



# **MANGO BASED AGRI-HORTCULTURAL SYSTEM FOR DEGRADED LANDS OF NORTH-WESTERN HIMALAYAS**



**CENTRAL SOIL & WATER CONSERVATION  
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## FOREWORD



A large area of foothills (35 % of total geographical area of Doon Valley) of north-west Himalayan region is lying unutilized as wastelands which lie in the path of meandering of torrents which deposit large amount of coarse material on land. Such lands have shallow soil depth (< 30 cm) and have gravels/pebbles/stones (70-75%), sand (20-25%), silt (3-5%) and clay (2-3%). Thus, poor site conditions lead to low water holding capacity and poor nutrient status which make these lands unfit for cultivation of agricultural crops and support only thorny bushes and seasonal grasses. However, these areas can be utilized economically by establishing agri-horticultural systems with pit profile modification and providing life saving irrigation to the fruit plants during the summers (March-June) either by drip irrigation or by manual watering.

Agri-horticultural systems is a land use and land management system in which agricultural crops, viz; pulses, flowers, medicinal & aromatic plants, spices & condiments are cultivated in and around an orchard. Mango is an important and popular subtropical fruit species of the region (grows up to 1200 m amsl). Mango plant is easy to establish and also it does not require much inputs for its maintenance and gives good returns. Mango based agri-horticultural systems help in employment generation through diversification by introducing the crops in the pure mango system, in addition to management of orchards and fruits processing, thereby increasing income and reducing migration of rural folk of foothill of Himalayan region to urban areas. Thus, to have more productivity from degraded lands through diversification create more opportunities for employment and income generation which will ensure the socio-economic development of the rural people of the area.

The research work conducted at the CSWCRTI, Research Farm Selakui (Dehradun) and has been presented in this brochure to make the farmers aware to utilize the degraded lands of the foothills of north-west Himalayan region economically viable implementing this technology.

A handwritten signature in blue ink, appearing to read 'K.S. Dadhwal', written over a horizontal line.

**(K.S. Dadhwal)**

Actg. Director

CSWCRTI, Dehradun

# MANGO BASED AGRI-HORTCULTURAL SYSTEM FOR DEGRADED LANDS OF NORTH-WESTERN HIMALAYAS

## INTRODUCTION

Doon Valley, situated on the periphery of the outer Himalayas has about one third of its area (one lakh hectares approximately) either occupied by gravelly river bed or is inhabited by perennial bushes like *Lantana camara* or seasonal grasses. The soil of these lands has boulders, gravels, stones, etc (70-75%), sand (20-25%), silt (3-5%) and clay (2-3%) with shallow soil depth (15-20 cm). Thus, lands are inherently infertile and cannot be used for cultivation of crops, but can be used for growing fruit trees or combination of trees and fodder yielding grasses.

Mango (*Mangifera indica*) (Hindi *Aam*) is an important fruit of the sub Himalayan region, and is raised at elevation ranging from 500-1200 m amsl. The fruit has high nutritive value, excellent flavour, and attractive appearance and is quite popular in the region. Trees of mango are long lived (50-60 years) and begin to bear fruits after 4-5 years to reach commercial bearing age by 10 years. The wide space between tree lines provides an opportunity to grow suitable intercrops with low input requirement. Shade tolerant crops like turmeric can also be grown on such lands after attaining full canopy by the trees. The suitable cultivars of mango are classified into two main groups.

- (i) Alternate fruit bearing cultivars like Dashehari, Langra, Chausa, Bombay Green, Fajri, Lucknow Safeda, Ramkela
- (ii) Regular fruit bearing cultivars like Dashehari-51, Mallika, Amrapali, Arka Aruna, Arka Puneet, Pusa Surya, Ambika, Pusa Arunima, Gaurav, Rajiv, CISHM-1 & 2, etc. which are suitable cultivars for the lower and mid elevation zones.

## TECHNOLOGY DEVELOPED

The degraded lands in north western Himalayas are poor in fertility and can be restored with deep rooted fruit plants along with cultivation of legumes as an intercrop. Technology (mango + cowpea *Toria* cultivation) was developed for utilization of marginal and degraded lands for improving productivity of mango based agro-forestry systems which is a prime concern of farmers / orchardists of the region. The production of sub-tropical fruits in these lands with suitable under-storey crops till tree canopy closure, is beneficial for productive utilization of these hitherto unproductive lands. Mango based agro-forestry systems can produce good dividends and also improve soil health.

## ESTABLISHMENT OF AGRI-HORTICULTURAL SYSTEM

- Degraded lands in Doon Valley can be restored through cultivation of deep rooted fruit plants with leguminous intercrops (Photo 1).
- Mango based agri-horticulture system was developed for utilization of marginal and degraded lands,
- Fruit species Mango block plantation.
- Inter crop- Cowpea-*toria*.

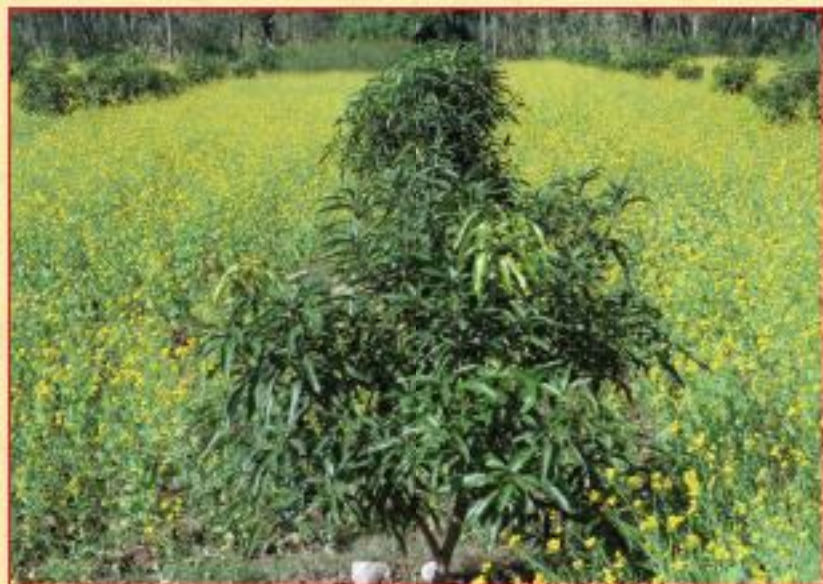


Photo 1 : *Toria* intercropped with mango on degraded lands

### Site Selection

- Clear the area of unwanted shrubs and weeds. Then mark the area for pit digging at 8 m apart in square or rectangular system.
- Preferably, triangular system of plantation system is to be followed as it accommodates 16% more plants as compared to square system of plantation.
- Proper drainage for safe disposal of water during rainy season should be provided.

### Pit Digging and Filling

- Pit digging is done during in the month of April to May so that natural sterilization of soil may take place in the sunlight for at least 15-20 days. 1x1x1 m pit size is suitable for mango plant.
- Remove stones and gravel from the pit. Pit filling mixture contains FYM @ 50 kg, sand, soil, (5:1:1) for degraded lands of Doon Valley and half dose of recommended NPK (50:25:50 g) with chloropyriphos @ 20 ml per 10 litres of water for drenching of pit. This mixture is filled back in the pit.
- The level of filling mixture into the pits should be up to 10-15 cm above the ground level.

### Planting

- Planting of selected mango cultivars of plants should be done with one year old plants of 1-1.5 m height during July - August. Keep graft union 20-30 cm above the ground and press soil firmly around the base.
- Provide support to mango plants with 1.5 m long stakes to keep plant straight.
- Provide water about 20 litre of water immediately after planting.

- Replace the mortality in early rainy season next year.
- The plants during December-February should be covered / thatched with locally available material to prevent damage from frost in the initial 1-3 years.
- Irrigation is to be done to save plants from frost damage.

### Irrigation Requirement

- Mango is hardy and need less water than many other fruit plants. Apply irrigation (4 cm) at 2-3, 4-5 and 10-15 days interval in 1, 2-5 and 5-8 years old plants, respectively during moisture stress period.
- 2-3 irrigations are required after 10<sup>th</sup> years onward from fruit set to fruit maturity with 4 cm depth in Mango plants.
- Flowering, fruiting and fruit development stages are critical stages in mango for considering irrigation.
- Apply 50 litre of water twice a week during summer or moisture stress period and 40 litre of water once a week during frost period upto ten years of age.
- Watering to the plants can be done during the moisture stress period (March to June) through drip irrigation system at weekly interval. 20-25 litre water per plant is applied through drip system at a pressure of 8 litres hr<sup>-1</sup> cm<sup>2</sup> to maintain various physiological activities in the plant system.
- Four drippers are installed in four directions in the plant basin for irrigation.

### Management of Orchard

- Dead, dried, diseased and overcrowded branches of mango plants are pruned to have strong framework. Water sprouts / off shoots are removed periodically. The cut ends of every branch and main shoot is pasted with *Chaubatia* paste or Bordeaux mixture (mixture of copper sulphate, hydrated lime and oil) available in the market in different formulations.

- Keep the plants upto 1.0 m from ground level without any branch. Train mango plants in modified leader system by allowing only 4-6 branches for better light infiltration to harvest good quality fruits.
- Remove weeds before placing fertilizers in the plant basin in February -March and September-October. A one year old mango plant requires 50 kg well decomposed farmyard manure, 100 g nitrogen, 50 g phosphorus and 100 g potash in addition to 25 g zinc, 25 g borax and 25 g lime powder in each pit.
- Doses of manures and fertilizers are increased with the increasing age and stabilized after 10 years of age. Mango trees at 10 years and above age require 1000 g nitrogen, 500 g phosphorus and 1000 g potash per plant, which is supplied by applying 1978 g urea, 1087 g diammonium phosphate and 1667 g muriate of potash.

## INTERCROPS

The operation calendar is given in Table 1.

- Introduce leguminous intercrops (black gram, red gram, green gram, cowpea, cluster bean, etc) to restore fertility of degraded lands.
- Introduce intercropping from second year onwards after planting.
- Avoid intercropping of voracious nutrient feeder intercrops like turmeric, potato and ginger upto 6-7 years.

### *Kharif*

- Field preparation for sowing is undertaken after the first onset of rains and FYM is added 5 t ha<sup>-1</sup>. Sowing of cowpea at the rate of 20 kg ha<sup>-1</sup> is carried out after the first monsoon showers in July.



**Table 1: Month wise calendar of operations in Mango orchard along with field crops**

Activities	Months											
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar
Site selection and clearing	✓	-	-	-	-	-	-	-	-	-	-	-
Pitting and filling back	-	✓	✓	-	-	-	-	-	-	-	-	-
Planting of Mango	-	-	-	✓	✓	-	-	-	-	-	-	-
Training & pruning of plants	-	-	-	-	-	-	-	-	-	-	✓	✓
Weeding hoeing, fertilizer application	✓	-	-	-	-	✓	✓	-	-	-	✓	✓
Propping up of plants, watering	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Harvesting of fruits	-	-	✓	✓	-	-	-	-	-	-	-	-
Monitoring for disease/pests	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ploughing of field and sowing of cowpea	-	-	-	✓	-	-	-	-	-	-	-	-
Cleaning & tending of plants, weeding in inter-crops	-	-	-	✓	✓	-	-	-	-	-	✓	✓
Harvesting of cowpea pods	-	-	-	-	✓	✓	-	-	-	-	-	-
Ploughing back of stover and sowing of toria	-	-	-	-	-	-	✓	-	-	-	-	-
Harvesting of toria	-	-	-	-	-	-	-	-	-	✓	✓	-

- Weeding is carried out 1-2 times and with a good crop 3-4 pickings of pods is possible.
- Crop residues / biomass is turned back into the soil by ploughing for improvement of soil characteristics which added 15.9, 6.35 and 32.3 kg ha<sup>-1</sup> of N, P, K once the pickings are over,
- Average yields of 14.0 q ha<sup>-1</sup> green pods of cowpea may be obtained under optimum management in degraded sites.
- Turmeric crop can be taken after 9-10 years of mango plantation as it grows well in shade and its yield is not affected much by developing mango canopy.

- Turmeric rhizomes may be planted @ 18.0 q ha<sup>-1</sup> in ridge and furrow system during May-June before onset of monsoon in the field. Two weedings are to be completed during rainy season, as and when necessary.
- Turmeric is harvested in the month of November-December. An average yield of 50.0 q ha<sup>-1</sup> of fresh rhizomes is obtained every year with recommended dose of nutrients. It also produced 20.0 q ha<sup>-1</sup> dried leaves, which can either be used as mulch for mango plants or recycled into field for improving fertility of degraded lands.

### **Rabi**

- Field is prepared in the first week of October by ploughing up to the plough sole depth.
- *Toria* @ 4.0 kg ha<sup>-1</sup> is broadcast just after the second ploughing on the same day or the next day.
- Crop is harvested in the month of January and stover is ploughed back into the soil.
- An average yield of 2.8 q ha<sup>-1</sup> is obtained from the degraded site.
- An average 7.2 q ha<sup>-1</sup> stover yield of *Toria* is harvested and ploughed back into the field for fertility improvement.

## DISEASES AND CONTROL MEASURES

### 1) **Powdery Mildew (*Oidium mangiferae*)**

**Symptoms** : The characteristic symptom of the disease is the white superficial powdery fungal growth on leaves, stalk of panicles, flowers and young fruits.

**Control** : Spray wettable sulphur @ 0.2 per cent (2 g Sulfex / litre) or Karathane @ 0.1% (1 ml / litre).

### 2) **Anthraxnose (*Colletotrichum gloeosporioides*)**

**Symptoms** : The disease causes serious losses to young shoots, flowers and fruits under favourable climatic conditions (high humidity, frequent rains and the temperature

range of 24-32°C). The disease produces leaf spot, blossom blight, wither tip, twig blight and fruit rot symptoms. Black spots develop on panicles as well as on fruits.

**Control** : Trees may be sprayed twice with Carbendazim or Bavistin @ 0.1% (1 ml / litre) at 15 days interval during flowering period. Spraying of copper oxychloride @ 0.3% (3 ml / litre) is recommended for control of foliar infection.

### 3) Mango Malformation

**Symptoms** : The malformed panicles remain unproductive and are characterized by a compact mass of male flowers, greenish in colour and stunted in growth.

**Control** : Some remedial measures to control mango malformation are as follows: (i) Spraying of 100 ppm solution of planofix or NAA during the first week of October followed by deblossoming at bud burst stage. (ii) Deblossoming of early infested panicles.

### 4) Fruit Drop

**Symptoms** : Fruit drop is caused by embryo abortion, climatic factors, disturbed water relation, lack of nutrition, attack of disease and pest and hormonal imbalances.

**Control** : Foliar application of NAA or 2, 4-D @ 20 ppm is effective in controlling fruit drop in mango.

### 5) Black Tip

**Symptoms** : The necrotic spot develops at distal end of the fruit. The pericarp and mesocarp disintegrate resulting dark brown flesh upto stone with a layer of collapsed tissues.

**Control** : The incidence of black tip can be minimized with spray of borax @ 1% or caustic (0.8%).

## PESTS AND THEIR MANAGEMENT

### 1. Mango hopper (*Idioscopus* spp. and *Amritodus atkinsoni*)

**Damage caused** : The nymphs and adults have piercing and sucking type of mouth parts from which hopper punctures and sucks the sap and sooty mould (fungal infection) develops with honey dew secreted by the pest (Photo 2a).

**Management** : Three sprays of 0.2% carbaryl or 0.04% monocrotophos or chlorpyrifos at 15 days interval control the hoppers effectively.

## 2. Mango mealy bug (*Drochicha mangiferae*)

**Damage caused :** Nymphs and adults suck the plant sap and reduce the vigour of the plant and destroy inflorescence and cause fruit drop and produce sooty mould (Photo 2b).

**Management :** (i) Fasten 400 gauge alkathene sheet of 25 cm width to the tree trunk, 30 cm above the ground level in mid December, (ii) If nymphs have already ascended the tree, spray 0.04% monocrotophos or 0.06% dimethoate.

## 3. Mango fruit fly (*Bactrocera dorsalis*)

**Damage caused :** The fruit fly causes serious damage to the mature mango fruits. The female punctures the outer wall of the mature fruits with the help of its ovipositor and inserts eggs in small clusters inside the mesocarp of mature fruits. After hatching, the maggot (larva) starts feeding on the fruit pulp, which appears normal from outside, but drops down finally (Photo 2c).

**Management :** Adult fruit fly can be controlled by bait sprays of carbaryl (0.2%) + protein hydrolysate (0.1%) or molasses starting at pre-oviposition stage during April-May. The spray is repeated once again just after 21 days.



(a) : Hopper nymphs

(b) Mango mealy bug

(c) Fruit fly

Photo 2 : Insects affecting mango productivity

## FRUIT YIELD

- ➔ Mango trees begin to yield fruits after the fourth year of planting and average yield of 45 kg tree<sup>-1</sup> (7.0 t ha<sup>-1</sup>) is expected. A fully grown mango tree (10<sup>th</sup> years onward) may give fruit yield in the range of 45 - 162.5 kg tree<sup>-1</sup> (average yield 103.75 kg tree<sup>-1</sup> equivalent to 16.2 t ha<sup>-1</sup>) (Photo 3).



**Photo 3 : Fruit laden Mango tree raised on degraded lands**

- ➔ Decline in the yield begins from the 50<sup>th</sup> year and by the 60<sup>th</sup> year the orchard needs to be replaced with a fresh plantation or rejuvenated. Rejuvenation is done by heading back of mango at 1-2 m height in the month of December - January. Allow only 4-6 shoots for 3-4 months. Grafting with desired mango cultivars may be completed by July-September in the same year.

## **BENEFIT**

- 1. Soil and water conservation :** A well-developed agri-horti system helps to conserve soil and water on sloping land, builds up soil organic matter and provides multiple benefits to the user.
- 2. Additional income during juvenile phase of orchard :** Small and marginal farmers who depend on cultivation of annual crops get income from this system. The yield of intercrops is available from the first year and the fruits from the fourth year depending upon the fruit species.

3. **Employment generation** : On a ten year cycle of mango orchard establishment, management and harvest of fruits, intercultural operations of intercrops generate employment opportunities of 130-140 man days/ha/year.
4. **Food and nutritional security** : Fruit based land use system will increase fruit availability and nutritional security to the farmers. Degraded land unfit for agriculture is utilized for mango based agri-horticultural systems using this cropping sequence for a period of about 8 years until canopy closure by the over storey begins and thereafter, shade tolerant crops like turmeric and colocasia can be grown as under storey crops.

## ECONOMICS

The cost of establishment of a mango orchard is ₹ 39,200 ha<sup>-1</sup>. This cost can be reduced further to ₹ 34,780 ha<sup>-1</sup> by adopting *in-situ* grafting technique of plant propagation (Table 2). Evaluation of the mango based agri-horticulture system revealed that there is positive effect of cowpea on the performance of mango yield.

**Table 2 : Cost of establishment of Mango at 8 x 8 m spacing (2010 Prices)**

Activity / Works	Approximate cost (₹ ha <sup>-1</sup> )	
	ex-situ grafting	in-situ grafting
156 plants @ ₹ 25 / plant in nursery raised and ₹ 5.0 / plant for <i>in-situ</i> grafting	3900	780
Cost of pit digging and refilling @ ₹ 60/pit	9360	9360
520 cft FYM @ ₹ 6 / cft	3120	3120
Pit filling mixture (soil, fertilizer, FYM and (0,2%) chloropyriphos @ ₹ 10 / pit)	1560	1560
Planting, staking and watering @ ₹ 5.0/unit	780	780
Pesticide application @ ₹ 5.0 / unit	780	780
Training of plants @ ₹ 5.0 / plant	780	780
Weeding, hoeing, fertilizer application twice in a year @ ₹ 10 / unit	3120	3120
Irrigation (14 Nos.) @ ₹ 1000 / irrigation	14000	14000
Gap filling against mortality (about 40 plants)	1000	-
Miscellaneous (implements, etc)	800	500
<b>Total</b>	<b>39200</b>	<b>34780</b>

Mango yield increased with age of plantation averaging 45 kg tree<sup>-1</sup> (7.0 t ha<sup>-1</sup>) upto 10<sup>th</sup> year. Net benefit (ha<sup>-1</sup> yr<sup>-1</sup>) from mango based agroforestry system in the first 10 years ranged between ₹ 12,582 to ₹ 16,849, whereas sole average income from mango is ₹ 12,191 (Table 3). After 10 years, net income (ha<sup>-1</sup>yr<sup>-1</sup>) from mango + turmeric and mango + colocasia was ₹ 29,808 and ₹ 21,308 ha<sup>-1</sup> yr<sup>-1</sup>, respectively.

**Table 3: Economic parameters of different agri-horti systems from first year to tenth year**

Economic parameters	Mango based Agri-horti Systems					
	Sole Mango - Toria	Mango + Cowpea - Toria	Mango + Sesame - Toria	Mango + Blackgram - Toria	Mango + Okra	Arhar alone
Input cost (₹ ha <sup>-1</sup> )	123790	198771	198756	218901	220761	187221
Output cost (₹ ha <sup>-1</sup> )	245700	324582	324582	360584	357900	325255
Net income (₹ yr <sup>-1</sup> ha <sup>-1</sup> )	12191	16849	12583	14168	13714	13803
Income after ten years						
	Sole Mango	Mango + Turmeric	Mango + Colocasia			
Input cost (₹ ha <sup>-1</sup> )	15560	70192	56692			
Output cost (₹ ha <sup>-1</sup> )	39000	100000	78000			
Net income (₹ yr <sup>-1</sup> ha <sup>-1</sup> )	23440	29808	21308			

## SCOPE OF APPLICATION

Mango based agroforestry practice is suitable for the lower western Himalayan region up to elevations of 1200m amsl. Degraded lands and lands not fit for raising field crops can be used for the cultivation of mango fruit along with intercrops.



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