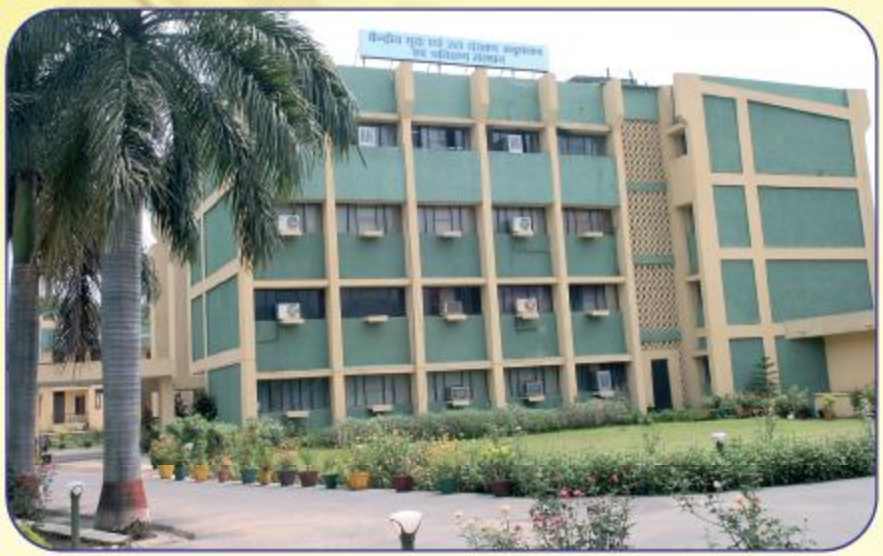

AONLA BASED AGRI-HORTICULTURE SYSTEMS FOR SLOPPY LANDS IN DOON VALLEY

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FOREWORD

Doon valley is dominated by rainfed farming characterized by soils of varying capability and slopes in a fragile eco-system beset with highly unpredictable and erratic pattern of rainfall giving rise to droughts of variable intensity and duration. Amount of residual soil moisture and status of soil fertility influenced crops productivity in post monsoon scenario. Fruit cultivation is widely practiced with or without intercrops in the lower Himalayan foothills and the Indo-Gangetic plains, where a large number of fruit species are grown at field boundaries as well as block plantation in Doon Valley.

Aonla (*Emblica officinalis* Gaertn) is known for its nutraceutical properties in our country. It thrives well in the subtropical to tropical climate under rainfed condition. Tree is planted in pits spaced 6m x 6m apart which allows an opportunity to utilize the interspaces for growing crops during initial years. As the agri-horticultural system is established on the sloppy lands with limited input use under rainfed conditions, it leads to early mortality and poor fruit productivity, making the system economically unattractive. Thus, to make the system more productive and get higher returns under prevailing situations, it is essential that system must be supplemented with conservation measures so that monsoon residual soil moisture may be conserved for use during post monsoon season. *In-situ* legume mulching is one such conservation practices which not only conserved the moisture but also enriches the soil with nutrients by recycling the biomass. Thus, aonla based agri-horticultural systems supplemented with conservation measures helps in enhancing the productivity on sloppy lands under rainfed conditions. The system leads to increased income by enhanced production which ensures food security and socio-economic development of the rural people.

Research conducted at CSWCRTI, Research Farm, Selakui (Dehradun) presented in this brochure indicates that aonla based agri-horticultural systems, with conservation measures, enhance production and conserve the natural resources on sloppy lands under rainfed conditions.

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AONLA BASED AGRI-HORTICULTURE SYSTEMS FOR SLOPPY LANDS IN DOON VALLEY

INTRODUCTION

Doon valley is characterized by soils of varying capability on different grades of slopes; depleting green cover giving rise to a fragile eco-system; unpredictable, erratic and aberrant rainfall that leads to heavy runoff and sediment loss and hatches droughts of variable duration and intensity; deficit residual soil moisture during post monsoon scenario and poor soil fertility. Deficit soil moisture or soil moisture aberrations and poor soil fertility need to be corrected for sustained agricultural production in dominant rainfed production system. Under such situations, various agroforestry options mainly the fruit based alternate land use systems like agri-horticulture, horti-pastoral, horti-silviculture, agri-horti-silviculture and horti-medicinal needs to be standardized from the point of view of agricultural production and conservation of natural resources. Out of the prominent fruit species in lower Himalayan region, aonla can be grown successfully in rainfed situations because of its hardy plant ideotype suited to adverse edapho-climatic conditions and less inputs. Since, about 80% of total fruit production comes from rainfed area in our country, therefore, to enhance overall production and monetary benefits from the system as a whole and to conserve natural resources than the sole crop of maize-wheat/ mustard and aonla independently, an aonla based agri-horti study was conducted at CSWCRTI Research Farm, Selakui, Dehradun on silty clay loam soil of class II land capability (poor in nitrogen, medium in phosphorus and high in potassium) at two percent slope for six years involving two spacings of aonla (6x6 m and 8x8 m), four conservation agronomic practices (sole maize, maize + cowpea intercrop, maize + *in-situ* live mulch and maize + *in-situ* sunhemp mulch) and two cropping sequences (maize-wheat and maize-mustard) under rainfed conditions.

TECHNOLOGY DEVELOPED

The agri-horti technology with aonla clearly established higher maize grain yields at 6x6 m aonla spacing; maximum productivity and net benfits under maize + live sunhemp mulch-wheat cropping sequence and highest growth of aonla in terms of height, crown diameter and diameter at breadth height as well as soil fertility build up under maize + live sunhemp mulch treatments. Live sunhemp mulch in maize conserved maximum residual moisture by promoting rain water conservation and minimizing the runoff. Live sunhemp mulch also led to higher soil fertility build up that resulted in more availability of soil moisture and nutrients to subsequent wheat crop during post monsoon scenario under rainfed conditions on 2% sloping land for sustainable overall productivity under an agro-eco situation where prevailing agri-horticulture system usually fail to give desired outputs in view of droughts, erratic rains, poor fertility status, lack of moisture during fruit set to fruit maturity period, etc. Trials for more than eight years revealed that aonla based agri-horticulture system can give good dividends and also enrich soil conditions by turning the green biomass of sunhemp.

- Fruit tree- Aonla plants (Cv NA-7) with plant density (277 ha^{-1}).
- Crop rotation- Maize (*in-situ* sunhemp mulching) - Wheat.

IMPLEMENTATION OF TECHNOLOGY

The details of establishment cost of aonla(6 x 6 m) is given in Table 1.

Table 1: Cost of establishment of Aonla orchard at 6x6 m spacing (2010 prices)

Activity / Work	Approximate cost (₹ ha^{-1})	
	Nursery raised	*In-situ* budding
277 plants @ ₹ 25 per plant in nursery raised and ₹ 5 per plant *in-situ* budded aonla	6,925	1,385
Cost of pit digging and refilling with mixture @₹ 50 per pit	13,850	13,850
554 cft FYM @ ₹ 6.0 per cft	3,324	3,324
Pit filling mixture (fertilizer, FYM, etc.) ₹ 10 per pit	2,770	2,770
Planting, staking and watering @ 5.0 per unit	1,385	1,385
Pesticide application @ ₹ 5.0 per unit	1,385	1,385
Training of fruit plants @ ₹ 5.0 per plant	1,385	1,385
Weeding, fertilizer application (2 times) @ ₹ 10 per pit	5,540	5,540
Watering (8 nos.) @ ₹ 1000 for each irrigation	8,000	8,000
Gap filling (25% i.e. about 70 plants)	1,750	-
Mulch application @ ₹ 10 $basin^{-1}$	2770	2770
Maintenance cost upto 6 years	14,065	14,065
Total	**63,149**	**55,859**

Digging and Filling of Pits

- Pits of 1 cubic metre are dug out in the month of April - May for natural solarization and planting is done during rainy season in July after pit filling.
- Pits are filled up to 10-15 cm above from ground level using pit filling mixture with Bavistin @ 1.5 g/litre or Diathane Z-78 @ 3 g / litre or Chloropyriphos @ 2 ml /litre of water.
- Young aonla plants at the time of planting require 50 kg FYM and 100:50:100 g NPK in addition to 25 g zinc, 25 g borax and 25 g lime powder in each pit.
- N, P and K can be supplied through urea (198 g), Diammonium phosphate (109 g) and muriate of potash (167 g) per plant.

Planting of Aonla

- One year old budded plants of aonla (cultivar NA-7) are planted during rainy season in July.
- Bud union is kept 20-30 cm above the ground while planting the budded sapling.
- Staking of aonla plants with 1.5 m long stakes is done for keeping plant erect.
- Watering is done immediately after planting with nearly 30 litres of water per plant.
- Thatching of young plants of aonla should be completed by October-November to protect the young plants during winter season for initial two years.

Water Management

- Irrigation should be applied at an interval of 6-7, 7-10 and 10-15 days in 1, 2-5 and 5-10 years old aonla plants during moisture stress period. 2-3 irrigations should be given after 10th year onwards and from fruit set to fruit maturity.
- A total of 8 irrigations are required for aonla with a depth of 4 cm in each irrigation.
- Live sunhemp mulch @ 20 kg per plant around tree trunk is applied for moisture conservation in post monsoon season.

Management of Orchard

- Dead, dried, diseased and overcrowded branches of aonla plants are pruned during January-February.

- The cut ends of pruned shoot should be pasted with *Chaubatia* paste or Bordeaux mixture.
- Branches (only 4-6 branches) are trained for ideal shape and better light infiltration for inter-crops till the 5th year.
- The main trunk of fruit plants should be allowed to grow erect up to one and half meter without any branch.
- Remove weeds before placing fertilizers in the plant basin in February-March and September-October.
- One year old budded aonla 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 increase in age and are stabilized after 10 years of age.
- Aonla trees aging 10 years and above require 1000 g nitrogen, 500 g phosphorus and 1000 g potash per plant. This can be supplied through urea (1978 g), diammonium phosphate (1087 g) and 1667 g muriate of potash per plant.
- Half dose of NPK with FYM is applied during Feb.-March in aonla before onset of flowering. Operation calendar is given in Table 2).

INTRODUCTION OF INTERCROPS

Kharif Season

- Maize field is prepared by one deep ploughing followed by two to three harrowings or three to four cross ploughing and planking.
- Seeds (20 kg/ha) of high yielding composites of maize (any one of Naveen, Kanchan, Navjot, Pusa composite 2, Pusa composite 1, Kiran and VL-88) treated with bavistin/ derosal/ agrozim @ 3 g per kg of seed, is sown at 90 x 20 cm spacing at a soil depth of 3-5 cm using seed-cum-fertilizer drill or behind plough with commencement of monsoon rains (25 June to 05 July). 40:30:30 kg NPK ha^{-1} is applied in maize crop as a basal dose by placing the fertilizer 3-5 cm in side at 3-5 cm more depth than the seed. 20 kg nitrogen per ha is top-dressed each at knee height and tasseling stages of maize.
- *In-situ* sunhemp mulch is grown during *kharif* season by broadcasting 50-60 kg good quality seed in one ha after maize sowing from second year onwards. Planking is done

Table 2 : Month wise calendar of operations in a new aonla 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 Anola	-	-	-	✓	✓	-	-	-	-	-	-	-
Training & pruning of plants	✓	-	-	-	-	-	-	-	-	-	-	✓
Weeding hoeing, fertilizer application	✓	-	-	-	-	✓	✓	-	-	-	✓	✓
Propping up of plants, watering	-	-	-	-	✓	✓	✓	✓	-	-	-	-
Harvesting of fruits	-	-	-	-	-	-	-	✓	✓	✓	✓	-
Monitoring for disease/pests	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ploughing and sowing of maize	-	-	-	✓	-	-	-	-	-	-	-	-
Cleaning and tending of plants, weeding in maize	-	-	-	✓	✓	-	-	-	-	-	-	-
Harvesting of maize	-	-	-	-	-	✓	✓	-	-	-	-	-
Ploughing back of stover and sowing of wheat	-	-	-	-	-	-	✓	✓	-	-	-	-
Weeding in wheat	-	-	-	-	-	-	-	✓	✓	-	-	-

after broadcasting the sunhemp seeds so that seed is covered by soil (to minimize losses due to birds). Green biomass of sunhemp is cut at 35-40 days and uniformly spread between maize and aonla spaces which are ploughed back at maize harvest. Being a leguminous crop, in addition to conserving moisture, it also restores fertility of the soil as well.

- Two manual weedings are carried out in maize crop at 20 and 35 days.
- Maize cobs are harvested in the month of September and field is immediately ploughed and planked after maize harvest for minimizing evapo-transpiration losses.
- Average grain yield of maize 28-30 q ha^{-1} is obtained under live sunhemp mulch apart from more soil and *in-situ* rain water conservation.

Rabi Season

- Field of wheat crop is prepared by one deep ploughing followed by two to three ploughing with disc or tines and two to three planking.
- Sowing of wheat can be done using seeds (120 kg ha^{-1}) of high yielding varieties (any one i.e. VL-738, HS-240, VL-719, UP-1109, VL-421, DT-46, VL-616 and HS-277) during 10-25 November at 5-6 cm soil depth through seed-cum-fertilizer drill or behind plough. 40:30:20 kg N, P, K per ha can be applied as a basal dose in wheat crop by placing fertilizers 3-5 cm below the seeds.
- One manual weeding at 20-25 days followed by spraying 2, 4-D (Badex G or Weeder @ 700 ml/Bladex C or Weedone @ 1.4 litre/ Tafacide or Fernoxone @ 625 ml dissolved in 400-600 litre water) at 32-35 days controls weeds in wheat crop.
- Wheat is harvested during April-May.
- An average grain yield of 16-20 q ha^{-1} wheat is obtained under rainfed conditions depending on winter rains.

PESTS AND DISEASES

Aonla is a hardy fruit tree and is rarely attacked by pests and diseases.

Pests

Two insects (bark eating caterpillar and shoot gall maker) mainly attack aonla. Following control measures can be adopted :

- Follow clean cultivation of orchard.
- Pruning of overcrowded branches.
- Apply three sprays of monocrotophos or endosulphon @ 1.0 ml per litre of water at 15 days interval against shoot gall maker.
- Inject monocrotophos or endosulphon @ 1.0 ml per litre of water into holes made by bark eating caterpillar.

Diseases

Aonla rust : It is a sporadic disease of aonla. Brownish black spots appear on the leaves as well as fruits, which lead to fruit drop. Apply three sprays of Diathane Z-78 or M-45 (0.2%) at 15 days interval against rust.

Disorders

Internal necrosis : Internal necrosis is observed in aonla fruits which starts with browning of mesocarpic tissue at the time of endocarp hardening in the month of September-October, which later extends towards the epicarp resulting into brownish black appearance of flesh.

- Grow necrosis tolerant aonla cultivars like Chakaiya, NA-6 and NA-7.
- Apply combined spray of zinc sulphate @ of 0.4% + copper sulphate @ 0.4% and borax @ 0.4% during September-October to manage internal necrosis of fruit.

FRUIT YIELD

- Cultivars of aonla have been classified into three groups, *viz*; early, mid, late season maturity.
- Aonla fruits are harvested during November to February.
- Aonla trees began to yield fruits after the fourth year of planting and average yields of 29.4 kg tree^{-1} (8.14 t ha^{-1}) under live sunhemp mulching with 277 plants ha^{-1} is harvested (Photo 1).

Photo 1: Branch laden with aonla fruit

- Commercial bearing begins from 10th year and yields upto 69.2 kg tree^{-1} (19.2 t ha^{-1}) with 277 plants ha^{-1}.
- Decline in the yields begin from the 40th year and by the 50th year the orchard needs to be replaced with a fresh plantation or rejuvenated with desired cultivars of aonla.
- Rejuvenation can be done by heading back of aonla at 1-2 m height in the month of December - January. Allow only 4-6 shoots to grow for 3-4 months. Budding with desired aonla cultivars can be completed by July-September in the same year.

BENEFITS AND ECONOMICS

Establishing aonla based agri-horticultural system on sloping lands in rainfed condition in the foothills of lower North-West Himalayan region, results in moisture conservation and addition of nutrients by recycling organic mulches. Cultivation of inter crops for the first six years is a useful method for enhancing productivity of rainfed areas in the region. Besides providing food security, the system also supplements the nutritional security to the farmers from fruits (*aonla*) as well.

Evaluation of the aonla based agri-horticulture system revealed that the practice is economically viable with a B:C ratio of 4.0 calculated for a period of 50 years life of aonla. Using the cropping sequence of maize - wheat for the first six years after planting, the payback period was calculated to be 5 years. Cultivation of maize - wheat, as inter crop in aonla plantation is a profitable land use system (Table 3). Average yields of maize (22.3 q ha^{-1}) and wheat (16.4 q ha^{-1}) were obtained in rainfed situation.

Table 3: Economics of aonla based agri-hori system (Average of 6 years)

Economic parameters	Fruit based agri-horticulture system (Aonla + Maize (Sunhemp mulch) - Wheat)		
	Sole Aonla	Maize + Wheat	Aonla + Maize + Wheat
Input cost (₹ ha^{-1})	63,149	1,41,402	2,04,551
Output cost (₹ ha^{-1})	1,95,451	2,56,692	4,52,143
Net returns (₹ ha^{-1} yr^{-1})	33,076	19,215	52,291
Runoff (%)	31.2	-	28.8
Soil loss (t ha^{-1})	6.0	-	4.9

SCOPE OF APPLICATION

Technology is suitable for the lower western Himalayan region up to elevations of 1000 m amsl where aonla fruit and maize-wheat crops can be grown together.