis*), Indian gooseberry (*Emblica officinalis*), ber (*Zizyphus mauritiana*), jackfruit (*Artocarpus heterophyllus*), blueberry (*Syzygium cumini*) and kokum (*Garcinia indica*). Tamarind which originated from South America has been introduced in India since several centuries and is now extensively used in Indian cooking. However, tamarind has not been cultivated as a regular crop. The trees are established through natural seeding on community lands and farmers generally establish a few trees in their backyards or field bunds for household use. The State Forest Departments have been raising seedlings for establishment on roadside as avenue trees and for distribution to farmers, but the response from farmers has been poor due to the long gestation and lack of clarity about its yield and economics. The harvested fruits are sun dried for a few days and the pulpy fruits are separated from the outer brittle shell, deseeded and mixed with a small quantity of salt (1-2%) before storing or selling in the local market. During the last 2-3 decades, the demand for tamarind has increased significantly because of the use of modern technologies for processing the pulp into ready-to-use cubes and powder. However, the farmers were still reluctant to take up the cultivation due to poor returns. To overcome this problem, various research institutions have identified superior germplasm having high acid content and yield. Vegetative propagation techniques were developed to produce elite planting materials, which have spreading growth habit and short gestation period. The tamarind plantations established from grafted plants could come into production at the age of four to five years and generate as much substantial income as from traditional fruit crops like mango. With such improved production practices, farmers in semiarid region are

motivated to establish tamarind plantations on a large scale.

Custard apple (*Annona squamosa*) is a popular fruit across the country, found naturally on degraded lands in arid and semiarid regions. The plants are non-browsable and drought tolerant. The local people harvest the fruits for home consumption. However, during the last 2-3 decades, special efforts were made to select superior germplasm and to develop techniques for vegetative propagation, to enable farmers to cultivate this species on a commercial scale. Jackfruit (*Artocarpus heterophyllus*) is a native fruit crop growing in humid and semiarid tropics. The plants either grow naturally or are planted by farmers in their backyards in small number. There is wide variation in the size, form and quality of fruits and it is difficult to predict them without sampling the fruits. As the trees start fruiting at the age of 8-10 years and only the fruits having firm and sweet fruitlets fetch better price, farmers are reluctant to cultivate this plant on a commercial scale. Unfortunately, no systematic work has been undertaken to select elite germplasm and to develop efficient techniques for vegetative propagation.

Indian gooseberry (*Emblica officinalis*), locally known as *Anola*, is used extensively for medicinal purposes. It not only grows naturally in village forests but is also cultivated on sodic lands of Uttar Pradesh State, because of its economic viability. However, during the last 2-3 decades, with the domination of modern medicine, the demand for herbal medicines reduced drastically resulting in poor price realisation for Indian gooseberry. Thus, farmers from other regions were not interested in cultivating Indian gooseberry, while the existing growers developed products such as pickle, jam, juice, squash, candy, etc. and marketed them as vitamin C rich health food. In the 1990s, with greater awareness on the use of herbal medicines, Indian gooseberry regained its importance and the demand for its fruits increased substantially. During this period, scientists developed superior

varieties, techniques for vegetative propagation and improved cultivation practices, which helped in extending its cultivation to many other states, particularly in arid and semiarid regions across India [4]. *Ber* (*Zizyphus mauritiana*) which bears small sour fruits was domesticated in the 1950s for cultivation in arid regions. With the application of modern technology and selection of superior table varieties, good quality fruits are now available in the market. The fruits can also be utilised for production of candy, jam, squash, etc. Presently, *ber* is being cultivated on degraded lands which otherwise were not suitable for cultivation. *Kokum* (*Garcinia indica*) is another fruit grown in the Western Ghats region of Western India, with food and nutritional value. The trees grow naturally in the tropical humid forests and their cultivation in homesteads is to a limited extent. Like mangosteen fruits, the seeds are covered with sweet juicy pulp. The thick, waxy fat extracted from *kokum* seeds is used in Ayurvedic medicines and cosmetics. The outer shell is soft, acidic and red in colour. Fresh shells are either dried with salt for using as spice or processed into syrup for preparing a refreshing drink, having nutraceutical value. The demand for *kokum* products has been increasing in recent years and with easy availability of good planting materials, the farmers in Western Ghats region have started planting *kokum* as a plantation crop [5].

Neem (*Azadirachta indica*) is an indigenous tree species known for its oil, pesticide and medicinal uses, grown naturally on barren lands. However, in the absence of selected elite germplasm, standard silvicultural practices and information on income, no serious attempts have been made to promote this species. *Jatropha* (*Jatropha curcus*) is another oilseed bearing shrub, planted across the country as a fence plant, which is gaining importance as a biodiesel crop in India, although there are doubts about its tolerance to drought, yield and profitability. *Mahua* (*Madhuca indica*) is an oilseed tree which grows naturally on village common lands in Central India. Its flower

consists of a sweet and juicy corolla which drops a few days after flowering. The local people, particularly the tribals, collect the fallen corolla and consume it in the fresh or dehydrated form. The seeds contain 30% edible oil. Long gestation period and poor income are major constraints for cultivation of *mahua* and many other underutilised tree crops. Techniques have now been developed to produce grafted plants of *mahua* which start bearing in the third year. Looking to the economics and short gestation period, farmers are now keen to establish plantation of *mahua* on their degraded lands as a commercial crop [6].

In a study undertaken by BAIF to popularise underutilised fruit crops, it was observed that the farmers were hesitant to take up the cultivation due to lack of awareness of economic benefits, availability of good quality planting materials, poor marketing network and lack of technology available for post harvest processing and value addition [4]. Based on these constraints, BAIF initiated the promotion of less known fruit trees by setting up field demonstrations, developing field manuals for best practices, training field extension workers and farmers and distributing posters and handouts. Decentralised nurseries were established to produce and supply better quality grafted plants. Farmers' Organisations were promoted for forward and backward linkages. These efforts made a significant contribution in popularising several underutilised fruit crops [7]. Looking to the potentials of underutilised species for contributing to the income of small farmers, selected species were introduced under the agri-horti-forestry system along with other fruit crops, as a part of this study.

With this background, this study was undertaken with the objective of enhancing income of small tribal farmers through introduction of underutilised tree species having good income potential in their farming systems.

The specific objectives of the study were: (1) To study the techno-economic feasibility of cultivating

underutilised trees species having economic uses; (2) To study the factors affecting their adaptation; (3) To popularise the cultivation of promising underutilised species.

2. Materials and Methods

The strategy was to introduce various less known fruit species, instead of promoting only mango and cashew as the main crops in the agri-horti-forestry system which was intended to promote sustainable livelihood for the tribal families. The fruit species included in the study were tamarind (*Tamarindus indica*), Indian gooseberry (*Emblica officinalis*), *ber* (*Zizyphus mauritiana*) and jackfruit (*Artocarpus heterophyllus*). Although, the farmers were aware of the benefits of these crops, none of these were cultivated on a large scale in these districts. Oilseed bearing tree species such as neem (*Azadirachta indica*), *mahua* (*Madhuca indica*) and jatropha (*Jatropha curcus*) were introduced on field borders and several food, vegetable and cash crops were introduced in the interspace. It was difficult to persuade the farmers to cultivate the less known crops as mono crops, in the absence of reliable information on the profitability and demand for the produce. Thus, the farmers were persuaded to set aside an area of 0.1 to 0.2 ha for new fruit crops, while planting mango and cashew on the remaining area. This was acceptable to them as the income from mango, cashew and intercrops was assured, and there was no risk of total failure. Observations on growth, yield and income from fruit trees needed five to six years.

The fruit crops under the study were cultivated by over 200 farmers, with more than 20 farmers for each species, during the years 1995-97. While there was no hesitation to establish tamarind, Indian gooseberry and *ber*, it was difficult to persuade the farmers to establish a plantation of jackfruit even on 0.2 ha land. Hence, the planting was restricted to field bunds and borders. Grafted plants of elite selections of tamarind, Indian gooseberry and *ber* and seedlings of jackfruit,

Table 1 Performance of various under-utilised tree species.

Species	Survival rate*	Growth rate	Tolerance to drought**	Age at fruiting	Yield***	Demand	Rank
Fruit species							
Tamarind	Medium	Medium	High	3	Medium	Medium	2
Indian gooseberry	High	High	High	2	High	High	1
Ber	High	High	Medium	2	High	Low	3
Jackfruit	Medium	Medium	Medium	7-8	Low	Medium	4
Oilseed trees							
Neem	High	Medium	High	5	High	High	2
Mahua	Medium	Low	Medium	10	Low	Medium	3
Jatropha	High	High	Medium	2	Medium	High	1

*Survival rate: High: above 80%, Medium: 60-80%, Low: below 60%;

**Drought tolerance is based on days of irrigation interval for plants below 3 years of age. High-3 weeks, Medium-2 weeks, Low-1 week;

***Yield per ha: Exact data could not be collected as newly established plants of some species need some more time to reach the stage of optimum yielding.

neem, *mahua* and *jatropha* were used for planting. The plantations were given spot irrigation during the initial three years. Various interventions such as water conservation through contour bunding, establishment of wind breaks, application of nutrients and plant protection using integrated pest management were carried out to improve the crop productivity. The intercrops were cultivated under rain fed conditions. The observations made under different field conditions were analysed. Based on the profitability and marketability of the producers, some of these species are being promoted for cultivation on a wider scale. The above information was collected from other farmers as well who had established these tree species earlier and it was too early to gather data on yield and economics from newly established plantations under this study.

3. Results and Discussion

The results on survival, growth rate, tolerance to drought of various underutilised tree species and the preference of farmers are presented in Table 1.

All the newly introduced fruit and oil seed species could be established on degraded lands with low rate of mortality and good growth. Among fruit species, Indian gooseberry was found to be the most accepted

species because of early bearing, high yield, better price realisation and good demand for the fruit in the local market. The trees established well with low mortality even on shallow soils and the trees did not need any special care. Tamarind was the next choice, which was also drought tolerant. The trees started bearing in the third year and the yield in the initial years was low. As there was no ready market for freshly harvested fruits, growers were compelled to sell the fruits to local traders at a low price. Hence, farmers' preference for tamarind is low as compared to Indian gooseberry. This may change with the increasing yield of growing trees and development of processing facilities, which in turn can increase the demand.

Ber is also tolerant to drought but responds well to irrigation. Grafted plants started bearing from the second year and yielded profusely from the third year. *Ber* fruit is not as delicious as other fruits for table purpose, although children like it. So the demand for fruit is limited and the price falls drastically during the peak season. Technology has been developed recently for processing of *ber* fruits into jam, squash and dehydrated fruits, but large scale cultivation of *ber* is risky, until these processed products become popular. Jackfruit plants also established well under semi-arid

and humid conditions and their growth was satisfactory. Trees started bearing fruits after 7-8 years and are expected to reach the optimum stage of bearing at the age of 12-15 years. The market for jackfruit is very limited due to large sized fruits, wide variation in the quality and lack of facilities for processing of fruits. In the absence of elite germplasm and superior quality planting material, estimation of yield and income was difficult and hence, the farmers were reluctant to cultivate this species on a large scale.

Trees of tamarind and Indian gooseberry are highly drought tolerant and hence, more suitable for semiarid regions where other fruit crops cannot establish well. These crops have good potentials in the future particularly in the semiarid region which is not suitable for mango, cashew and other fruit crops. In the absence of proven technologies for processing, it is difficult for jackfruit to compete with other fruit crops which are presently cultivated by farmers. Hence, farmers may be encouraged to grow jackfruit on field bunds or boundaries, till processing facilities are developed on a large scale or alternate market outlets are established. Selection of superior germplasm and development of vegetative propagation techniques are also essential for popularisation of its cultivation.

With regard to oilseed species, trees start bearing fruits from the second, fifth and tenth year in *Jatropha*, neem and *mahua* respectively. *Jatropha* being a shrub, it can be maintained as a fence crop without suppressing the growth of fruit trees, while neem and *mahua* grow into large trees and affect the growth and yield of fruit trees. Lopping of side branches would affect the yield of seeds. Hence, farmers are reluctant to cultivate neem and *mahua* under the agri-horti-forestry system. As a fence plant, average yield of *Jatropha* has been 350-400 gm per plant during the third year, which further increased with the age. As this is an additional source of cash income without any extra effort, farmers are happy to establish *Jatropha* on their farm fence. *Jatropha* seed has good

demand for biodiesel and the price offered is remunerative.

Based on this study, BAIF is now popularising mango and cashew in high rainfall areas and Indian gooseberry and tamarind in semiarid areas. *Jatropha* is now being promoted by replacing other species such as *Euphorbia*, *Prosopis*, *Acacia*, etc. for fencing. To ensure better price for the produce, small-scale cooperative processing units have been established in the project areas. Although such units do not have the capacity to process the entire quantity of fruits grown by the members, the procurement price fixed by the cooperatives can prevent the traders from exploiting the growers. These processing units are generating additional employment for local youth, preferably those from landless families.

The study provided an opportunity to explore the potentials of several tree species, without causing any concern or loss to the participant farmers, as their major income was assured from commercial fruit crops like mango and cashew. It also enabled selection of several underutilised species, which can be planted on barren lands as an income generation activity. Cultivation of new crops would not only enable the farmers to enhance their income, but also improve the bio-diversity and ecosystem.

It was observed that the following are critical factors which influence the acceptance of underutilised species by farmers for cultivation:

- (1) The produce should have good demand and ready market for direct consumption or processing;
- (2) The crop should have short gestation and high returns, to attract farmers to shift over from their traditional crops;
- (3) It is necessary to select elite germplasm to ensure the production of superior quality produce and develop technology for production of superior quality planting material;
- (4) Suitable cultivation practices should be developed to improve the yield and quality of the produce;
- (5) Timely support for forward and backward linkages

and technical guidance should be readily available for farmers. This should also include development of new products, exploration of new uses and consumer awareness about the specialities of new products.

4. Conclusions

There are many underutilised food and non-food plant species, having good potentials to contribute to the income of farmers. However, it is essential to validate their adaptability, demand for the produce and profitability in comparison to the alternative crops grown in the region. While promoting underutilised fruit trees and oilseed tree species in the Western Ghats region of Gujarat and Maharashtra States, it was observed that the success in promotion of underutilised crops was dependent on the crop yields, price for the produce and marketability either in fresh or processed form. It is easier to promote food crops because of the local market but difficult to promote non-food crops without prior market linkage. Promotion of underutilised crops without marketing back-up being risky, it is advisable to introduce such crops on a small scale, without seriously affecting the assured source of income. This will also give time to expand the market in the future. Subsequently, successful species can be replicated on a large scale. Many underutilised species tolerant to drought and other stress conditions can be cultivated on degraded and barren lands as an income generation activity while improving the biodiversity and ecosystem.

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