CHAPTER 5

Genetic improvement

The traditional uses of jatropha as a hedge plant and the harvesting of various parts of the tree for medicinal uses have not encouraged selection for high seed or oil yields over time. As a result, jatropha currently has the status of a wild plant with low and variable oil yields. However, it also has a high potential for improvement by breeding high-yielding varieties and hybrids. The possible scale of this improvement can be seen by comparing some domesticated crops with their wild ancestors.

PRESENT STATUS

Breeding to raise oil yields became a focussed area of research with the 2004/5 surge in interest in jatropha – an effort led mainly by the private sector. Given the time required for promising accessions to mature and be evaluated, it is clear that work to improve yields through breeding is at a very early stage and that present jatropha plantations comprise, at best, marginally improved wild plants. As jatropha is mainly open pollinated, any genetic improvement to date has resulted from the effect of superior plants having been grouped and grown together.

A comparison of yields of wild varieties over four years under semi-arid conditions (shown in Figure 7 in Chapter 3) found that only 5 percent (one individual out of 19) gave a good yield approaching 1 kg. A little more than 50 percent gave poor yields of 200 grams or less. The study also found that individual yields of unimproved plants can vary up to 18-fold, although high-yielding plants were seen to be consistent over time, suggesting genetic rather than environmental causes. There are large variations in the oil content of jatropha seed, ranging from 25 to 40 percent. This needs testing over time and in different locations to determine the relative influence of genetic and environmental factors.

THE IMPORTANCE OF YIELD

Maximizing oil yield per ha requires breeding for seed size, oil content and for parameters that affect the number of seeds produced. The economic importance of yield can be seen in the sensitivity analysis in Table 9. Yield and price have a far bigger impact on profit than direct costs and, since price is market dependant, the aim must be to improve yield.

TABLE 9: **JATROPHA GROSS MARGIN SENSITIVITY ANALYSIS**

ITEM	GROSS MARGIN USD/HA	VARIATION %
Expected yield, cost and price	208	0
Yield increase of 50%	436	110
Price increase of 50%	558	80
Cost decrease of 50%	384	32

Source: Parsons (2008).

PRODUCTION-ORIENTED BREEDING OBJECTIVES

The following would be appropriate objectives to maximize oil yield:

- improve dry matter distribution, with greater assignment to fruit than to vegetative parts,
- increase the ratio of pistillate (female) flowers per inflorescence to staminate (male) flowers, in order to improve the potential for fruit formation,
- increase synchronicity of flowering and seed maturity in order to lessen the labour intensity and enable mechanization of harvesting,
- increase seed weight and seed oil content, and
- increase the number of branches, flowers, seeds and fruits.

Other breeding goals would be:

- improve oil quality,
- develop non-toxic varieties to ensure human safety and to add value by enabling the seed cake to be used as fodder, and
- improve plant architecture, with more branching for maximizing yield and lower plant height for easier harvesting.

PRO-POOR BREEDING OBJECTIVES

While maximizing oil yield is a priority breeding objective, there will be other objectives for small jatropha growers, especially poor farmers. These will be for those traits that minimize risk, such as having acceptable yields under low rainfall, and resistance to pests and diseases.

The following would be appropriate pro-poor breeding objectives:

- improve drought resistance and productivity under water stress conditions,
- increase pest and disease resistance in order to avoid need for costly agrochemicals,
- improve plant architecture to have deeper rooting and a smaller canopy to allow for intercropping,
- enable easier shelling and seed crushing suited to simple extraction technologies,
- increase productivity under low-to-medium soil nutrient conditions, and
- maintain inedible leaves to ensure its utility as a livestock hedge.

PRODUCING IMPROVED VARIETIES OF *JATROPHA CURCAS*

The success of any programme of genetic improvement is enhanced by the existence of a large and diverse gene pool. Unfortunately, the genetic resource base of *Jatropha curcas* in India, Asia and Africa is small (Jongschaap, 2008). It was thought that accessions from jatropha's centre of origin in Meso and South America would offer larger genetic variation and, indeed, studies found more genetic variation in accessions from this region. However, a recent study by Popluechai *et al.* (2009) found that accessions from Mexico and Costa Rica had a 70 percent similarity to accessions from other parts of the world. This may limit the potential of intra-specific breeding programmes for *Jatropha curcas*. The same study also raised the prospect of increasing heterozygosity by breeding inter-specific hybrids, such as *Jatropha curcas* x *Jatropha integerrima*. The hybrid was backcrossed to *Jatropha curcas* and the resulting progeny exhibited stable inheritance of general desirable characters.

Jatropha displays a phenomenon, perhaps associated with epigenetic mechanisms, whereby there can be large phenotypic variation among genetically identical plants – characteristics such as seed size and oil content can vary considerably despite their similar or identical genetic composition. For example, Aker (1997), studying flowering of a single accession from Cape Verde on a field in Nicaragua, discovered that flowering time, number of flowers and male-female flower ratio all varied substantially depending on soil fertility, soil moisture, precipitation, evaporation and temperature.

True-breeding improved progeny are still some years from commercialization. Field evaluations of promising accessions and new varieties grown from seed take at least two years. Plant breeders working on jatropha are now using modern genetic marker techniques that speed up the screening process, but these selections still need to be grown to maturity for validation.

Use of tissue culture can speed up the multiplication of high-yielding varieties. Producing large numbers of genetically identical plants from one individual under closely controlled laboratory conditions is an established technique for many plant species. In addition to mass production of new plants from scarce parent material, a further advantage is that the new plants are disease free. Researchers have had a 100 percent survival rate in producing jatropha from tissue culture, but the technique has not yet reached commercial scale.

It is also possible to graft the stems of superior clones onto strong seedling rootstocks in order to grow clones of genetically improved plants on strong taproots. However, there is little, if any, experience of grafting jatropha. While this is feasible, it is laborious and time consuming. The hollow stem may result in a weak graft union prone to break in windy conditions. Still, this merits consideration in view of the need to improve existing plantations established with poor planting stocks.

BREEDING GOALS


Photo: HENNING

PLATE 20: A high-yielding, early fruiting tree (7 months old) in Cambodia.

In the short term, the goal for crop improvement should be to produce superior cloned material by scaling up tissue culture techniques or, at least, using micro-cuttings. But it should be stressed that, due to the genetic-environment interaction, superior performance may not transpose to other growing sites and management regimes. In the longer term, improved varieties need to be developed based on provenance trials, the selection of superior accessions and by breeding inter-specific hybrids for a range of production practices and agro-ecological and socio-economic conditions.

Information on the results of breeding work by the private sector is limited but it may be assumed, given the global interest and investment so far, that advances have been made and that this investment in crop improvement will be ongoing. The private sector will focus its efforts on optimizing yield to maximize return on investment. It will remain for the public sector institutions to develop jatropha varieties with the pro-poor breeding objectives described above.

Photo: FAIDUTTI

CHAPTER 6

Experience of Jatropha in sub-Saharan Africa and South Asia

This chapter reviews selective experience from West Africa, East Africa and India. Lessons learned from successes and failures can help define the types of interventions most likely to contribute to poverty reduction through adopting sustainable systems of jatropha production and utilization.

West Africa – Mali

Much of Mali is semi-arid with rainfall ranging from less than 200 mm in the north to 1 200 mm in the south. Rural Malians have grown *Jatropha curcas* for centuries as a hedge plant to protect crops from wandering livestock and to reduce wind and water erosion of the soil. A study found that 1 m of hedge produced about 1 kg of seeds which yielded 0.2 litres of oil. Each village had an average of 15 km of hedge with capability of yielding 12 tonnes of seed – potentially making 2 400 litres of oil available for local utilization (Henning, 2007). Traditionally, women collected jatropha fruits to extract oil which they used for medicine and soap making.

Jatropha system project

In 1987, GTZ launched a development project to improve the utilization of jatropha hedges within the framework of a renewable energy programme.

The project developed a "jatropha system" to support renewable energy at the village level together with components that covered erosion control and soil improvement, promotion of women and poverty reduction.

- Renewable energy: used jatropha oil in Lister-type diesel engines as both fuel and lubricant to drive grain mills and water pumps. Continuity of supply of diesel or a diesel substitute in the form of jatropha oil is important in areas with poor road access and therefore irregular supplies. Producing jatropha oil more cheaply than bought-in diesel would help to assure continuity of supplies to remote villages.
- Erosion control and soil improvement: used jatropha hedges to reduce wind erosion and planted the hedges across slopes where their roots formed earthen bunds that reduced erosion by decreasing rainwater run-off and increasing infiltration. The seed cake was found to be a useful fertilizer in a country where organic matter is rapidly depleted and imported inorganic fertilizers are costly.
- Promotion of women: installed engine-driven grain mills to reduce the tedium of women's work. Engine-driven expellers allowed women to improve their traditional soap production methods and increase their cash incomes.
- Poverty reduction: improved community potential for accruing financial benefits by using locally produced oil in place of diesel which reduced the mill running costs and reduced cash outflow from the villages. Financial benefits also accrued from substituting seed cake for bought fertilizers, reduced crop losses from wandering livestock and decreased erosion (Henning, 2007).

The project concluded that similar projects would have the greatest chance of success in areas with:

- high transport cost due to remoteness or poor roads,
- extensive wastelands unfit for food and cash crop production,
- available labour for harvesting and processing, and
- high costs of mineral diesel fuels and thus an advantage to substitute with a cheaper domestic alternative.

GTZ (2002), based on its experience in Mali and Zambia, noted that certain local conditions must be met for the jatropha system to be successful:

- planting: plants selected must be adapted to the site and available in sufficient numbers,
- soap production: caustic soda must be available,
- oil production: simple mechanical oil mills must be available, and
- powering: diesel engines must be capable of running on pure plant oil.

Early in the project, a problem arose when men claimed ownership of the jatropha trees. They had allowed women to harvest seeds for making soap for their own use, but when the women attempted to turn this into a cash-generating activity, the men wanted a share of the proceeds. This led to some loss of interest in the project (Henning, 2004b).

A study of the system's economic viability found a 49 percent internal rate of return on investment in cases that fully accounted for internal transport costs and which used the Sundhara oil expeller[3] powered by the Lister-type diesel engine. Using the hand-operated Bielenberg ram press gave negative returns. The study concluded that the production of jatropha oil was competitive with imported diesel (Henning, 2004b). However, local diesel prices change according to variables such as oil prices and exchange rates, so it cannot be assumed that jatropha oil will always remain competitive with diesel.

In fact, only one year later, Brew-Hammond and Crole-Rees (2004) found and reported that jatropha oil was not competitively priced and, as a result, the GTZ project was terminated. However, they also reported that the Mali Folkecentre, a Bamako-based NGO, felt the audit did not account for the added value of soap making and other products, that the price of jatropha seeds had since fallen, and that a cheaper supplier of the Sundhara oil press had been identified. The Mali Folkecentre continues to initiate projects in jatropha technology transfer and development of sustainable management models.

The GTZ project found soap production to be quite profitable. Three litres of oil could be extracted from 12 kg of jatropha seed, producing 4.7 kg of soap worth USD 4.20 and 9 kg of seed cake worth USD 0.27. Factoring in the cost of seeds, caustic soda and labour which totalled

[3] The Sundhara oil expeller was developed by FAKT, a non-profit consulting engineering firm, for use by rural communities in Nepal.

USD 3.04, it still resulted in a profit of USD 1.43 that could be made from five hours work (Henning, 2004b).

Multifunctional platform project

In the mid-1990s, the Government of Mali, with support from UNDP and UNIDO, introduced a multifunctional platform (MFP) project. The MFP has a simple diesel engine that can power a variety of tools such as a cereal mill, a seed husker, alternator and battery charger. The engine also can generate electricity for lighting, refrigeration and to pump water. By June 2001, 149 platforms were operational and the project planned to install

BOX 3. **Mali – Lessons learned**

- Projects using the jatropha system have the greatest potential for success where there are extensive wastelands unfit for food and cash crop production. There also must be available labour for harvesting and processing that does not conflict with other demands.
- The economic advantage of substituting jatropha oil for diesel improves in regions with high transport costs.
- Power-driven oil expellers appear to be more efficient than hand presses. However, in terms of viability, they are not more successful if they are not affordable and easily repaired by local artisans. In terms of soap production, the hand press is less expensive and more suitable for small-scale soap production, which makes it more pro-poor.
- The Lister-type diesel engine is less costly than more modern diesel engines that are designed to run on pure plant oil (such as the Hatz diesel engine). The technology is simple and can be repaired by local engineers with rudimentary facilities.
- Jatropha production benefits from value addition, e.g. soap making, and from the value of by-products such as seed cake.
- Selection of plants adapted to the site and available in sufficient numbers is essential when planting jatropha.
- Gender-differentiated access to resources may prevent uptake of jatropha oil processing and income-generating opportunities. Extension workers and community facilitators need to work with men and women together to find ways to overcome social constraints.

platforms in 450 villages serving about 10 percent of the rural population by the end of 2004. It was proposed that 15 percent of the MFPs should run on jatropha oil (Henning, 2004b), but a 2004 review in Mali found only one doing so. The review found that the MFP project had significantly reduced poverty in rural areas, particularly for women, and the model was expanded to other West African countries (Brew-Hammond and Crole-Rees, 2004). Lessons learned from Mali are summarized in Box 3.

East Africa – Tanzania

Tanzania has a tropical equatorial climate. Its annual rainfall ranges from less than 600 mm in the central region to more than 1 150 mm in the coastal and western regions.[4]

Jatropha seed production

In Northern Tanzania, Messemaker (2008) found that the jatropha seed price tripled between 2005 and 2008. By 2008, the price was highly variable, ranging from TZS 180[5] to TZS 300 and even TZS 500 in the most remote areas. The main demand in 2008 was for seed for planting and producing seedlings. An analysis of the economics of producing jatropha seedlings for sale indicated high returns with gross margins of 55 percent regardless of the seed cost.

However, for small-scale jatropha farmers producing seed, the gross margin showed a poor return (see Table 10). From the lowest to the highest seed price received, the gross margin was estimated between –130 percent and +23 percent, without accounting for any plantation establishment costs.

No farmers were observed applying fertilizers or other inputs, and weeding was minimal. Seed cake had limited use – for biogas generation and making fuel briquettes – and its value as a fertilizer was not well known.

Based on limited data, the yield was estimated at 1.65 tonnes per ha. The yield required to break even was 1.9 tonnes at the mid-range seed price of TZS 200 per kg and 3.8 tonnes at the lower price of TZS 100 per kg.

4 Information for this section is taken from in-country studies by Henning and Messemaker (2008).

5 For this report, exchange rate of TZS 1 150.00: USD 1.00.

Whether these yields could be achieved with minimal expenditure on fertilizers, irrigation and pesticides is doubtful. In all, this suggests that profitability is low and that jatropha farming in this situation is a risky enterprise.

TABLE 10: **GROSS MARGINS FROM SMALL-SCALE JATROPHA FARMING, OVER ONE YEAR (TZS/HA)**

	LOW SEED PRICE	MEDIUM SEED PRICE	HIGH SEED PRICE
Costs			
Irrigation	12 250	12 250	12 250
Weeding	24 500	24 500	24 500
Harvesting	343 000	343 000	343 000
Total costs	379 750	379 750	379 750
Revenue			
Harvest (kg/ha)	1 653	1 653	1 653
Price (kg)	100	200	300
Total revenue	165 300	330 600	495 900
Net benefit	-214 450	-49 150	116 150
Gross Margin	**-130%**	**-15%**	**23%**

Adapted from Messemaker (2008).

One large farmer confirmed low yields of about 1 tonne per ha, despite using seed sourced from various countries. Another said that seed sales could not cover the cost of harvesting. Gross margin calculations showed that large-scale farming was highly unprofitable if fertilizers, pesticides and irrigation were used, although this was based on very limited data (Messemaker, 2008).

Production of jatropha oil

The Vyaumu Trust, established by the Evangelical Lutheran Church of Tanzania, provided farmers with a locally manufactured Sayari oil expeller, originally developed for processing sunflower seeds. This was based on the diesel-powered Sundhara expeller (referred to earlier) that was used by GTZ in Mali.

Messemaker found that oil extraction was more profitable than growing jatropha. The figures are shown in Table 11.

TABLE 11: **GROSS MARGINS OF MANUAL OIL EXTRACTION OF 8 LITRES IN ONE DAY FROM 40 KG SEED (TZS)**

	LOW SEED PRICE[a]	MEDIUM SEED PRICE[b]	HIGH SEED PRICE[c]
Cost			
Seeds	4 000	8 000	12 000
Labour	2 500	2 500	2 500
Depreciation	153	153	153
Total cost	6 653	10 653	14 653
Revenue			
Extracted oil	16 000	16 000	16 000
Net benefit	9 347	5 347	1 347
Gross margin	**58%**	**33%**	**8%**

[a] TZS 100 per kg, [b] TZS 200 per kg, [c] TZS 300 per kg
Source: Messemaker (2008).

An extraction efficiency of 1 litre of oil from 5 kg of seed was used in the analysis, although the efficiency was observed on occasions to fall to 1 litre from 8 kg of seed. The jatropha oil price was always around TZS 2 000 per litre, whereas the seed price varied by area and supplier. The break-even seed price was TZS 334 per kg, above which oil production would be unprofitable. High seed prices in 2008 threatened the short-term viability of this business, but long-term oil extraction would appear profitable. Respondents confirmed the viability of mechanical oil extraction using powered Sayari expellers.

Soap production

Kakute Ltd, one of the Tanzanian organizations promoting jatropha for oil production, erosion control and soap making, conducted an evaluation in 2003 of the profitability of jatropha-related activities. It found soap making to be more profitable than oil extraction which, in turn, was more profitable than seed collection or production (see Table 12).

TABLE 12: **PROFITABILITY OF JATROPHA-RELATED ACTIVITIES**

ACTIVITY	RETURN ON LABOUR USD PER HOUR
Collection and sale of jatropha seeds	0.29
Oil extraction	1.09
Soap making	2.82

Source: Henning (2004b).

Soap produced from jatropha is sold as a medical soap, effective in treating skin ailments. Henning (2004b) noted that jatropha soap is sold in dispensaries at a higher price than other soaps on the market.

Photo: MESSEMAKER

PLATE 21: Jatropha soap, Tanzania.

However, Messemaker (2008) found soap production to be less profitable. The gross margins of the Kakute Ltd and Messemaker studies were not directly comparable, as the Messemaker study factored in fixed costs of rent and equipment depreciation, and higher costs for packaging materials. The Messemaker study respondents indicated that many people had stopped making soap due to the high price of jatropha oil.

Limited demand for the product, at three times the price of other soaps, was probably a contributing factor. On a small scale, with low overheads, soap making may be considered marginally profitable at an oil price of TZS 2 000 per litre.

Use of jatropha oil

Two northern Tanzanian firms, Diligent Energy Systems and InfEnergy, both with experience in producing biodiesel from jatropha oil, reached similar conclusions:

- manual seed selection is necessary,
- powered oil expellers are most economical,
- continual laboratory quality testing is required, and
- methanol must be imported as none is produced in-country.

By 2008, both firms had ceased production of biodiesel from jatropha oil, due to the high price of jatropha seeds. Economic viability could only be achieved at prices of TZS 30–40 per kg, indicating that producing biodiesel from jatropha was not profitable (Messemaker, 2008).

The Kakute stove, a cooking stove using jatropha oil developed by Kakute Ltd, proved unpopular due, in part, to the price of jatropha oil which, at USD 2.00 per litre, was three times the price of diesel and kerosene (Henning, 2004b). In addition, Messemaker (2008) found that jatropha oil was not used for cooking or lighting because the jatropha oil stoves and lamps did not work satisfactorily.

A number of organizations installed multifunctional platforms (MFPs)[6] in rural areas with plans to scale up the programme. For example, the towns of Engaruka and Leguruki both had MFPs in 2008.

[6] A multifunctional platform consists of an energy source (usually a diesel engine) mounted on a chassis, that powers a variety of end-use equipment such as grinding mills, de-huskers, oil presses, battery chargers and generates electricity for lighting, welding, refrigeration and water pumping.

However, in Engaruka, there were ownership and management issues with the MFP and it was not in operation. The Engaruka MFP charged TZS 3 000 (USD 2.61) per month for electricity with permission to connect two light bulbs. The maximum number of consumers possible for its generating capacity was 100, although there had only been 24 subscribers. The actual running costs per household when fully subscribed, excluding installation costs, was TZS 5 595 (USD 4.87) per month (see Table 13).

The Leguruki MFP had no oil expeller and so was running on mineral diesel. During daylight hours, it provided services such as grain milling, and at night, it generated electricity for six hours.

TABLE 13: **ENGARUKA MULTI-FUNCTIONAL PLATFORM COSTS PER MONTH (TZS)**

INVESTMENT COSTS (INSTALLATION)	**TZS**	**USD[a]**
MFP	135 000	117.39
Mini-grid	133 333	115.94
Pre-paid meter for 100 HHs	100 000	86.96
Connection for 100 HHs	66 667	57.97
Total installation cost	435 000	378.26
VARIABLE COSTS		
Maintenance (at 10% of installation)	43 500	37.83
Electricity 6 hours per day – diesel		
Diesel – 6 litres per day	366 000	318.26
Operation and management (2 workdays)	150 000	130.43
Total running cost excluding installation	559 500	486.52
COST PER HH USING DIESEL	**5 595**	**4.87**
Total cost with installation	994 500	864.78
Cost per HH	9 945	8.65
Electricity 6 hours per day – jatropha oil		
Jatropha seed required including for oil for expeller	903.9 kg	
Seed cost per TZS / Kg	300	0.26
Total seed cost	271 159	235.80
Operation and management (2 workdays)	152 093	132.25
Total electricity running cost on Jatropha oil excluding installation	466 752	405.87
COST PER HH USING JATROPHA OIL	**4 675**	**4.06**
Total cost with installation	901 752	784.13
Cost per HH	**9 017**	**7.84**

aExchange rate of TZS 1 150: USD 1.00. Source: Adapted from Messemaker (2008).

Comparing the cost of kerosene lamps and off-grid electricity strengthens the case for MFPs as a pro-poor technology. An average household using 6 to 9 litres of kerosene per month will spend approximately TZS 12 000, while the full cost per household for power from a jatropha-fuelled MFP is TZS 9 017 per month.

Using jatropha oil with a seed cost of TZS 300 per kg would reduce the subscriber cost to TZS 4 675 (USD 4.07) per month. The seed cost would need to rise above TZS 400 before diesel would be the cheaper option. The calculations assumed no consumer tax would be imposed on the oil. There was no metering of consumption and no use of low energy light bulbs which would make utilization more efficient. Box 4 summarizes the Tanzanian lessons learned.

BOX 4. **Tanzania – Lessons learned**

- Jatropha seed production is marginally profitable at best, based on present varieties and agronomic practices. Short-term profitability may be high where the price is inflated by demand for seed for planting. Lack of knowledge and low productivity are the main obstacles to profitable farming of jatropha.
- Jatropha oil extraction and soap making are both more profitable than growing jatropha. The scalability of soap making is limited by local market demand. Regional and overseas markets need to be explored.
- Biodiesel production was not feasible in 2008 when the jatropha oil price was TZS 2 000 per litre compared to the diesel retail price of TZS 1 600 per litre.
- MFP units are most in demand for de-husking and milling grains, according to the UNDP project. While provision of off-grid electricity using MFPs appears to be less costly than kerosene lamps, breakdowns, fuel shortages and operational issues probably constrain greater acceptability. It is important that the MFPs use sustainable technology in remote environments to avoid extended periods of non-operation.
- Using jatropha oil instead of diesel can lower running costs of MFPs when the costs of jatropha seed and oil extraction are included in the business model. This assumes no increased repair costs or depreciation resulting from using oil in the place of diesel.
- Jatropha oil-burning stoves and lamps need further improvement before widespread acceptance can be expected.

Asia – India

Between 1986 and 2003, farmers in Nashik, Maharashtra State, began growing *Jatropha curcas*, reaching a peak in excess of 8 000 ha involving more than 2 500 farmers. The planting material was sourced globally but yield expectations were not met and, after seven years, yields stabilized at less than 1.25 tonnes per ha. The optimum spacing was found to be not less than 3.0 x 3.0 metres and, while irrigation increased vegetative growth, there was a less-than-proportionate increase in yield. The plantations were abandoned by 2003, mainly because of low seed yield, poor oil content and poor or variable oil quality. The trees' non-uniformity was easily observed in the field (Ghokale, 2008).

In 2003, India set up a "national mission" to plant jatropha in wasteland areas. With a goal of using jatropha to meet renewable energy needs, in spite of the failed Nashik project, strong government support for jatropha has included setting guaranteed prices at the state level and making various grant schemes available. Research into the agronomy and utilization of jatropha in India has led to gaining meaningful field experience.

Community scheme wasteland development

In 2004/5, as part of the national mission, India's National Oilseeds and Vegetable Oils Development Board (NOVOD) launched a jatropha research and improvement programme, coordinating input from 35 institutions across 23 states. They collected 726 jatropha accessions, followed by yield trials and agronomic research.

Through a cooperative effort by NOVOD, ICRISAT and the District Water Management Authority (DWMA), projects were initiated in Ranga Reddy and Kurnool Districts of Andhra Pradesh for the rehabilitation of degraded lands to improve the livelihoods of the rural poor, through growing *Jatropha curcas* and *Pongamia pinnata* for oil production. The strategy involved the use of degraded common property resource (CPR) lands held by the *panchyat* (local village council). Self-help groups of landless people and small farmers were formed with the assistance of a local NGO, and thrift and credit activities were initiated. Labour for establishment and care of the plantation was paid for at the rate of Rs 60 per workday as an employment creation scheme.

PLATE 22: **Jatropha plantation on wasteland, Velchel, Andhra Pradesh.**

In Ranga Reddy District, this benefited 80 members of the local Velchel community. While the scheme members were given usufruct rights to the land for harvesting the produce, the land and trees remained in public ownership.

The Velchel plantation was established in 2005 with 150 ha of jatropha planted at 2.0 x 2.0 metre spacing with lines of pongamia every 100 metres. The annual rainfall in the area is 780 mm. The soil, a stony laterite, is deficient in nutrient and organic matter.

Plantation operations reportedly carried out included:

- watering in the first year only, to aid establishment of the tree seedlings,
- ring weeding the trees and laying the cut weeds as mulch,
- fertilizing the trees in 2005 and 2007 with 25 kg per ha each of diammonium phosphate (DAP) and urea, with plans to continue to apply every other year,
- digging basins around the trees and staggered trenches across the slopes, to trap water and encourage infiltration,
- pruning, to increase branching, and
- intercropping the trees in the first year with pigeon pea, millet and castor bean (although crops were subsequently destroyed by grazing animals).

No insecticides were used, although insect pests were present, in particular the scutella bug and termites.

The 2008 harvest yield – 40 grams per tree – was equivalent to 100 kg per ha (Wani, S. P., personal communication, 23 April 2009). The yield is projected to be 1 000 kg per ha by 2011 (Wani *et al.*, 2008). The trees on the plantation were seen to be highly variable with male/female flower ratios of 5:1 to 30:1. Velchel was expected to benefit from the installation of a jatropha oil-fuelled diesel power unit and power-driven oil expeller in the village. Farmer respondents thought it likely that seed cake would be used for fertilizer on higher value food crops.

A gross margin analysis for 2008 and a projection for 2011 are shown in Table 14. This does not include fixed costs of establishment, infrastructure, rent and scheme administration.

TABLE 14: **GROSS MARGIN FOR JATROPHA SEED PRODUCTION ON MARGINAL LAND AT VELCHEL**

	YEAR 2008 *(no fertilizer)*			**YEAR 2011 *(with fertilizer subsidy at 2008 prices)***		
	Units /ha	**Rs/ha**	**USD/ ha[d]**	**Units/ ha**	**Rs/ha**	**USD/ ha[d]**
DAP fertilizer (kg/ha)	0	0		50	1 350 [a]	32.40
Urea fertilizer (kg/ha)	0	0		50	850 [a]	20.40
Labour for fertilizing, weeding, pruning [b]	44 work days	2 640	63.36	44 work days	2 640	63.36
Labour for harvesting, husking [b]	25 work days	1 500	36.00	25 work days	1 500	36.00
Total variable costs		4 140	99.36		6 340	152.16
Seed production (kg)	100	1 000c		1 000	10 000[c]	
Net benefit (loss)		(3 140)	(75.36)		3 660	87.84
Gross margin		**-314%**			**37%**	
Yield (kg/ha) to achieve B/E	414			634		

[a] 2008 subsidized farm-gate price for DAP of Rs 27 000 per tonne and for urea of Rs 17 000 per tonne.,

[b] Rate paid of Rs 60 per workday., [c] Jatropha dry seed sale price of Rs 10 per kg., [d] USD 1.00 = R 41.67 (June 2008).

Source: Brittaine (2008).

The gross margin, with a 50 percent fertilizer subsidy, is projected to be positive at plantation maturity and for yields in excess of 634 kg per ha. DAP and urea will be applied in alternate years at the rate of 50 kg per ha each. No fertilizer was applied in 2008, which would go some way towards explaining the low yield. However, other important benefits will accrue from implementing this type of scheme and which should be accounted for, including employment generation in remote rural areas, reclamation of degraded land and the sustainable local production of a renewable energy source. Lessons from India are summarized in Box 5.

BOX 5. **India – Lessons learned**

- Despite using seed sourced worldwide, India's experience with growing jatropha has included variable phenotypes with low yields, and poor oil content and quality. Yet low seed yields can be part of a sustainable model, as shown by the NOVOD–ICRISAT–DWMA initiative. The initiative included broader objectives such as embracing wasteland reclamation, employment generation and local production of renewable bioenergy to improve living standards and catalyse the development of the rural non-farm sector. The question is whether continued government support is sustainable and whether the approach is scalable.
- Land tenure problems can arise with wasteland reclamation programmes due to uncertain ownership and the potential for future competing land claims as the land becomes productive. Retaining public ownership but allowing usufruct rights appears to be a workable solution.
- The inclusion of other tree oilseed species in jatropha plantations is a pro-poor strategy, such as Velchel's inter-planting of jatropha with slow-maturing *Pongamia pinnata* and the fast-maturing castor bean. Intercrops may be damaged by grazing livestock, meaning planting boundaries of jatropha may be worthwhile.

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