PEST MANAGEMENT IN DRYLAND HORTICULTURAL CROPS

SHRAVAN M. HALDHAR • SUSHIL K. MAHESHWARI

BIOTECH

ISBN 978-81-7622-491-8

Published by: **BIOTECH BOOKS®**
4762-63/23, Ansari Road, Darya Ganj,
New Delhi - 110 002
Phone: 09899295259, 011-43003222
E-mail: biotechbooks@yahoo.co.in
Website: www.biotechbooks.in

Typeset at:**Classic Computer Services**
Delhi - 110 035

Printed at:**Replika Printing Press**

PRINTED IN INDIA

Chapter 13

Suitable Genotypes of Underutilized Fruit Crops for Pest Management

K. Kumar[1] and S.M. Haldhar[1,2]

[1]ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner – 334 006, Rajasthan
[2]Present Associate Professor, Entomology, College of Agriculture, CAU, Imphal

Sustainable crop production is facing so many challenges; climate change is one of them. Indian hot arid ecosystem is most heavily affected by prolonged droughts and desertification. Inhabitants of such ecosystem have to survive and thus their crops should withstand such harsher conditions like high temperatures, drought and poor soils *etc.* (Kumar *et al.*, 2018). World-wide, underutilized fruit crops such as lasoda (*Cordia myxa*), phalsa (*Grewia subnaequalis*), karonda (*Carissa canjesta*), cactus pear (*Opuntia ficus indica* (L.) Mill.), mulberry (*Morus* spp.), ker (*Capparis decidua*), pilu (*Salvadora* spp.) *etc.* are becoming popular due to their unique adaptation mechanisms.

Production Technology of Lasoda, *Cordia myxa*

Arid zones of India come under wastelands, and also are not being utilized up to their full potential. Among arid crops, Lasoda is very suitable crop for cultivation in such type of climate. In hot arid regions, lasoda can be grown successfully with minimum use of inputs. Lasoda is also known by several other names *viz.*, lehsua, gunda, goondi, glue berry (due to mucilaginous pulp), assyrian plum, Indian cherry and cherry of the desert *etc.* It is multipurpose underutilized fruit crop and widely distributed in areas which fall under category of arid and semi-arid regions. It is suspected that it might be originated from the eastern Mediterranean

region to eastern India and distributed in the Australia, Europe, western tropical Africa to Italy, tropical America and South-East Asia. Lehsua is found mostly in the northern part of India, naturally growing in the north-western region and distributed abundantly. It is a deciduous, medium sized and broad leaved tree. It is widely found spreading in arid and semi arid zones of northern India because of its great capacity to tolerate drought. Lasoda is distributed at about 200- 1500 m above mean sea level from plains to the hills. Till date, most of the scientific work published on lehsua is from naturally grown population. It is being commercially cultivated from last two decades in arid and semi arid regions of the country and abroad for its fruits and culinary utilizations. Uses of different plant parts of lasoda for ethnobotanical purposes are an age old practice. In the current era of advanced tools and techniques, efforts are being made to have gunda genotype (s) with high yielding potential and develop its clonal propagation method by use of conventional as well as non-conventional approaches.

Nutritive Value and Uses

It is a multipurpose plant, so has long been associated with health, nutrition and other uses. Almost all its plant parts are used for one or other purposes such as immature fruits (vegetable or making pickles), mature fruits (nutrition) *etc.* Mature fruits are rich in carbohydrates, vitamins, minerals and total ash with high medicinal values. Mature fruit can be used as a diuretic, anti-helmenthic, demulcent, expectorant, anti-tumorigenic and also used in preparation of Ayurvedic medicines. Leaves of it are used as feed for cattle, goat, sheep and making pattal (trays/plates). Lasoda wood is generally used for making agricultural implements, furniture, house-posts, *etc.* (Sivalingam *et al.*, 2012). Its fruit contains about 80 per cent pulp~the pulp contains per 100g dry weight: ash 6.7 g, crude protein 8.32g, lipid 2.2 g, crude fibre 25.7g and carbohydrates 57.08 g and 281.4 k calorie (Aberoumand, 2011).

Genetic Diversity and Varietal Improvement

In India, there is lot of genetic variability present in existing lasoda plantations especially *C. myxa* of Rajasthan, Haryana, Gujarat, Madhya Pradesh, Himachal Pradesh and Uttar Pradesh. However, there is few named cultivar/variety released

for cultivation. In Rajasthan big fruited type is recognized as 'Thar Bold' from ICAR-CIAH, Bikaner, 'Maru Samridhi' from ICAR-CAZRI, Jodhpur, 'Karan Lasoda' from Jobner. There are two types of plants, big and small fruited are found growing and sold by nurserymen. Small fruited types locally called as goondi and much liked by rural people of Rajasthan and Gujarat. This fruit tree has not yet been utilized as an orchard crop, though its importance and uses are well known. The lack of suitable genotypes/variety for commercial cultivation and no commercial exploitation for value added products for consumer preference are two major reasons for its under-utilization (Sivalingam *et al.*, 2012). Conservation of genetic diversity is the primary requirement for the selection of desirable genotypes of lasoda. 'Thar Bold' a cultivar of it has been recently identified and released at institute level by ICAR-CIAH, Bikaner which is big fruited and heavy bearer. Reports are very few on diversity analysis of lasoda using molecular markers. Therefore, Sivalingam *et al.*, 2012 was determined the diversity of its germplasm stock conserved and maintained at field gene bank of ICAR-CIAH, Bikaner by morphological and Random Amplified Polymorphic DNA (RAPD) markers and morphologically characterized ten year-old lasoda trees for 17 traits indicated wide variations. Out of them, AHCM22 line was reported to be a superior germplasm for most of the horticulturally important traits. This germplasm had higher percent of fruit set, fruit weight and pulp: stone ratio; and high significant positive correlation between leaf, fruit characters and pulp: stone ratio. Out of 50, RAPD markers, 25 were found polymorphic. Average polymorphism was reported 69.8 per cent with an average PIC value of 0.43, genetic diversity between 0.44 and 0.94 by Jaccard's co-efficient and concluded that there is high genetic diversity present among germplasm lines available at ICAR-CIAH, Bikaner.

Soil and Climatic Conditions

Lasoda plants are very hardy and can survive well having average rainfall of 250-300 mm, thus can grow and thrive well on neglected, low fertility, sandy swampy saline alkaline soils and; hence can be best used for afforestation ofthe wastelands. However, moist sandy loam soils are the most suitable for vigorous growth and productivity. It can tolerate salinity up to certain extent. Soils which are enrich with organic matter, plants produce higher yield. Water logged soil is also not suitable for its cultivation. Lasoda thrives well up to an elevation of 5000 feet from tropical to sub-tropical climates, susceptible to frost and requires warmer climatic conditions. But can tolerate 0 °C temperature for some days and few weeks. It can withstand drought to a very greater extent and can tolerate high temperature up to 48 to 50°C during the summer months especially in arid region of Rajasthan.

Plant Propagation

It is generally propagated by seed and vegetative means. Lasoda is propagated by freshly extracted seeds on large scale because of release of very fewimproved cultivars/varieties (Thar Bold from CIAH, Maru Samridhi from CAZRI, Karan Lasoda, Jobner). Being a cross pollinated crop, seed propagation yielded greater variability in the population. For improving this crop, selection of high yielding genotypes with desirable characters from seedling population and perpetuation of

the same by clonal propagation is the best strategy. Clonal propagation through patch budding was standardized and planting materials are being supply to farmers for cultivation. Based on big fruit size, high fruit yield potential and other desirable attributes, one elite genotype *i.e.*, 'Thar Bold' was identified at institute level for commercial exploitation.

Transplanting

Lasoda is transplanted at 5-6 meter spacing in square system in well prepared 1 x 1 x 1 m sized pits filled with soil, FYM (15-20 kg) and 50 g Methyl Parathion 5 per cent dust. Application of organic manure is beneficial for the establishment and moisture retention. Pits should be dug one month prior to transplanting. Rainy season, *i.e.* July to September is the optimum time for transplanting. *In situ* planting and patch budding at appropriate time is successful method for rain fed fruit production of lasoda.

Training and Pruning

To develop a good framework of the plant training is essential. Four to six branches are allowed on the stem 1 m from ground level having good crotch angle. Lasoda plant does not require regular pruning. However, suckers emerging from main trunk or rootstock, undesired, weak and diseased branches should be pruned. Manual or chemical defoliation through potassium iodide (KI) enhances early flowering and fruiting and it is beneficial practice in lasoda orchards for taking economic yield.

Manuring and Fertilization

Application of FYM before flowering and fertilizers including N, P and K after pruning and fruit set in split doses helps in good vegetative growth and fruiting. Application of 100 g N, 125 g P_2O_5 and 50 g K_2O/tree should be done to achieve good growth and fruiting in arid regions, besides this 10 kg FYM per plant during monsoon season. Application of 20-30 kg FYM and 1.00 kg diammonium phosphate to five years old plant is found beneficial to increase fruit yield in semi-arid areas.

Water Management

In situ water harvesting by providing 5-10 per cent slope in two directions of plants is found suitable to increase productivity of the plants in rain fed, arid and semi-arid regions. Though lasoda is drought hardy plant but requires irrigation at initial stage of about 15-20 days intervals during winters and 8-10 days during summers.

Flowering and Fruiting

Flowering commences in lasoda from March-April. Flower is short, stalked, bisexual and appear in loose corymbose cyme. Inflorescence is generally terminal is usually white in colour. Being a bisexual plant, both male and female flower found on same tree. The fruit set is noted to be very low. Generally fruits come in bunches and bear on terminally, axillary and even from main branches and trunk

called cauliflorous bearing. Fruits are picked at horticultural maturity for their culinary exploitation and ready for picking by the middle of May. The fruits should be plucked manually along with the fruit stalk. Fruit yield varies according to climate, tree age and management practices involved. Budded trees start flowering and yielding fruits after 4-5 years of transplanting. Young plants produce 5-10 kg green fruit/plant while a developed plant yields about 50 kg fruits, which can be increased by adopting improved orchard management practices up to 100 kg per tree. In normal rainfall conditions it gives 100-150 kg yield per tree which is also according to the genetic potential of genotype.

Postharvest Handling and Value Addition

Injured fruits are sorted out after harvesting. Healthy fruit bunches are packed in bamboo baskets or gunny bags and send for marketing. For distant transportation, it is always better to pack them in bamboo baskets. Room temperature storage of fruits is not advisable for longer period because they turn yellow becoming unsuitable for cooking and pickle purpose.

Plant Protection

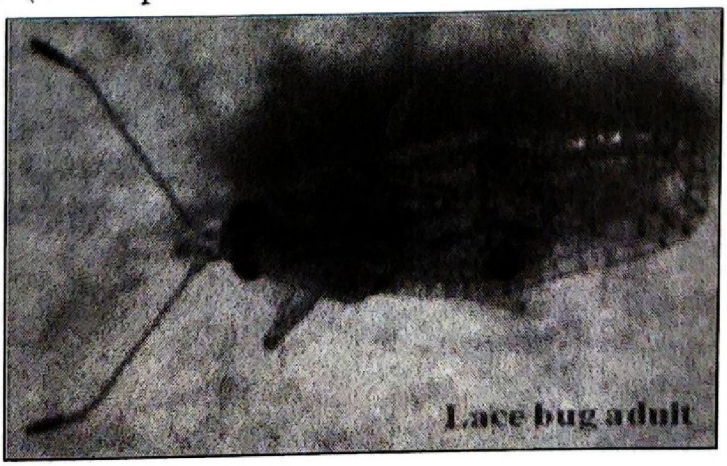
Lasoda plant is an excellent host for lac insect, which may cause economic loss. Leaf gall midge and borers cause damage to leaves and fruits respectively. These can be controlled by spray of 0.05 per cent monocrotophos or any other systemic insecticide. *Eriophyes cordiae* mites also attack on *Cordia dichotoma*, which causes leaf gall formation.

Insect pests

Insect damage on *Cordia africana* seeds was 45 per cent, 30 per cent and 20 per cent from Sekoru, Arjo and Wondo Genet places, respectively according to the National Tree Seed Project (1999). Tibebu (2002) studied pre-dispersal insect seed predators on seeds of these two tree species, 10 and found 20 per cent of *Cordia africana* seeds collected from Sekoru, and 8-10 per cent of seeds collected from Denbi, Jimma and Arjo places.

Tingid Bug, *Dictyla cheriani*

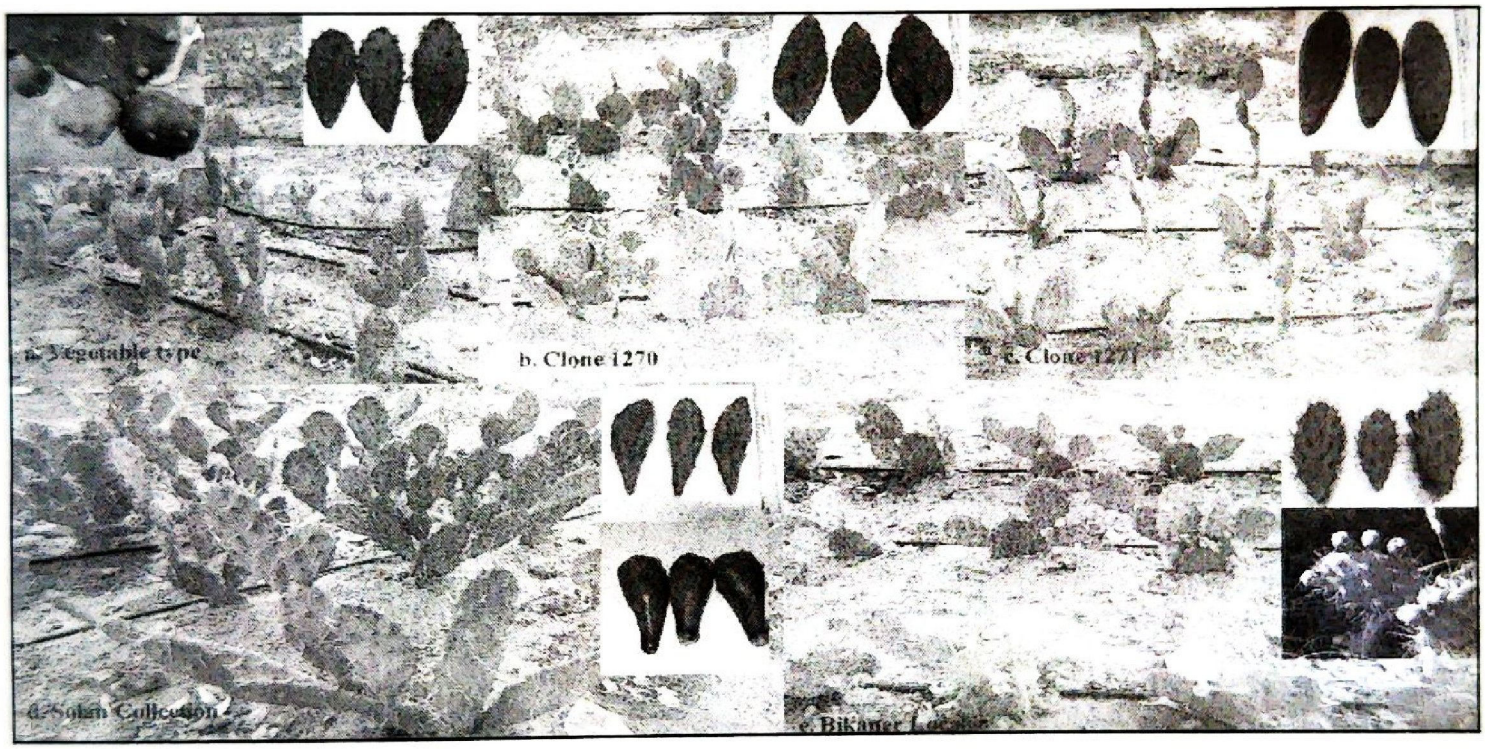
Haldhar and Singh (2014) first reported the infestation of *Dictyla cheriani* on Indian cherry (*Cordia myxa*) in 2010 at ICAR-CIAH, Bikaner. They observed maximum incidence (51.67 per cent on bold and 76.67 per cent on small seeded



Cactus cultivation in higher rainfall areas is unsuitable. It can establish and grow well under heavy, alkaline, rocky, and gravely soils.

Suitable Genotype and Site for Cultivation

ICAR-CIAH, Bikaner has collected a number of germplasm from different region of country as well as from abroad and evaluated under field conditions for their suitability. Institute has identified 6 promising genotypes which are suitable for culinary exploitation and fodder purposes and 3 spiny genotypes. Orchards of spineless, vegetable type cactus cultivars should be considered near to household vicinity where human presence provides safety from damaging pests *viz.*, domestic ruminants, wild animals as well as squirrels.Spineless, vegetable type is easy to handle and good for culinary exploitation. Low cost net house is much suitable for safer cultivation (Kumar *et al.*, 2018).



Notation a denotes genotype suitable for vegetable, salad, pickle, squash, animal feed, edible, fruit production; b. suited for fodder; c. suitable for animal feed and biofencing; d. means, genotype suitable for biofencing and fruit production; e. suited for fruit production and biofencing

Planting Season

Cactus pear can be transplanted twice in the field. First is transplanted during July– September and second during February- April. Cultivation in the low cost green house can be done round the year. Plant survival was found maximum from July– September transplantation.

Propagation

It can be easily propagated by vegetative means from its 5-6 months old mature cladodes. Cactus can be propagated twice in a year during February- April and

July- September. it can be propagated round the year in the green house. Plucked the cladodes and keep the detached cladodes under shade forabout two weeks for curing so that proper healing and dehydration may take place for better conservation and establishment under field condition (Kumar *et al.*, 2018). Black polythene bags are ideal material for the purpose. It is very sensitive to water logging condition situation. Thus, selection of ideal planting and propagation medium is necessary. Soil, sand and FYM in a proportion of40: 30: 30 is the suitable medium for cactus pear (Kumar *et al.*, 2018).

Field Planting

Cladodes before planting can be treated with fungicide *viz.*, bordeaux mixture or mancozeb 2 gram per liter water to protect them from rotting. Its planting distance is depends on its genotype whether it is compact or spreading. The cladodes should be planted upright position keeping 1/3rd lower part in the soil. Several institutions have given various planting distances *viz.*, 5 x 4 m, 4 x 3 m, 4 x 2 m, 3 x 3 m, 3 x 2 m and 2 x 1 m. But, at ICAR-CIAH, Bikaner a closer plant spacing (1 x 0.6 m) has been adopted for vegetable type, spine less clone on drip. Because it is reported in literature that cactus crops can be grown successfully at a closer plant distance (Kumar *et al.*, 2018).

Water Management

Optimum irrigation should be provided during early stages of growth because this crop is very sensitive to water conditions. It is suggested to do not irrigate plants immediately just after planting in the field and light watering is done after 2-3 days. After that, watering should be given at 10-15 days interval. The established orchard should be given light irrigation for profitable yield. Cactus has highest water use and rain use efficiency among other drought hardy crops thus, no need to irrigate orchards where rains are good.

Manures and Fertilization

Cactus pear requires low nutrient but its deficiencies can cause losses to plant health and economic yield. Application of manures and fertilizers in winter has been reported very effective in obtaining new cladodes as well as fruits (Kumar, 2018). Generally, 6-10 tonnes per hectare FYM should be given before planting. The application of 5 MT FYM and 60: 30: 30 kg NPK/ha at the time of planting for suitable growth of the cactus orchards. Application of 3-5 g per liter NPK grade (19: 19: 19) was found beneficial in new sprouting of cladodes after every picking of cladodes and/fruits under green house condition. After every harvest apply 20 kg Nitrogen is found beneficial in enhancing new sprouts for production of nopals (Kumar, 2018).

Flower and Fruit Development

In vegetable cactus pear flowering and fruiting initiation occurred first year of planting under green house as well as field condition at ICAR-CIAH, Bikaner while reported it take 2-3 years to flower and fruit (Kumar, 2018). More than six month old cladodes are able to produce flower which bears terminally and sub-terminally.

Time required from vegetative bud initiation to nopal/edible stage of cladode was recorded 15-20 days which weighed from 22- 46 g/nopal, while flower bud took 30-40 days and it required almost 75-90 days for ripening of fruits (Kumar, 2018).

Harvesting and Yield

Harvesting period of cactus and number of pickings is varying according to product purpose of the cactus. For culinary purposes tender nopals are harvested during the early stages of cladode growth, when they reach 10 to 15 cm long and about average weight of 30 g/nopal. With the advancement of cladodes age the fibre content increases and become more difficult to process. There after cladodes are more ideal for animal feed (Kumar, 2018). Nopales can be harvested regularly at an interval 15-20 days under greenhouse with an average yield of 1.5 kg tender nopales per plant per year. It is started yielding after one year of planting but commercial yield is obtained after 4-5 years. Ten to twelve mt/ha fruits and 10-150 mt/ha fodder per year can be harvested from improved cultivars of cactus. Clone 1308 can yield 80–90 tonnes biomass per hectare per year (Kumar *et al.*, 2018).

Pests, Disease and Disorders

Pests of Economic Importance

Several insect pests have been found associated in damaging cactus cultivation. In India, spine less, vegetable type, less thorny fodder type genotypes are severely damaged by wild animals as well as domestic ruminants and squirrels (Kumar *et al.*, 2018). Cochineal insect (*Dactylopius opuntiale* Cockerell) and Phycitid moth (*Cactoblastis cactorum* Berg.) are most damaging pests for cactus orchards. The other pests are armoured scale and med fly are of economic importace. At present phycitid moth is found all over the cacti growing areas of the world and causes severe attack and damage on young plants. Attack was observed only on cladodes but in acute cases it also damagefruits (Kumar *et al.*, 2018).

Cochineal Bug, *Dactylopius opuntiale*

It is most harmful insect of cactus which causes death of the plant in acute condition. But it also reared in many countries for pink coloured dye production. It causes damage to whole plant parts *viz.*, stem, cladodes, fruits. Affected cladodes and fruits detached automatically from the plants. These cladodes and fruits fell down and loss their economic value (Kumar *et al.*, 2018). It was observed at CIAH, Bikaner that extreme temperature and sunlight reduced the infestation when severely attacked vegetable cactus plants were shifted from green house to open condition. The spray of imidacloprid 17.5 SC @. 0.5 ml l^{-1} of water at 15 days interval was found effective in managing of this insect. Although some bicontrol agents such as ladybird (*Exochomus flaviventris* Mader), Australian coccinellid (*Cryptolaemus montrouzieri* Mulsant) and a fungal pathogen (*Entomophtora lecanii* Zimm.) were found effective in controlling of the pest. Spraying of acephate chemical @ 2g l^{-1} at weekly intervals from early attack significantly contolled and killed the cochineal population and saved the nopal cactus plants under green house at CIAH, Bikaner (Kumar *et al.*, 2018).

Diseases and Disorders of Cactus Pear

Cacti have high water in its cladodes that is why attacked by several dieases caused by bacteria, fungi, nematodes, yeast, viruses *etc.* which caused damage to plants and reduce the biomass and yield. Physiological disorders are caused due to the environmental and nutritional imbalance, genetic causes and faulty agro-techniques resulting low production and productivity (Kumar *et al.*, 2018). The major diseases attacking cactus are wilt, bacterial spot, Armillaria root, stem and foot rot. An experiment at ICAR-CIAH, Bikaner was conducted by Nallathambi *et al.* (2005) on foot rot *(Phytophthora nicotianae)* in cactus genotypes and observed that this disease was major hindrance in initial establishment of cactus orchads. They have reported that 23.5 per cent foot rot incidence occurred in germplasm colections during the month of August and November and soil drenching with 0.1 per cent Ridomil and dipping of cut ends of cladodes in fungicide at the time of planting found efffectinve in controlling of foot root (Nallathambi *et al.*, 2005).

Production Technology of Mulberry, *Morus* spp.

Mulberry crop is found growing from subtropical to tropical and temperate regions of the world. It can thrive well in a variety of edapho-climatic conditions. Mulberry domestication was started several thousand years ago because of requirement for silk worm rearing. Mulberry is common all over India. *M. laevigata* is an important timber species of north-east and Western Ghats. Its large scale cultivation is being done in Andhra Pradesh, Karnataka, West Bengal, Tamil Nadu, Uttar Pradesh, Assam, Manipur *etc.* Although, themaximum utilization of mulberry is in Asia, it does not mean that cultivation is limited only to Asian countries. Mulberry is present in almost all continents of the world and is being used for several purposes, including ornamentals, in gardening and landscaping (Vijyan *et al.*, 2012).

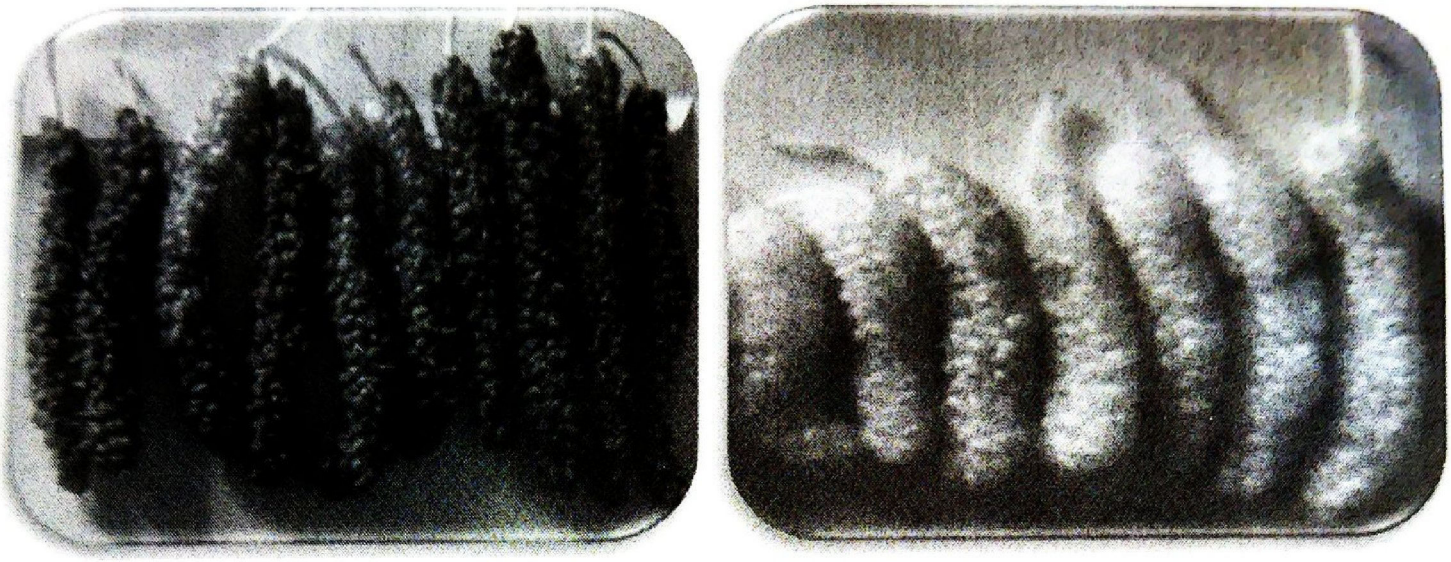
Nutritive Value and Uses

The ripe fruit of mulberry is highly appreciated for its delicious taste which is consumed fresh or after extraction of juice from fruits. Chutney is prepared from immature fruits. Mulberry fruit is used to treat weakness, dizziness, tinnitus, fatigue, anemia, and incontinence. The ripe fruit is sweet in taste with acidic blend due to the presence of high water content and low level of other flavouring ingredients. The ripe fruits constituted 8-9 per cent sugar and 1-2 per cent acid. Mulberry is also considered as *"Kalpa Vriksha"* because almost all the parts of it have economic value. Throughout the Asia, mulberry is highly appreciated for its delicious and thirst quenching fruits, which is utilized either fresh or in juice form. Sericulture industry needs mulberry foliage for the rearing of silkworm. In India, most of the states have initiatives sericulture as an important agro-industry with excellent results. By growing mulberry, a farmer obtains fodder, fuel and fertilizer (manure).

Genetic Diversity and Varietal Improvement

Huge diversity exists in available germplasm pool of mulberry in India and abroad. Mulberry being perennial and out breeding tree, exhibit high degree of

heterozygosis and often produces recalcitrant seed. Hence for conservation of mulberry outside its natural habitats, a field gene bank established at a Central Sericultural Germplasm Resources Centre, Hosur, Karnataka which maintains *M. austral*, *M. cathay Ana* Hems, *M. multicaulis* Poir, *M. rotundiloba* Koidz, *M. alba* L., *M. indica* L., *M. teliaefolia* Makino, *M. nigra* L., *M. serrata* Roxb., *M. laevigata* Wall., *M. rubra* L., *M. sinensis* Hort. and *M. bomycis* Koidz. Many cultivars of mulberry have been introduced in India from France, Romania and Japan.



Mulberry Selections 'Thar Lohit' and 'Thar Harit' (CIAH M-2).

Selection and Hybridization

Until now, selection has only been a method of crop improvement in mulberry for fruits. However, hybridization has been in vogue for mulberry genetic improvement in sericulture, which follows a very specific procedure (Vijayan *et al.*, 2012). Prior to parental selection, the characterization of germplasm accessions is carried out using morphological, biochemical and physiological characters, rooting ability of stem cuttings, leaf yield, leaf moisture, protein and sugar contents, photosynthesis, water use efficiency *etc.* Based on a statistical assessment, parents with desired traits are selected and control hybridization is done. Till recently, no variety was developed in mulberry for commercial fruit production. However promising selections *viz.*, CIAH Mulberry Selection-1 and CIAH Mulberry Selection-2 for commercial cultivation have been released at ICAR-CIAH, Bikaner. Recently, CIAH M-1 has been identified as 'Thar Lohit' at the Institute level from ICAR-CIAH, Bikaner. Mulberry genotype Thar Lohit was found better than CIAH M-2 in terms of antioxidant attributes such as total antioxidant activity, polyphenol, flavanol, and flavonoid. Besides these two, another genotype of mulberry called Delhi Collection has also been shown promising with respect to fruit length (5-9 cm), width (1-1.2 cm), weight (4-6 g), attractive colour (reddish to maroon), organoleptic attributes and consumers acceptability.

Soil and Climatic Conditions

Mulberries like well-drained soil, preferably a deep loam. However, studies at

CIAH, Bikaner reported that it can also be grown well in sandy soils with proper filling of pits with organic manure and clay soil during planting time. The mulberry requires 6.5 to 6.8 optimum soil pH but can be cultivated with soil pH from 6.2 to 6.8. To correct the soil, amendments can be used for desired soil pH. It can hrives well under different edapho-climatic conditions and optimum temperature ranged from 24 to 28°C. However, Thar Lohit can tolerate temperature ranges from 3 to 48°C under arid conditions. Mulberry selections 'Thar Lohit' Mulberry selections 'Thar Harit'

Plant Propagation

Mulberries are mostly propagated through budding. A T-cut is made in the rootstock and a smooth cut made on the lower side of the scion. The scion is then inserted into the T and wrapped and sealed. Other types of grafts are also usually successful, although there may be incompatibility between white and black mulberries. The stem cutting is the most common method of propagation due to the distinct advantages like speedy multiplication and maintenance ofthe desired characters. Hardwood, softwood and apical shoot are suitable methods for propagating mulberries. The mature shoots of 6-8 month age with 15-20 cm length, 10-12 mm in diameter, 3-4 healthy buds are selected for the purpose. Cuttings should be made at an angle of 45° with a sharp knife without bark split. Cuttings are potted in sand beds or pots during winter which start sprouting with increase in temperature during spring season which can be shifted to polythene/ earthen pots for growth. Irrigation is done regularlyafterwards. Plants are ready for transplanting in the field during monsoon season. Semi hard wood cuttings give better result in respect of sprouting and survival. *In situ* budding during March to September months can also be done under arid and semi arid climate conditions.

Planting and Orchard Establishment

Mulberries need full sun and also adequate space. The distance between trees should be at least 15 feet. The trees should not be planted near a sidewalk. The fallen fruit will not only stain the walkway, but are likely to be tracked indoors. The trees are quite wind-resistant. Pits of 60x60x60 cm can be dug out during summer months in arid regions. Fully decomposed FYM is mixed with soils and pits are filled. Planting should preferably be done during monsoon. The distance between trees should be 6x6 m in square system.

Training and Pruning

No special pruning techniques are needed after the branches have been trained to a sturdy framework, except to remove dead or overcrowded wood. A mulberry tree can be kept to a tidy form by developing a set of main branches, and then pruning laterals to 6 leaves in July in order to develop spurs near the main branches. It is not advisable to prune the trees heavily since the plant is inclined to bleed at the cuts. More than two inches in diameter cuts generally do not heal and should be avoided at all cost. The bleeding will be minimum when trees pruned in their dormant phase.

Manuring, Fertilization and Water Management

Application of organic manure, FYM @ 10 tonnes/ha as basal dose is necessary for successful establishment of the orchard. Thereafter, periodical fertilizer applications to the young growing plants should be done. Rainfed orchards receive optimum rains from the South-West monsoon. This should be taken as dvantage to make a good framework so that the plant may stand the drought months very well. Application of two doses (25 and 40 kg N/ha) of Ammonium Sulphate or Urea as nitrogen source śhould be done at an interval of three months. Thereafter, the normal fertilizer application programme could be done 100, 50, 50 kg N, P and K per hectare per annum). It may be applied in two equal split doses. The first dose should be applied in last week of August and the second dose in the last week of November. Although mulberry is droughthardy crop, it needs irrigation during fruiting period. Irrigation through drip system is recommended for better fruit quality in arid conditions.

Mulberry Germplasm Evaluation at ICAR-CIAH, Bikaner

For assessing feasibility of mulberry fruit production in hot arid climate, 15 genotypes were collected from different areas including 02 genotypes from ICAR-NBPGR at ICAR-CIAH, Bikaner. Clonal plants of each three genotypes (CIAH Selection 1, 2 and Gurgaon Local) were transplanted in the field for evaluation. CIAH Mulberry Selection 1 (Purple red colour) and CIAH Mulberry Selection 2 (Greenish white) was found superior to Gurgaon Local. A wide range with respect to fruit length (0.9 cm to 9.4 cm) and weight (0.5 g -7.2 g) was recorded in these genotypes. The mulberry plants found to tolerate extreme cold and hot temperatures of the arid region. Very recently MI 572 germplasm was evaluated which showed promising response. Fruit was sweet in taste with slight sourness and reddish in colour. Average yield was recorded 1.51kg per plant. This genotype ripens two weeks earlier than Thar Lohit. The fruits harvesting started for from 09th March, whereas Thar Lohit started from 23rd of March.

Harvesting and Yield

White and red mulberry fruits are ready to harvest from March and April. The mulberry fruits are often harvested by spreading a sheet on the ground and shaking the limbs. Morning time is usually preferred. Harvesting is done by shaking of individual secondary branches on tree at maturity stage or picking of individual fruits. There is severe damage to fruits if they fall directly on the ground. The harvested fruits should be disposed off quickly in local markets because of very short shelf life. Mulberry (Thar Lohit) gives an average yield of 26.5 kg during 8th year of orchard life under rainfed conditions of hot arid ecosystem.

Plant Protection

Mulberries are generally free from attack of pests and diseases. Young plants are sometimes damaged by termites particularly during dry period under arid environment. The ripe fruit is very attractive to birds, but there is usually enough fruit left over for harvesting. Termites form an earthen sheath on the stem. This may

result in reduction in leaf yield and drying or killing of plants. Mulching with dry twigs favours the populations build up in endemic areas. Damage is observed more in case of sandy soils of arid zones. For its management, location and destruction of termite colonies by removing queentermite, treatment of mounds with 50 ml chlorpyriphos 20 EC, swabbing or drenching of established plants at the base with 50 ml chlorpyriphos 20 EC are Recommended Several bird species including sparrows, crows, house finches, parrot *etc.* also cause substantial damage by feeding on ripening fruit. These can be most effectively managed to frighten them by making noises and use of visual repellents like bird scaring ribbon in the orchards. Besides, there are some minor pests of mulberry like Bihar hairy caterpillar, mealy bug, thrips, jassids, scale insects, short horned grasshopper *etc.*

Production Technology of Phalsa, *Grewia subinaequalis*

Phalsa (*Grewia subinaequalis* L.) is known to be one of the oldest indigenous fruits in India and widely distributed in tropical and subtropical regions of India, Pakistan and Bangladesh. It is grown commercially in states like Punjab, Uttar Pradesh, Madhya Pradesh, Haryana, Rajasthan and the Himalayanregions, and is found up to 3,000 feet above sea level and smaller scale in Karnataka, Mahara shtra, Andhra Pradesh, Gujarat, West Bengal and Bihar. Phalsa is drought-hardy crop and thus suitable for arid and semi-arid zones. It comes under underutilized fruit crops but have nutritional and medicinal value. The nutritional and medicinal value of phalsa is due to its high phenolic compounds, organic acids, tannins, anthocyanins, and flavonoids present in it. Despite the highly nutritional value of the fruit, its commercial scale ultivation and production did not receive a fair response from the industry. Traditionally, it is cultivated as subsistence farming and hence it is mostly consumed in fresh fruits and juices. In India, ripen fresh fruits consumed during summer months and also preparation of refreshing cool beverage. It is an ideal plant for multi-story cropping. However, its popularity is restrictedowing to highly perishable nature, small size of fruit and non-synchronous maturity, which necessitates repeated harvesting. Therefore, the plantation ismainly confined to the surroundings of big cities. Its cultivation is also possible with the minimum or no use of synthetic chemical nutrients that also has a sustainable effect on environment and the soil. Due to this reason, organic production is also possible with excellent quality fruits. At ICAR-Central Arid Horticulture Institute, Beechwal, Bikaner, experiments are being done to take 100 per cent organic production of phalsa.

Soil and Climatic Conditions

Phalsa is a crop of hot dry arid and semi-arid regions but adapted to thrive well and give good yield tropical to subtropical climates. However, the optimal growth areas for phalsa are where a specific summer and winter season can be found. For fruit and colour development, fruit ripening and quality it requires optimum sunlight and warm temperatures. It can be grown in various types of soils. However, sandy loam soil having good drainage facility is ideal for good growth and development of the plant.

Varietal Improvement

There is not much attention given to the phalsa improvement by research institutes and state agricultural universities. Thus, there is no better variety available for commercial cultivation of phalsa. From last twenty years at ICAR-CIAH, Bikaner collection, conservation and evaluation of several genotypes (CIAH – P – 1, P – 1–1, P – 1–2, P – 2, P – 2–1, P – 2–2, P – 2–3, P-3, P-4, P-5, P-6, P-6-1, P-6-2, P-6-3) under field condition have been done. These genotypes have variations in plant, stem, leaf, flower, fruit size and color *etc.* which have collected from different states of the country and on which continuous research and evaluation was done for good quality and high yield production. Results of several years of continuous study, two varieties have been identified at institute level which is capable of producing high yields in limited resources in hot dry climate."*Thar Pragati*" is suitable variety for semiarid and "CIAH-P-1" for arid areas which are being promoted for commercial cultivation.

Phalsa Cultivar 'Thar Pragati'

Phalsa Cultivar 'CIAH-P-1

Plant Propagation

Preparation of plants from seeds and cuttings has been standardized for propagation of phalsa. Commercially phalsa is being promoted through seeds. It is reported that July-August is the most suitable time to prepare plants from cuttings. For seed propagation, seeds should be sown 1.5-2.0 cm deep in poly bags filled with equal proportion of FYM and soil in June month and irrigate immediately with watering can. Watering should be done time to time as and when required. Thus seed germination is obtained about 85-90 per cent. The plant is ready for transplanting in 5-6 months.

Transplanting

Phalsa transplanting should be during monsoon season from July - September. Irrigation to the plant should be done after transplanting. Transplant the phalsa at

3 x 2 or 3 x 1.5 m. distance from row to plant. One to two months before transplanting, pits (60 x 60 x 60 cm size) should be dug in summer and filled with soil and FYM.

Water Management

Phalsa does not require much irrigation for its successful production. However, one to two light irrigations is required during summer so that the plants can tolerate high temperature. Apart from this; at an interval of 15 days, two irrigations should be given after pruning during December-January months that makes early sprouting of phalsa bushes. To increases the quality of the fruits, two irrigating should be given after flowering and fruiting during March-April months.

Training and Pruning

Successful phalsa production is mainly depends upon two things *i.e.* training and pruning. This crop is trained in such a way that it can take the shape of a bush. Because bush more fruiting branches, resulting the higher the yield per bush. It is pruned once in North India and twice in South Indian conditions. To obtain higher quality yield, the pruning time and height of the bushes has been standardized at ICAR-CIAH, Bikaner. Pruning should be done at a height of 15-20 cm from the ground level around 15-20 January. In South India, pruning is done twice, first in the December month and second in June.

Manuring and Fertilization

This crop successfully can be cultivated and produce quality fruits without application of manure and fertilizers. In order to get quality fruits in arid soils manures and fertilizers should be controlled. To maintain proper humus and fertility in the soil, FYM should be given every year. After three years of transplanting, every year after pruning 10 kg per bush FYM should be given that improves sprouting and plant growth. In addition to this, urea, DAP and MOP should be given at 100, 50 and 100 gram per plant/bush per year respectively, which is given twice at a interval of one month.

Flowering and Fruiting

Flowering begins in about two months after pruning and cutting. Flowering is completed within 15-20 days under arid ecosystem. The flowers are come in bunches and yellow in colour. Approximately, 90–100 days after pruning, fruit ripening begins from April and lasts till May.

Harvesting and Yield

In the second fortnight of April, fruits started ripening and completed up to third week of May. Phalsa fruits are round, small, attractive and red to dark purple in colour. The fruits are ready for harvesting when taste is slightly sweet. Fruits are plucked manually and placed in baskets. Phalsa fruits come under highly perishable commodities. Therefore, fruits should be consumed fresh within 24 hours of harvesting. *'Thar Pragati'* cultivar fruit yield was noted 3.60 kg/bush during 4th year of planting under rainfed conditions of hot semi-arid ecosystem and 3- 5 kg per bush from selection 'CIAH-P-1' under hot arid condition with limited irrigation water.

Plant Protection

Mainly in arid region, phalsa crop does not much affected by pests and diseases and also the damage is very less. Due to congenial environment to pests sometimes they cause damage. There are two main pests found on phalsa in this area *i.e.* aphids and caterpillars which cause damage to phalsa. For managing aphid neem oil, neem leaves and neem alkaloid *etc.* should be sprayed. Spray imidacloprid 17.5 SL from 0.4-0.6 ml l^{-1} or dimethoate 30 EC with 1.5 ml l^{-1} of water for effective management. If there is more damage noticed from caterpillar, spray Malathion 50 EC or dimethoate 30 EC with 1.5 ml l^{-1} of water. To control this pest, spray Thar Jaivik 41 EC with 2-3 ml l^{-1} of water.

References

Haldhar, S, M. and Singh, R. S. (2014). Report of *Dictyla cheriani* (Hemiptera: Tingidae) on Indian cherry (*Cordia myxa*) in Rajasthan, India: Incidence and morphometric analysis. *Indian Journal of Agricultural Sciences*, 84 (1): 128–130.

Kumar, K., Singh, D. and Berwal, M. K. (2017). Cactus pear: A multipurpose climate smart crop for higher income in arid zone. In the compendium entitled "Doubling Income through Advance Approaches for Fruits and Vegetables in the Arid Region" (*Eds.* Saroj, P.L., Sharma, B.D. and Jatav, M.K.), ICAR-CIAH, Bikaner, Rajasthan.

Kumar, K., Singh, D. and Singh, R. S. (2018). Cactus pear: Cultivation and Uses. CIAH/Tech./Pub. No 73, pp. 38. ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, India.

Nallathambi, P., Umamaheswari, C. and Singh, R. S. (2005). Foot rot in cactus pear *(Opuntia spp.)* genotypes under arid conditions. *Annals of Arid Zone.* 44 (1): 59-63.

National Tree Seed Project. (1999). Annual progress report of national tree seed project. Addis Ababa, Ethiopia.

Saroj, P. L., Singh, D. and Kumar, K. (2017). Culinary exploitation of nopal cactus pear in arid region. *Indian Horticulture*, 62 (4): 13-16.

Sivalingam, P. N., Singh, D. and Chauhan, S. (2012). Morphological and molecular diversity of an underutilized fruit crop *Cordia myxa* L. germplasm from arid region of Rajasthan, India. *Genet. Resour. Crop Evol.*, 59: 305–316.

Vijayan, K., Srivastava, P. P., Raju, P. J. and Saratchandra, B. (2012). Breeding for higher productivity in mulberry. *Czech J. Genet. Plant Breed*, 48: 147-156.