INDIAN JOURNAL OF ARID HORTICULTURE
2006, Vol. 1 (1) : 1-7

Arid horticulture : An overview

D.G. Dhandar* and R. Bhargava
Central Institute for Arid Horticulture, Bikaner-334006, Rajasthan

Abstract

The arid region is spread over 38.7 million hectane mainly in states of Rajasthan, Gujarat, Haryana, Punjab and Andhra Pradesh. The area is marked by extreme chimatic conditions due to which the cultivation of traditional crops is non-economical. In a situation such as this, arid horticulure has ample scope to develop the arid regions. The present communication attempts to perform an overview of the technologies developed which can be used to make arid ecosystem a horticulural bowl and provide income and nutritional security to the inhabitants.

Key words : *Arid Horticulture, emeging issues, nutrient management, orchard management*

The arid regions are spread over about 38.7 million ha including both hot arid and cold arid regions mainly in the States of Rajasthan, Gujarat, Andhra Pradesh, Punjab and Haryana. The hot arid region inhabit on an average 61 persons per square km making up a population of nearly 20 million people besides a high population density of animals. The Indian arid zone is characterised by high temperature and low and variable precipitation which limit the scope for high horticultural productivity. However, these conditions greatly favour development of high quality in a number of fruits such as date palm, ber, aonla, grapes, kinnow and in vegetables cucurbitaceous crops, spices and some medicinal plants. The existing low productivity could be increased by following optimized technologies and inputs. It is now realized that there is a limited scope for quantum jump in fruit and vegetable production in the traditional production areas. The amelioration of the extreme conditions is also considered vital for life support to the inhabitants of this area. The recent awareness regarding the potential of these ecologically fragile lands for production of quality horticultural produce has not only opened up scope for providing economic sustenance for the people of this region, but also for bringing in new areas to increase production. The state wise distribution of arid land is given in Table 1.

Table 1. Area under arid region in India

State	Total area (M ha)
A. Hot arid region	
Rajasthan	19.6
Gujarat	6.2
Punjab	1.5
Haryana	1.3
Peninsular India	3.1
B. Cold arid region (J&K)	7.0
Total	**38.7**

Constraints in arid horticulture

The arid zone soils are very poor in fertility. The soils of the north-western arid region described as 'desert soils' and 'grey brown soils' of the Order Aridisols are light textured. The solum of these soils is moderately calcarious (0.2% $CaCO_3$) and below this solum at depths of 40-120cm, a sharply differentiated zone rich in alkaline earth carborates (5-45% $CaCO_3$) is present in the form of hard crystal-like concretions, which may be many metres thick. Most of arid areas (about 64.6%) are duny where the soils often contain only abut 3.2-4 per cent clay and 1.4-1.8 per cent silt. The brown light loam soils occupy 1.7 per cent area, which has loamy fine sand to fine sandy loam on the surface and heavier subsoil underlain with calcium carbonate concretions. Besides this, about 5.9 per cent area is covered by soils having hard pan, 5.6 per cent is under hills and pediments, 6.8 per cent area is alluvial duny and 1.6 per cent is sierozems extending from the soils of Haryana and the Punjab. In Gujarat also, grey brown soils are widespread besides a large area having deltaic alluvium with small area in Kachchh having deep black and medium black soils. In the peninsular India, a considerable part of arid region has red sandy soil and some parts have mixed black soils.

The soils are poor in organic matter having per cent organic carbon of 0.03 in bare sand dunes to 0.1 in the

***Coressponding author :**
Director, CIAH, Bikaner
Email : dhandardg@rediff.com

stabilized dunes. The Soils are generally rich in total potassium and boron but are low in nitrogen, phosphorus and micronutrients such as copper, zinc and iron. The soils often have high salinity.

The ground water resource is not only limited owing to poor surface and sub-surface drainage but is also generally highly saline. The depth of water ranges from 10m to as high as 140m. The other irrigation water resources in the region are seasonal rivers and rivulets in Gujarat, surface wells and some runoff water storage devices (e.g., tanks, *khadins*). Thus, the water resources in arid region are limited and can irrigate hardly 4% of the area.

The mean annual rainfall in the Indian arid regions is very low and varies from 100 mm in north-western sector of Jaisalmer to 450 mm in the eastern boundary or arid zone of Rajasthan. In Gujarat, it varies from 300 to 500 mm and in Haryana and Punjab from 200 to 400 mm. In peninsular region, the rainfall varies from 520 mm in Bellary (Karnataka) to 748 mm in Cuddapah (Andhra Pradesh). Most of the precipitation in north western arid region occurs during July-September in about 19-21 rain spells.

Prospects in arid horticulture

Vast land resource, surplus family labours, increasing canal irrigated area, developing infrastructural facilities, plenty of solar radiation, etc. are the strength in arid region for research and development in arid horticulture. However, appropriate management practices are required for success of arid horticulture. Some of the important aspects in field of arid horticulture are mentioned below.

1. Selection of hardy crops and varieties

While selection of fruit crops for dryland horticulture, one of the basic requirements is that those crops, which complete their vegetative growth and reproductive phase during the period of maximum moisture availability should be selected. The fruit such as *ber,* guava, pomegranate, custard apple, aonla and sour lime, conform to this prerequisite. The crops must have xeric characters such as deep root system (e.g. aonla, ber), summer dormancy (e.g. ber), high 'bound water' in the tissues (e.g. cactus pear, fig), reduced leaf area (e.g. Indian gooseberry, tamarind), leaf surface having sunken stomata, thick cuticle, wax coating and pubescence (fig, ber, phalsa, tamarind), and ability to adapt to shallow soils, rocky, gravelly, and undulating wastelands (pomegranate, aonla, bael). Some of the crops suitable for dryland areas are given in Table 2.

Varietal variation in endurance to drought has also been observed in horticultural crops. Early ripening cultivars seem to escape stress conditions caused by the receding soil moisture stored in the soil profile during the monsoon. Ber cultivars Gola, Seb and Mundia for extremely dry areas, Banarasi Karaka, Kaithli, Umran and Maharwali for dry regions, and Sanaur-2, Umran and Mehrun for

Table 2 : Fruit crops for drylands in different rainfall zones of India

Rainfall (mm)	Tropical and subtropical zone
< 500	Jhar ber, Gonda or lasora, Karonda, Ker, Khejri, Ber, Phalsa, Custard apple, Bael, Pilu, Jamun
500-1000	Ber, Aonla, Jamun, Woodaple, Mahua, Custard apple, Wild date palm, Indian almond, Guava, Sour lime, Lemon, Mango, Palmyra palm, Tamarind, Bael, Custard apple, Chironji, Wood apple, *Karonda*, Mango, Cashew nut, Grape fruit, Pomegranate, Passion fruit.
> 1000	Mango, Litchi, Jackfruit, Persimmon, Mandarin, Avocado, Tamarind, *Jamun, Kokum*, Palmyra palm, Guava, Cashew nut, Barbados cherry, Pomegranate.

comparatively humid regions have been recommended. Apart from morphological parameters, plants should also have physiological parameters for endurance to drought for commercial cultivation in this region. Some physiological parameters identified in ber are no mid day depression in photosynthetic rate, low rate of transpiration, maintenance of leaf water balance, growth, canopy development, dry matter allocation, high water use efficiency, etc. It has been demonstrated that plant having capacity for drought endurance are able to maintain tourgour, dry matter allocation, leaf and fruit growth even under low soil moisture level. Suitable cultivars of some crops have been identified (Table 3).

Table 3 : Promising cultivars of fruit and vegetable in drylands

Crop	Cultivars
Fruit's	
Ber	Gola, Seb, Umran, Mundia, Kaithali, Banarasi Karaka, CIAH H-1 and CIAH Sel.-1
Bael	NB 5, NB 9, Pant Aparna, Pant Suwarna
Pomegranate	G 137, GKVK 1, IIHR selection, Mridula, Bhagwa
Aonla	NA 7, Kanchan, Krishna, Balwant, NA 6, NA 10
Sweet orange	Blood Red Malta, Mosambi, Pineapple, Valencia
Custard apple	Arka Sahan, Balanagar, Mammoth, Island, Gem, Red Sitaphal
Guava	Allahabad Safeda, L-49, Kohir Safed, Safed Jam, Chittidar
Papaya	Coorg Honeydew, Pusa Delicious, Pusa Majesty, Pusa Dwart, Pusa Giant, Co 1, Co 2
Sapota	Kalipatti, Cricket Ball
Fig	Poona, Dianna, Dinkar, Conadaria, Excel
Mango	Banglora, Neelam, Keshar, Bombay Green, Langra, Chausa, Dashehari
Tamarind	PKM 1, Pratisthan, Yogeshwari
Vegetable's	
Chilli	Pusa Jwala, Mathania, Pant C-1, Arka Mohani, Arka Gaurav, Arka Basant, Bharat, Indira
Cowpea	
Cluster b	
Onion	
Tomato	
Brinjal	
Amaran	
Okra	
*Pumpki	
Musk m	
Waterm	
Bottle g	
Bitter g	
Kachri	
Snapme	
Kakdi	

2. Orcl

Fr
used t
tap roo
in cont
plants
to pene
establi
al. 199
in 300
diamet
yard n
seedli
These
after b
growth
Thus,
coiling
suitabl
Plantii
mulbe
roots.
Tl
soil fer
systen
the top
the pl
rectan

Cowpea	Pusa Dofasali, Pusa Phalguni, Pusa Barsati, Pusa Rituraj
Cluster bean	Pusa Sadabahar, Pusa Mausami, Pusa Navbahar, Durga Bahar
Onion	Patna Red, Nasik Red, N-53, Pusa Red, Pusa Ratnar, Pusa White Round, Pusa White Flat, Punjab Selection, Agrifound Dark Red, Arka Pragati
Tomato	Pusa Ruby, Pusa Early Dwarf, Pusa-120, HS-102, Sweet-72, S-12, Mangla, Punjuab Chhuhara
Brinjal	Pusa Purple Long, Pusa Purple Round, Pusa Kranti, Pusa Anmol, Arka Sheel, Arka Shirish, Arka Kusumakar, Arka Navneet
Amaranth	Co-1, Co-2, Co-3, Chhoti Chauali, Badi Chaulai
Okra	Pusa Makhmali, Punjab No. 13, Punjab Padmini, P-7, Parbhani Kranti
Pumpkin	Arka Chandan, Co-1, Co-2
Musk melon	Pusa Sharbati, Pusa Madhuras, Hara Madhu, Punjab Sunehri, Durgapura Madhu
Watermelon	Sugar Baby, Arka Manik, Arka Jyoti, Durgapura Meetha, Kesar, Mateera (AHW-19 and AHW 65)
Bottle gourd	Pusa Summer Prolific Round, Pusa Summer Prolific Long, Pusa Meghdoot, Pusa Manjari, Pusa Naveen
Bitter gourd	Pusa Do Mausmi, Arka Harit, Pride of Gujarat
Kachri	AHK 119 and AHK 200
Snapmelon	AHS-10 and AHS 82
Kakdi	AHC-2 and AHC-13

2. Orchard establishment

Fruit plants propagated in the nursery are generally used to raise orchards. Such plants, invariably lose their tap roots as a result of repeated transplanting. Plants raised in containers develop coiled roots. For success in drylands, plants must have a root architecture with a strong tendency to penetrate deep into the soil. *In situ* technique of orchard establishment is preferred under such situation (Saroj *et. al.* 1994). Rootstock seedling of ber are raised in the nursery in 300 gauge polythene tubes (25 cm length and 10 cm diameter, open at both ends), filled with a mixture of farm yard manure (FYM), sand, and clay in 1:1:1 ratio. The seedlings can be budded when about 90-100 days old. These plants become ready for transplanting, 1-2 months after budding. This technique helps to retain the straight growth of the tap root as the tubes are open at the bottom. Thus, the tubes neither restrict root growth nor induce coiling. Budded plants raised by this technique are also suitable for transportation to distant place (Pareek, 1978). Planting of stem cuttings of pomegranate, phasla, fig and mulberry in such polytubes would also induce straight roots.

The plant density mainly depend upon the plant type, soil fertility status and management practices while planting system to be adopted in drylands depends largely upon the topography of the land, fruit species and soil type. In the plains, planting is generally done in square or rectangular system. On slopy lands, fruit trees are planted on contour terraces, half moon terraces, trenches and bunds, and microcatchments. On marshy and wet areas mounding and ridge-ditch method of planting have been suggested. The trenches and bunds made across the slope are staggered (Saroj *et al.*, 1994). In a microcatchment, which may be triangular or rectangular, trees are planted at the lowest point where runoff accumulates.

Some of the seed originated plants having very poor fruit quality are already growing in some of the degraded areas. They can be rejuvenated by top working. Cold arid of the Himalay region is quite rich in this context. The wild plants of ber, bael, aonla, guava, custard apple etc. growing in waste lands of plains can be rejuvenated into productive conditions by top working (Saroj *et al.*, 1994).

3. Training and Pruning

Training at initial stages of growth gives proper shape and strong frame to the trees. The bushy pomegranate should be trained keeping 3-5 stems from the ground level (Anonymous, 1985) while in other fruits, single stem training keeping 3-4 main branches is adopted. However, pruning is essential to regulate reproductive phase of plants. *Ber* is pruned during January in Tamil Nadu, by the end of April in Maharashtra, and by the end of May in north India. The main shoots of the previous season are cut back retaining 15 to 25 nodes, depending upon location, cultivar, and age and vigour of tree (Anonymous, 1991). All the secondary shoots are completely removed. As a result of light pruning for several years, long non-flowering shoots develop. To eliminate this, half the number of shoots on the tree should be pruned keeping normal length and remaining half should be pruned keeping one to two nodes to induce new growth for fruiting in the following year. In *phalsa*, the time of pruning should be regulated according to the flowering period and should result in maximum number of new shoots on which bearing takes place. Established *phalsa* bushes should be pruned at 150 cm height once a year during January in north India and twice a year (December and June) in south India. Pruning from ground level is done either to rejuvenate old bushes or to train young plants into bush form.

4. Water management

Water is the major constraint in commercial cultivation of arid horticultural crops. Hence, the need of the hour is to develop technologies which not only requires low water input but also have high water use efficiency.

Water being a rare commodity in arid eco-system, the first and foremost requirement is to conserve the available soil or rain water. For conservation of rain water both *in situ* and *ex-situ* technologies have been developed. Pareek (1993) have reported that microcatchment slopes greater than 5 per cent did not significantly affect runoff at Jodhpur and that the highest *ber* yields were obtained when 0.5 per

cent and 5 per cent slopes had 8.5m and 7m length of run, and 72 m^2 and 54 m^2 catchment area per tree, respectively. Work done at Aruppukottai (Tamil Nadu) and Anantapur (Andhra Pradesh) has indicated usefulness of *in situ* water harvesting technique for fruit production (Anonymous, 1989).

Arora and Mohan (1988) found V-shaped microcatchment with run-on surface mulched with grass to enhance the productivity of lemon, sweet orange and plum in Doon valley. At Hyderabad, micro-reliefs of 3 m width and 25 cm height, spaced 9 m from ridge to ridge, have been used to store extra rain water for fruit trees such as kagzi lime, coorg mandarin, and sweet orange with tomato and okra as intercrops.

Mulching with organic materials (e.g., hay, straw, dry leaves, and local weeds) has been found highly beneficial in reducing evaporation loss. The practice also suppresses weed growth, prevents erosion, and adds organic matter to the soil (Gupta, 1995). Black polythene mulch is very effective in *ber* orchards in western India (Anonymous, 1989). Although, local organic mulch materials are cheaper than polythene mulches but these require proper care to maintain effective cover thickness. Leaf mulch has been used to conserve soil moisture in *sapota* orchards in Karnataka, Tamil Nadu, and Andhra Pradesh. Sugarcane trash mulch in pomegranate, fig, and custard apple was found effective in Maharashtra (Anonymous, 1989).

At CIAH, Bikaner, the work on in-situ water harvesting has been undertaken in Pomegranate, aonla and vegetables. It has been demonstrated that application of black polythene mulch and local weeds helps in conserving soil moisture status in above crops. It has been demonstrated that plant growth and development remains optimum with use of above mulching materials (Anonymous, 1998; Anonymous, 2003). Mulching studies with respects to soil hydro thermal regimes in brinjal revealed that organic mulches curtailed soil temperature during warm months, while an increase was recorded during the winter month. Significant increase in fruit yeld by 66 and 58% could be obtained through *lasoda* (*Cordia* spp.) and *kheep* (*Leptodenia pyrotechnica*), Awasthi *et al.* (2006).

Among the *ex-situ* water conservation methods, in arid ecosystem, emphasis has been given mostly on pressurized irrigation system. It has been demonstrated that fruits and vegetables can be grown economically by use of drip or sprinkler irrigation system. At CIAH, Bikaner and its regional station it has been demonstrated that crops such as pomegranate and ber can be grown succesfully under drip irrigation system. It has been proved that water saving to the tun of 25% can be achieved if pressurized irrigation system is used as compared to conventional flooding or bubbler system (Anonymous, 2003).

The use of drip alone or in combination with mulching has been demonstrated as a successful technology for cultivation of pomegranate at Anantapur (Anonymous 2006). The studies have shown that highest number of 'B' grade pomegranate can be harvested under drip + mulch.

Application of pitcher irrigation was attempted in cactus pear at CIAH, Bikaner and it was recorded that growth of cactus pear was better under this treatment as compared to control.

The use of double ring system to conserve the moisture applied for production of fruit crops was attempted in aonla. It was observed that by this method the water is applied in zone having functional roots and hence, water use efficiency is enhanced (Shukla *et al.* 2006)

Water loss due to transpiration can be reduced by use of radiation reflectants, stomata closing chemicals, and plastic films. Spraying of 4-6 per cent Kaolin, 0.5-1.0 per cent liquid paraffin, and 1.5 per cent power oil, after occasional rains in low rainfall areas and after the post monsoon rains in high rainfall areas, considerably reduce plant water losses (Anonymous, 1989; Pareek and Sharma, 1991). Chemicals such as phenyl mercuric acetate (PMA), decinyl succinic acid (DSA), abscisic acid (ABA), and cetylalcohol cause stomata closure and thereby reduce transpiration (Jones and Mansfield, 1971; Chundawat, 1990). Shelterbelt and windbreaks can reduce evapotranspiration by reducing the wind speed and stabilizing microclimate (Muthana *et al.*, 1984).

Control of weeds has special significance in rainfed orchards in reducing soil moisture losses. Timely weeding is essential to improve fruit quality even in high rainfall zones. Application of pre-emergence weedicides such as diuron, bromacil, and atrazine @ 2-3 kg ha^{-1} and post-emergence weedicides such as grammaxone (paraquat) and glyphosate @ 1 L ha^{-1} have proved effective in checking weed growth.

5. Nutrient Management

Use of manures and fertilizers in required doses at appropriate time according to the age of plants is essential. In *ber* orchards, besides 10-15 kg organic manure, annual application of 100 g N, 50 g P_2O_5 and 50 g K_2O per tree is recommended. Fertilizer doses should be raised according to the age of plants and soil fertility of the region. Application of 15-20 kg FYM per tree has been found beneficial in aonla, custard apple, and tamarind. At Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, in addition to 50 kg FYM, 625 g N, 225 g P_2O_5 and 225 g K_2O has been recommended for application to 5-year-old pomegranate trees (Anonymous, 1985). At Bangalore, application of 500g N + 250g P + 125g K produced six times higher yield than in the control (Anonymous, 1989). In 6 to 7 years old fig trees planted at 5m x 5m spacing, fertilization with 900g N + 250g K improved fruit production (Anonymous, 1985).

The nutritional trials has been undertaken in arid fruits at CIAH, Bikaner and centres of AICRP on Arid Zone Fruits.

The studies conducted on Date palm at Abohar showed that application of 300-400 g N/tree/year gave maximum number and weight of bunch. Similarly in pomegranate it has been demonstrated that application of 50% recommended dose of Nitrogen at monthly interval gave best performance (Anonymous, 2006).

In order to conserve the costly input such as fertilizer, attempts were made to supply this along with water under pressurized irrigation system. The studies conducted in pomegranate and *ber* has demonstrated that fertilizer saving to the tune of 25% can be achieved if plants are ferti-irrigated through drip.

Keeping in view the export potential of pomegranate, attempts have been made to assess the organically production of this crop. In this pursuit, substitution of in-organic with organic fertilizers were attempted. The results have demonstrated that a good crop of pomegranate can be harvested by giving 50% RD of NPK through Vermicompost and 50% through inorganic fertilizer. Thus, the use of inorganic fertilizers can be reduced to half through this technology (Anonymous, 2003).

Micronutrients are often found deficient in semi-arid and arid soils. Foliar feeding of nutrients such as nitrogen (0.5-2.0% urea), zinc (0.05 to 1.0% zinc sulphate), and boron (0.05 to 1.0% borax) has given beneficial results in these areas (Pareek and Sharma, 1991). In the medium rainfall region of eastern Uttar Pradesh, application of FYM, pond soil, gypsum, and pyrite in sodic soils resulted in better establishment and growth of *aonla* and *bael* plants (Pareek and Vishal Nath, 1996).

6. Fruit based cropping system

Monoculture in arid zone is highly risk prone due to crop failures, hence a suitable tree crop combinations is essential for alleviating the risk, generation of income, improvement productivity per unit area/volume as a result of efficient use of natural resources and inputs, and ameliorate and improve adverse agroclimate. Agri-horticultural combinations with legume intercrops such as mung bean, moth bean, cluster bean, and cowpea are beneficial. In the rainfed orchards of guava and *ber*, cluster bean, okra, and cowpea in *kharif* (rainy season) proved good in the medium rainfall region of Gujarat (Raturi and Hiwale, 1988). At Godhra, growing cluster bean as *kharif* intercrop in *ber* and guava a net return of Rs. 14,630 ha^{-1} was obtained. Even vegetables such as brinjal and chilli could be grown as intercrops. Besides, cover cropping with grasses such as *Cenchrus ciliaris* and pasture legumes such as *Stylosanthes hamata* could be done without deleterious effect on the fruit trees. At Hyderabad, cowpea, green gram, cluster bean and horse gram in *ber* orchards and bitter gourd, tomato and okra in acid lime orchards have been grown as intercrops.

In areas with large livestock population, horti-pastoral system would be beneficial. In the arid areas, the system could have combinations such as *khejri* (*Prosopis cineraria*)+ber+*dhaman* (*Cenchrus ciliaris, C. setigerus*) or *sewan* (*Lasiurus sindicus*), or *tumba*. In semi-arid areas, perennial trees (Mango, *mahua*, tamarind, *sapota*, jackfruit and palmyra palm) could be grown with fodder crops.

Fruit trees can also be planted in association with forest trees, and they yield wood for packaging and fuel. Multi-storey combinations incorporating large trees, small trees, and ground crops can be used. In low rainfall (300-500 mm) zone, combinations such as *khejri* or ber+ber or drumstick+ vegetables (Legumes and cucurbits); in 500-700 mm rainfall zone, combination of mango or *ber* or *aonla* or guava +pomegranate or sour lime or lemon or drumstick+solanaceous or leguminous or cucurbitaceous vegetables; and in 700-1000 mm rainfall zone, combination of mango or jackfruit or *mahua* or palmyra palm or tamarind or guava+sour lime or lemon or pomegranate or *aonla* + vegetables can be adopted (Pareek, 1999).

In arid ecosystem, attempts have been made to develop models for crop diversification. Keeping in view the traditional overstorey crops as *ber* and new introduction aonla, the cropping models have been developed. It has been demonstrated that in ber based cropping system cultivation of Indian aloe can be taken up as a remunerative model Dhandar *et al.* (2004). Similarly, in aonla based cropping system, it has been demonstrated that model consisting of aonla + ber alongwith moth bean or fenugreek can be adopted as a sustainable model for nutritional and income security of the inhabitants (Awasthi, 2006).

7. Pest and disease management

Besides wild animals, rodents and birds there are many insects and diseases causing severe loss of crops. Major diseases of arid horticultural crops and their control are presented in Table 4.

Termites cause considerable damage particularly in low rainfall areas. Heptachlor dust (5%) should be applied in the pits (50 g pit^{-1}) dug for planting fruit trees. Subsequently, water soluble insecticides (chloropyriphos) should be applied with irrigation water. Fruitfly (*Carpomyia vesuviana*) causes serious damage to *ber* fruits. To keep the infestation under check, the chemical spray schedule should consist of spray at pea stage with 0.03 per cent monocrotophos, second spray after 15 days with 0.05 per cent fenthion, and third spray after another 15 days with 0.1 per cent carbaryl XLR. During maturity of the fruits, if necessary, sprays should be done with 0.5 per cent malathion mixed with 0.5 per cent *gur* or sugar solution. This schedule has also been found effective against fruit borer (*Meridarchis scyrodes*) which causes serious damage in southern and western India. Pomegranate butterfly (*Virachola isocrates*) causes considerable damage to pomegranate fruits. Bagging of fruits with butter paper gives good protection. For control, 0.02 per cent deltamethrin and 0.2 per cent carbaryl 50 WP sprayed in rotation at 21

Table 4 : Major pests and diseases of arid horticultural crops and their control measures.

Crop	Pests/disease	Control measures
Pests		
Ber	Fruit Fly	Comprising digging of soil in basin, mixing of 50g insecticidal dust. spray of 0.05% Monocrotophos at monsoon, 3-spray of Monocrotophos (0.3%) at pea stage.
Pomegranate	Fruit borer	Two spray of Deltamethrin (0.02%) and carbaryl 50 WP (0.2%) at 21 days interval.
	Barkeating caterpillar	Plugging of holes with mud followed by spray Dimethoate/ Monocropthos (0.08%).
Aonla	Leaf gall midge	Spray of Endosulphon (0.05%) minimize the problem.
Diseases		
Pomegranate	Leaf and fruit spot	One spray of Ziram (1.0%) or Bordeaux (1.0%) at flowering or fruit setting and subsequent 4 sprays at 20 days interval.
Date palm	Graphiola leaf spot	Spray of Bavistin (0.1%) or Blitox 50 WP (40%) minimize the disease
	Fruit rot	Spray of Carbendazim (0.1%) minimize the rotting.
Aonla	Rust	Three spray of Moncozeb (0.3%) at 15 days interval from diseases initiation (Faizabad). Four spray of Chlorothalonil (0.2%) at 10 days interval.
Fig	Rust	Two spray of Moncozeb (0.3%) is effective.

day intervals starting from fruit set is the most cost effective.

For the control of *ber* powdery mildew, fungicides such as 0.1 per cent dinocap or carbendazim or triademorph or thiophenate methyl and 0.2 per cent wettable sulphur have been found most effective when sprayed 2-4 times at 15 to 20 day interval starting from initiation of the disease (Anonymous, 1989; Pareek and Vishal Nath, 1996). One spray of the fungicide at initiation of new growth after pruning is an effective prophylactic measure. Black leaf spot (*Isariopsis indica*), found under more humid conditions, can be controlled by 2-3 sprays of 0.2 per cent captafol or copper oxychloride or mancozeb and 0.1 per cent carbendazim at 15 day intervals (Anonymous, 1985). For the control of leaf and fruit spot in pomegranate, four sprays with 0.25 per cent ziram and 1 per cent bordeaux mixture at 15 day intervals are most effective. Since, the intensity of the disease is more under humid conditions during *mrig bahar* as many as 10 sprays at 10 day intervals may be necessary. Fungicides such as captafol, mancozeb, carbendazim, copper oxychloride, and thiophenate methyl could also be used. For the control of rust in *aonla*, 4 sprays of 0.2 per cent chlorothalonil at 15 day intervals soon after initiation of symptoms give the best control (Anonymous, 1997).

Apart from chemical control, attempts have also been made to use bio pesticides for control of pests in arid fruit crops. It has been demonstrated that application of Neem Seed Kernal Extract (2.5-5%) on various crops effective in controlling pests in pomegranate, aonla, chilli and brinjal (Anonymous, 2003).

Similarly use of bio-control measures to control ber powdery mildew was also attempted. It has been demonstrated that isolates of *Trichoderma* has potential to be used as bio-control of her powdery mildew. The isolates thus obtained are resistant even to fungicides and hence can be used in combination with pesticides (Anonymous, 2003).

The studies conducted on control of date palm scale insect has revealed that *Chilocorus nitritus* is a potential predator of *Parlatoria*. It has further shown that during larval period on an average 437.35 scales are consumed by various instars. The adults consumed 20.86 scales/day and an average of 1317.72 scales during the life period (Anonymous, 2006)

Emerging issues in arid horticulture

Although, great effects have been made to develop technology compatible for commercial production of arid horticultural crops, yet there is a need to address various issues for further refinement of technology, improvement in socio-economic status of arid region and development of sustainable agro-horti-system. The major issues are,

- Efficient utilization of water resource
- Rehabilitation of degraded lands
- Utilization of solar and wind energy
- Conservation of biodiversity
- Breeding for resistance to abiotic stresses
- Diversified farming systems
- Value addition
- Human Resource Development

Refe
Anon
on
Ag
No.
Zon
Anony
on
Uni
No.
Zon
Anony
Wo
Hon
Tec
Frui
Anony
Hort
Anony
Hort
Anony
for A
Anony
Work
April
ICAI
Anony
Work
duri
S.K.
Awasthi
sche
subm
Awasthi
mulc
yield
Hour
Arora, Y
moist
Natio
CRID
Chunday
Oxfor
Dhandar,
2004.
irrigat
Arid I
Eswaran,
challe
Indian
Gupta, J.
agricul
of Dry
Publis
Jones, R.J

References

Anonymous, 1985. Proceedings. Third National Workshop on Arid Zone Fruits Research. Mahatma Phule Agricultural University, Rahuri, July 5-8, 1985. Tech. Doc. No. 18, Hisar, India: Coordination Cell, AICRP on Arid Zone Fruits, ICAR.

Anonymous, 1989. Proceedings. Fifth National Workshop on Arid Zone Fruit Research, Gujarat Agricultural University, Sardarkrushinagar, July 6-9, 1989. Tech. Doc. No. 27, Hisar, India: Coordination Cell, AICRP on Arid Zone Fruits, ICAR.

Anonymous, 1991. Proceedings, Group Meeting of Research Workers on Arid Zone Fruits. Indian Institute of Horticultural Research, Bangalore, December 18-20, 1991. Tech. Doc. No. 31. Coordination Cell, AICRP on Arid Zone Fruits, ICAR.

Anonymous, 1997. Annual Progress Report, NRC for Arid Horticulture, Bikaner

Anonymous, 1998. Annual Progress Report, NRC for Arid Horticulture, Bikaner

Anonymous, 2002. Annual Progress Report, Central Institute for Arid Horticulture, Bikaner.

Anonymous, 2004. Proceedings, Group Meeting of Research Workers on Arid Zone Fruits. ARS, Kumarganj, Faizabad, April. 2004. Coordination Cell, AICRP on Arid Zone Fruits, ICAR.

Anonymous, 2006. Biennial Report (2004-05) of XIII Group Workers Meeting of AICRP on Arid Zone Fruits held during 10-12 May 2006 at S.D. Agricultural University, S.K. Nagar, Dantiwada, Gujarat.

Awasthi, O.P. 2006. Annual Report 2005-06, AP Cess fund scheme on aonla based multistrata cropping system submitted to ICAR, New Delhi.

Awasthi, O.P., Singh, I.S. and Sharma, B.D. 2006. Effect of mulch on soil hydro thermal regimes, growth and fruit yield of brinjal under arid conditions. *Indian Journal of Hourticulture*, 63 (2): 192-194.

Arora, Y.K. and Mohan, S.C. 1998. Water harvesting and moisture conservation for fruit crops in Doon valley. National Seminar on Dryland Horticulture, 20-22 July 1988 CRIDA, Hyderabad.

Chundawat, B.S. 1990. Arid Fruit Culture. New Delhi, India: Oxford & IBH Publication Co. Pvt. Ltd.

Dhandar, D.G., Saroj, P.L., Awasthi, O.P. and Sharma, B.D. 2004. Crop diversification for sustainable production in irrigated hot arid eco-system of Rajasthan. *Journal of Arid Land Studies*, 148 : 37-40.

Eswaran, H., 1992. Role of soil information in meeting the challenges of sustainable land management. *Journal of Indian Society of Soil Science*, 40: 6-24.

Gupta, J.P., 1995. Water losses and their control in rainfed agriculture. In : Singh, R.P., (ed.) Sustainable Development of Dryland Agriculture in India . Jodhpur, India: Scientific Publishers, pp. 169-176.

Jones, R.J. and Mansfield, T.A. 1971. Antitranspirant activity of the methyl and phenyl esters of abscisic acid. *Nature*, 231:331-332.

Muthana, K.D., Yadav U.S., Mertia, R.S. and Arora, G.D. 1984. Shelterbelt plantations in arid regions. *Indian Farming*, 33:19-21.

Pareek, O.P. 1978. Quicker way for raising *ber* orchards. *Indian Horticulture*, 23:5-6.

Pareek, O.P. 1993. Irrigation management in fruit crops. In Singh D.P. and Sharma, H.C. (Eds.) Important Aspects of on farm water management. CCS HAU, Hisar.

Pareek, O.P. 1999. Dryland Horticulture. In : Singh *et al.* (Eds.), Fifty Years of Dryland Agricultural Research in India, CRIDA, Hyderabad.

Pareek, O.P. and Sharma, S. 1991. Fruit trees for arid and semi-arid lands. *Indian Farming*, 41:25-30.

Pareek, O.P. and Vishal Nath. 1996 Coordinated Fruit Research in Indian Arid Zone-A Two Decade Profile. NRC for Arid Horticulture, Bikaner.

Raturi, G.B. and Hiwale, S.S. 1988. Horticulture based cropping systems for drylands. In: National Seminar on Dryland Horticulture, 20-22 July, 1988. CRIDA, Hyderabad.

Saroj, P.L., Dubey, K.C. and Tiwari, R.K. 1994. Utilization of degraded lands for fruit production. *Indian Journal of Soil Conservation*, 22 (1&2):162-176.

Saroj, P.L., Samra, J.S., Sharma, N.K., Dadhwal, K.S., Shrimali, S.S., and Arora, Y.K. 1999. Mango based agroforestry systems in degraded foothills of north-western Himalayan region. *Indian Journal of Agroforestry*, 1(2): 121-128.

Sharma, B.D., Dhandar, D.G. and Vashishtha, B.B. 2002. Response of ber (*Ziziphus mauritiana* var. rotundifolia Lamk) to drip fertigation in aridisols of western Rajasthan. Abstract, National Seminar on Sustainable Management of Water Resources for enhanced agricultural production held during 26-28, 2002 at Dr. Bala Saheb Sawant Konkan Krishi Vidyapeeth Dapoli.1.

Sharma, K.D., Pareek, O.P. and Singh, H.P. 1982. Effect of runoff concentration on growth and yield of jujube. *Agriculture and Water Management*, 5:73-84.

Sharma, K.D., Pareek, O.P. and Singh, H.P. 1986. Microcatchment water harvesting for raising jujube orchards in arid climate. *Trans. ASAEI*, 29:112-18.

Shukla, A.K., Singh, D., Meena, S.R., Singh, I.S., Bhargava, R. and Dhandar, D.G. 2006. Enhancement of water use efficiency in aonla through double ring system of irrigation under hot arid agro-ecosystem. In : Abstract. National Seminar on Input use efficiency held at IIHR, Bangalore, August 9-11, 2006, Pp. 99.

Singh, R.P. and Vishnumurthy, T. 1988. Micro-reliefs for citrus and vegetables under dryland conditions. National Seminar on Dryland Horticulture, July 20-22, 1988. CRIDA, Hyderabad.

Srinivas, K., Vittal, K.P.R. and Sharma, K.L. 1999. Resource characterization of dry land : soils. In : Singh *et al.* (Eds.), Fifty Years of Dryland Agricultural Research in India. CRIDA, Hyderabad, India.