Technical Bulletin No. 40

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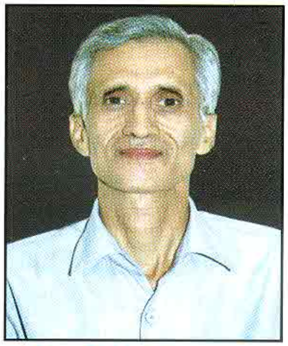

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PREFACE

The arid horticulture is a new paradigm in the field of horticultural development. It is a potential area for horticulture development and has a great scope in future, particularly in hot arid regions of our country. In last two decades, considerable knowledge has been generated in research and development work of the arid horticulture and it has already assumed of great importance for the development of the vast drought prone areas of the country. It may be boon for socio-economic upliftment of the people of hot arid regions like western part of Rajasthan. It may provide tremendous opportunities for employment, income generation for the poor people of arid regions and also reducing soil erosion /aridity. Recently, technological development through the functioning of Central Institute for Arid Horticulture, Bikaner (Rajasthan) and its 18 centres under All India Co-ordinated Research Project on Arid Fruits working in different states of our country, ICAR Institutions and different SAUs, enhanced the scope of horticultural development in hot arid regions to make them blossom. However, the progress of adoption of innovative arid horticultural technologies developed by the above research Institutions is very poor on farmer's fields. There may be some constraints which inhibit the progress of adoption of horticultural crops and their agro-techniques in hot arid regions. Keeping the above facts in mind, the scientists of the Institute surveyed the hot arid region of Rajasthan and collected the information from different sources about the reasons of low adoption of horticultural technologies in the region. The scientists of the Institute observed several constraints related to ecological, technological, infrastructural, economic and socio-psychological constraints on the part of the farmers which discourage the adoption of horticultural crops and their agro-techniques in hot arid regions. The scientists also gathered some innovative ideas to make strategic plans and approaches to escape the negative effect of existing constraints while adopting innovative technologies of arid horticulture. This technical bulletin deals with constraints faced by the farmers of hot arid region in adoption of horticultural technologies on their fields and some strategic considerations to escape the negative effect of these constraints. I hope, the matter of this bulletin will be helpful for the researchers/scientists, planners, police makers, administrators, etc. while making any innovative plan for horticultural development in hot arid regions. Keeping the above constraints in mind, they can invent location specific suitable technologies/ strategies for the horticultural deployment in such regions.

March 2011,
Bikaner

(S. K. Sharma)
Director

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1. INTRODUCTION

The hot arid regions of the country are spread over 32 million ha (0.32 million Sq.Km.) in the state of Rajasthan (61%), Gujarat (20%), Andhra Pradesh(7), Punjab (5%), Haryana (4%), Karanataka (3%), and Maharashtra(0.4%), in addition to the cold deserts in the sates of Jammu and Kashmir and Himachal Pradesh which are characterized by hostile agro-climate and fragile eco-system. The hot arid zones are characterized by an annual rainfall between 100 – 500 mm with a coefficient of variation (CV) varying from 40 – 70 per cent, low and erratic rainfall combined with extremes of temperature (450-500 cal/cm^2/day); low relative humidity; high potential evapo-transpiration value ranging from 1600 mm in eastern part and 1800 mm in western part of the region. The relative humidity (RH) is highest during monsoon season (July – August) which goes upto 60 – 80 % and starts dropping down sharply from October and onward which reaches at lowest level (<30 %) during the month of March – April. However, the status of RH is not static and changed year to year depending the onset of monsoon and wind velocity / directions. Other important characteristics of hot arid regions of the country are, hot and high wind velocity (25 – 35 Km/ hr); poor soil condition (with low organic matter and low water holding capacity); in large tracts the ground water is poor, brackish and saline in reaction; high sunshine and abundant solar energy leading to high rate of evapotranspiration (average 05 –10 mm); poor vegetation; frequent occurrence of drought and frost; limited and inefficient transportation and marketing facilities, etc., *(Yadava and Soni,* 2008*)*. The hot arid regions have unique characters in comparison to other regions of the country. There are several strong constraints which impede the adoption of horticultural technologies in these regions. The major constraints in adoption of horticultural technologies in hot arid regions are narrated in details as under.

2. CONSTRAINTS IN ADOPTION OF HORTICULTURAL TECHNOLOGIES IN HOT ARID REGIONS

(i) Ecological constraints

(a) Acute shortage of water: In hot arid regions like western Rajasthan, the water is most precious and most scare commodity. The acute shortage of water in hot

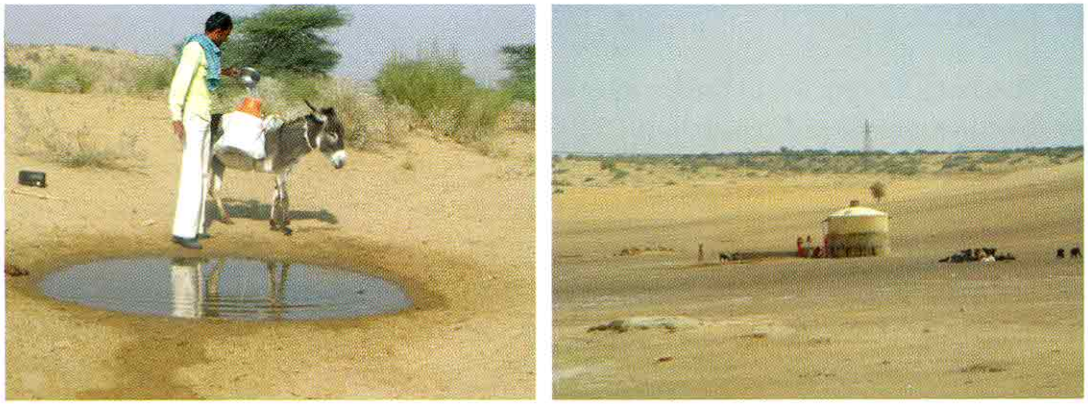

Fig. 1. Depicting scarcity of water

arid regions is a major challenging constraints in adoption of improved technologies of arid horticulture.

The major source of surface water in arid zone of western Rajasthan is the *Luni* river and its tributaries but due to the low rainfall, it also fails to provide water for agriculture or other uses of human being. The Rajasthan state has 10.4 %, 10.6 %, and 5.5 % geographical area, agricultural contribution and population of the country, respectively but only 1.0 % surface water of the country is available in the state. Hence, it is very difficult to adopt and grow the horticultural crops in hot arid regions.

(b) Poor and erratic rainfall: The very poor and erratic rainfall is well known and evergreen constraint in the hot arid regions of western of Rajasthan for the adoption point of view of any crop. In this region, the Monsoons are mostly failure and erratic in nature too. There are 12 districts under hot arid zone of western Rajasthan of which the annual rainfall never exceeds to 50 centimetres. In ending areas of border district Jaisalmer of Rajasthan, the annual rainfall is only 10 – 15 centimetres. In last hundred years, the rainfall occurred during 25 years only in this dristrct. In these regions, the rainy days in a year are very less that is from 50 to 80 days only. Coefficient of variation (C. V.) of annual rainfall is varies from 37 – 59 percent. Occurrence of first rain for sowing the crops is also another common aberration which may be as late as first week of August in western part and third week of July in eastern part of the regions, instead of normal period 01 – 15 July (*Nathuramka,* 2008). In such conditions, the job of adoption of horticultural technologies becomes very difficult and challenging.

(c) Occurrence of drought and famine: The occurrence of drought and famine are regular and inseparable phenomenon of the hot arid regions. They are synonymous to each other and work permanently in reflective manner. The long back history and past experiences plots that after every 2 – 3 years interval droughts and famines are occur on regular and hazardous manner through out the hot arid regions. Most of these are triplicate famines *(Triakal)* in nature where the acute shortage of food, fodder and water is faced by human being, flora and fauna of the regions.

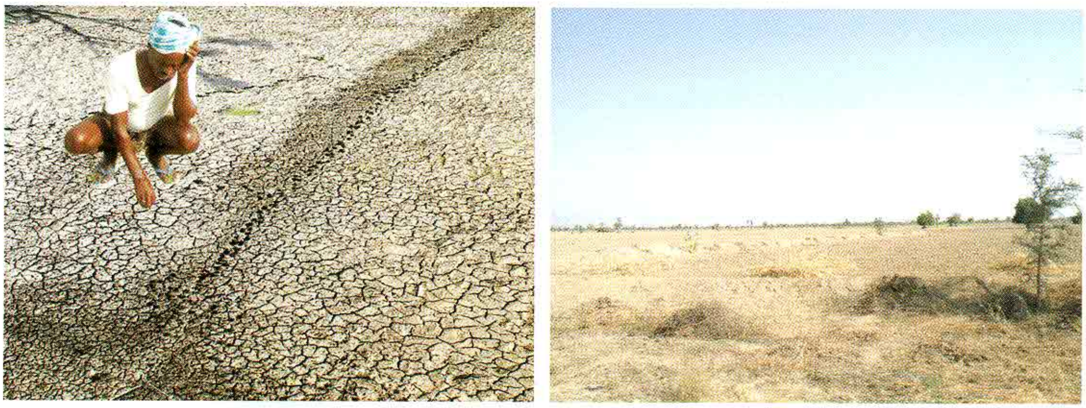

Fig. 2. Photo showing severe drought conditions

Not only the intensity but also the spread and the sphere of these drought and famines are very wide and chronic. For example, out of total 32 district of Rajasthan, 30, 29, 26, 31, 32, 31 districts were badly affected by severe drought and famine during the year of 1991- 92, 1995-96, 1999-00, 2000-01, 2002-003, 2004-05, respectively. It was also observed that the bad impact of the above drought and famine was more severe in 12 western districts of hot arid region (as demarcated by planning commission, Govt. of India) of Rajasthan (Anonymous, 2007-08).

(d) Severe frost/chilling injury during winter season: In recent years, the frost injury has become a major challenging constraint for horticultural development in hot arid regions, particularly in western part of the Rajasthan. In hot arid regions,

Fig. 3. Severely affected plant of (a) Aonla (b) Lasora (c) Pomegranate by frost/ chilling injury

temperature goes below to freezing point during winter season. For example, during 2006, 2007, 2008 and 2011 the temperature dropped to sub-zero to zero level and at some places below to zero level during the month of January and persisted continuously for three days.

The majority of the horticultural crops viz. Aonla, Lasora, pomegranate, mulberry, bael, ber, phalsa, moringa , and vegetable crops of winter season were severely affected by frost/chilling injury during 6 – 8 January, 2011 when the temperature fell down as low as -2 to -3.5° C and some of the crops could not recovered at all. Hence, occurrence of severe frost during winter season becomes a curse for the horticultural development in hot arid regions.

(e) Very deep and salty ground water: The ground water in hot arid regions is not only scare but also very deep with a complex of the salts. The pH and EC range of ground water of hot arid regions is 8.0 to 10.0 and 10 – 40 dS/ m, respectively and the depth of ground water is from 300 to 500 feet or more. Thus, due to high salt content, it can not be used for long time or not at all for irrigation and drinking purpose. In most of the areas, the ground water is considered unusable and detrimental to soil, crops, animals and human health due to presence of harmful complex of salts in it. Hence, the degraded quality of ground water is also a major constraint in adoption of arid horticultural crops / technologies in hot arid regions.

(f) High temperature during summer season: The hot arid regions, as the name indicate, have extremes of temperature during summer season. In the history, the temperature in hot arid regions of western Rajasthan has been recorded as high as 52.2 °C during month of June, 1991. The high temperature during summer season of each and every year is a common phenomenon of hot arid regions of the country and its normal range is 45 to 50 °C (with 450-500 $cal/cm^2/day$). Moreover, the bright sunshine hours are varies from 6.6 hours in July – August and > 10 hours in summer. Average incoming solar radiation is 22.05 MJ m^2 (8.40 – 27.30 MJ m2) during the month of April – May creating very hot and hostile climate (*Rathore, et. al.* 2008). In such conditions, the soil temperature, in general, remains higher than air temperature by 10 °C and the temperature of surface soil may be as high 60 °C during the summer (May–June) season. The diurnal temperature rage of surface soil of sand dune areas varies from 25 – 40 °C during monsoon season also (Ramkrishna*, et. al.,* 1990). In such conditions, growing of any crop is too difficult.

(g) Poor soils and problematic topography: In the hot arid regions of Rajashan, Haryana, Punjab and eastern part of Gujarat, the soil have developed from alluvial and aeolian parent materials. In these areas, 30.6 % area has light brown sandy soil with dune dominance and 34 % area is associated one, 1.7 % area has light brown soil, 13.6 % area has grey brown soil, 5.9 % area has surface hard pan and 1.7 % area has seirozem soil (Dhir, 1977). Kolarker*, et. al.* (1998) reported that 12 districts of hot arid zone of western Rajasthan is dominated by sandy soil and it covers about 14.3 million hectares area.

Fig. 4. Typical sand dunes

These soils are very poor in fertility having very low carbon content (0.03 – 0.1) with light texture called desert soil (North Western part) of the aridisols order. The lime content of sandy soil of hot arid region is 1–15 %. The dunes generally contain

70% to 85.5 % fine sand , 5- 10 % coarse sand , 3.2 – 6.2 % clay and 1.8 – 5.8% silt. These soils are single – grained, non – coherent and non plastic. The specific gravity ranges from 1.6 to 1.7 and the total pore space of these soil is less. As a result , there is free and rapid movement of water during rainfall or irrigation leading heavy percolation of water below the root zone. Steady and strait infiltration rate of water in the sand dune ranges from 15 – 30 cm/hr. The available water capacity of the sand dune ranging from 3.0 % to 4.5 % (w/w). The calcium carbonate in sand dune is 0.1 to 5.0 % and the pH is 8.2 to 8.9. Major part of the organic carbon is present in non-humic form followed by fluvic and humic form. These soils are poor in nitrogen and phosphorous content also. The nitrogen content ranges from 0.005 % to 0.006 %. The average content of phosphorous in these soils is < 20 kg. ha-1, in which 80 – 85 % is found in inorganic friction mainly composed of Ca-bound (Joshi, 1990 and Chaudhari, et. al.1979). These soils are deficient in iron and zinc also. Undulating topography with dominance of sand dunes and inter-dunal plains is the major characteristic of soils. The shifting of sand dunes and sand particles, fast leaching of plant nutrients, deep percolation / immediate infiltration of water in soils are other major problems of the hot arid region which leads the reluctance to non adoption of the improved arid horticultural production technologies in these regions.

(h) High hot wind and strong sand storms: The hot arid regions, particularly in western Rajasthan, experienced very hot and strong wind regimes. The peak hot

Fig. 5. Strong sand storm

wind speed are recorded in the month of June with an average speed varies from 14.6 – 18.50 kmph and during monsoon season, their speed is recorded between 9.0 – 13.0 kmph. In post monsoon season also (from October and onward) these winds blow with speed of about 7.0 kmph.

The region experienced 3.0 – 8.0 strong sand storms every year. In general, when the rainfall is low during a particular monsoon season, the sharpness and strongness of the sand storms is increased during the subsequent year and vice – versa.

(i) Soil erosion and land degradation: Out of total geographical area of western Rajasthan, 77.57 % area is affected by wind erosion of soil and their deposition hazards. This includes 2.78 % very severe, 12.33 % severe, 35.22 % moderately severe, and 25.29% slightly severe. About 22950 sq. km.or 10.99 % area of the region has been affected by water erosion. About 4.82 % of the region has been affected by secondary salinization/ sodicity in soils.

Fig. 6. Salt affected soil

About 22745 ha area in Hunumangarh, 14663 ha in Sri Ganganagar, 3643 ha in Bikaner and 851 ha in Jaisalmer district is affected by water logging problems. The water logging problems are existed / increasing in hot arid areas of Haryana and Punjab also (Rathore, et. al. 2008). In hot arid regions, the crop growing period is hardly 8 to 12 weeks. Sand dunes and inter dunes, which were formed during late Pleistocene and stabilized in early Holocene period, account for 75-80% area of the

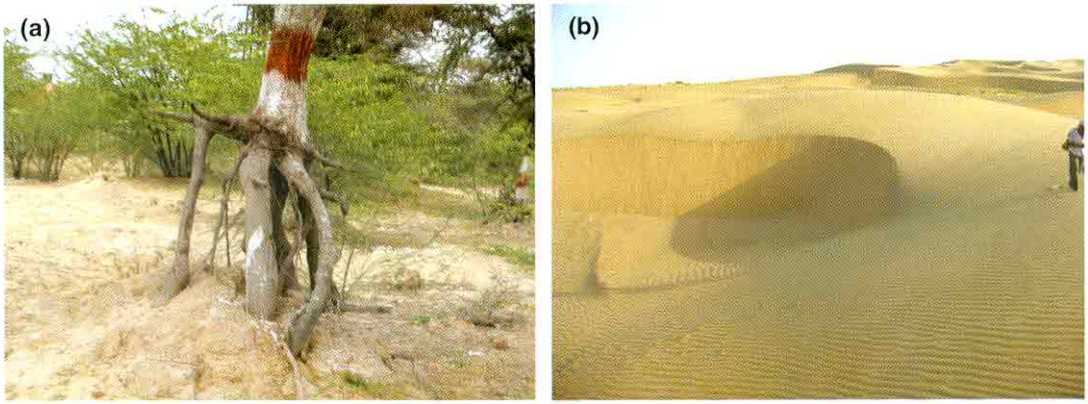

Fig. 7. Depicting (a) heavy soil erosion and (b) B*arkhans*

region. The renewed aeolian activities in the late Holocene period have given birth to active B*arkhans*, sub-coppice, sand dunes and sand sheeting on the existing landforms. These are some of the examples of land degradation in the hot arid regions which inhibit the progress of adoption of improved crop production technologies of horticulture.

(j) Low density of population and scattered poor rehabilitation: Low density of population also affect the rapid adoption the technologies as the technological interaction and diffusion process of the technologies is slow down amongst the farmers due to their less density or long distance between to each other.

Fig. 8. Scattered rehabilitation with poor conditions

(k) Attack of wild animals: The wild animal like blue bulls, deer, wild pigs, etc. harm the horticultural crops, and some times damage the crops very severely. Therefore, the farmers of the region reluctant to adopt the horticultural crops due fear of attack of wild animals.

Fig. 9. Severely damaged ber plant and coriander inter crop by wild animals

(ii) Technological constraints

(a) Lack of location specific and need based technologies: The hot arid regions of the country have typical and a peculiar environment / situations and they are very different from the other regions of the country. Not only the climatic factors but also the high heterogeneity is persisting amongst the farmers with respect o their socio-economic need and other work ecology. Thus, in such high heterogenic or differential situations, a particular improved technology can not be adopted universally by all farmers, even in the same area of a particular hot arid region. While an improved technology is developed, the researchers / scientist do not take account of the location specific need, problems / constraints and other situational elements associated with individual farmers. Hence, unsuitable technologies which can not meet the location specific and felt need of the farmers, leads to non adoption of the technologies.

(b) Lack of proper technical guidance: In the field of arid horticulture various promising technologies have been developed by various ICAR Institutes including

CIAH, Bikaner, SAUs and other research Institutions but they are not reaching to farmers field due to lack of proper communication system and guanine technical guidance. The proper guidance and motivation play a crucial role in adoption of any improved technologies/crops. Without proper guidance, farmers are unable to follow the actual science and essentiality of a particular technology. In such conditions a farmer / client can not exploit the full potential of the proven technology and intended out puts or some time it is totally failure. It create tension and loose the credibility of the technology thereby farmers become reluctant to adopt it and drop it up. Thus, the wrong messages about the credibility of the technology spread sharply amongst the other farmers / clients and it is rejected being promising / potential one.

(c) Other important technological constraints are: Lack of technological demonstrations on farmer's field, lack of farmers visit to research institutions and experimental sites, lack of trainings, no technical interaction in mass between the farmers and scientific community, scientific vision and understanding of the farmers / clients about the technologies is legging behind, negative attitude of farmers about the authenticity of the technologies, etc. are other important constraints which lead to poor adoption of horticultural technologies in wet arid regions.

(iii) Infrastructural constraints

(a) Lack of local markets: It is very important infrastructural constraint in adoption of the improved arid horticultural technologies. Since the farmers of the hot arid region are very poor and unaware about modern marketing techniques and changing dynamics. Although, they want and are able to produce arid horticultural quality products in huge quantity but they can not reach and catch the markets on time to sale their produces due to many reasons like long distance of market, lack of time and man power, lack of money and transport facilities, monopoly in markets, middle man hurdles, etc. On the other hand, majority of the horticultural produces are highly perishable and can not store for long time at farmers level. Hence, the farmers avoid such technologies which create problems, uneconomic and risk wearing also.

(b) Lack of authentic sources of inputs at local level: It is another important infrastructural constraint which is responsible for low adoption of the technology by arid farmers. Here also, more or less same factors work as in case of lack of local markets to sell the produces. Again, they are able and want to adopt improved technologies of arid horticulture but due to lack of awareness, long distance of markets, lack of time and man power, lack money and transport facilities, lack of authentic source of inputs, monopoly of input dealers / shopkeepers, etc. they can not reach / do not want go to such markets to purchase the improved inputs / technologies.

(c) Lack of need based credit support system: The Lack of need based credit support system also discourage the adoption of improved technologies. Due to the factors like poverty, risk, high cost of inputs and management, etc. farmers are not able to purchase the desirable high cost inputs and other essential materials required for the horticultural production.

(d) Other important infrastructural constraints: The other important infrastructural constraints which inhibit the progress of adoption of the improved technologies are, lack of quick and reliable information system, limitation of road and transportation facilities, poor and irregular supply of electricity, lack of supportive organization, lack of motivational institutions, etc.

(iv) Economic constraints

(a) Distress sale and low price of the products in the markets: The farmers reported in a study that the daily selling management process of horticultural produces is more difficult than the production of the same due to the absence of local markets / *Mandies* or long distance of markets / *Mandies*, monopoly in markets, lack of transportation facilities, shortage of man power and time, poverty, etc.. The selling process like timely harvesting of fruits / vegetables, shortening / grading process, packing, loading and unloading, transportation, interference of middlemen, market competition, mental and physical labour and cost involve in all above processes is very exhaustive and pain full. Moreover, even after taking a lot of pain, exertions and risk, the farmers get very low price of their horticultural products in markets which ultimately results in discontinue of the adopted technologies or non adoption at all.

(b) Highly perishable nature of the produces/products: It is also another major problem which discourages the adoption of horticultural crops in hot arid regions. The majority of the arid fruits and vegetables are immediately perishable in nature. They can not be kept safe, fresh and consumable by the farmers on their own level due to the factors high perishable nature of the products, high temperature, lack of cold storage facilities and so on. On the other hand, the market price of the products remains very low during the peak period of the production. But due to high perishable nature and non availability of cold storage facilities for the products, the farmers are strongly compelled to sell their produces in the market on the existing price whether it acceptable or not. In this juncture, the farmers remain in painful dilemma and they have only two options that is either sell their produces on existing market price (which is most of time low) or left to decay / rot. Ultimately, they feel high stress and sell their produces even at lowest market price. It creates high frustration in their mind and psychological stress and lastly, discontinue the adopted technologies or adopt not at all. This massage diffuses to other neighbouring / fellow farmers and they do not also adopt such kind of risky and painful technologies.

(c) Other important economic constraints: Non availability of reliable inputs at local level on reliable cost, lack of subsidy and credit facilities, unfamiliarity with developmental schemes and programmes, lack of insurance and support price, heavy economic loss due to pests/diseases and hazards, etc. are other important economic constraints which limit the progress of horticultural development in hot arid regions.

(v) Socio-psychological constraints

Amongst the socio-psychological constraints, the major constraints are poverty and low literacy, deep faith in traditional cropping system and cultural practices, lack of awareness, interest and knowledge, avoidance of risk wearing business (fear of crop failure, low income and market sale), uncertain mind about the success of crops/technologies, fear of diseases and pests attacks, faithlessness in research work, lackadaisical (Lazy and carelessness) nature of the farmers,orthodoxy thinking, low scientific vision of farmers, lack of social institutions, etc.

3. THE STRATEGIC CONSIDERATIONS TO ESCAPE THE NEGATIVE EFFECT OF EXISTING CONSTRAINTS

Despite the various bio-physical constraints, the hot arid region offers wide scope for cultivation of fruit crops like Ber (*Ziziphus mauritiana* Lam), Date palm (*Phoenix dactylifera*), Pomegranate (*Punica granatum* L.), Aonla (*Emblica officinalis* Gaertn), Bael (*Aegle marmelos* correa ex Roxb), Lasora (*Cordia* spp.), Karonda (*Carissa carandas* Linn), Ker (*Capparis deciduas* Edgew), Mulberry (*Morus alba* Linn), Khejri (*Prosopis cineraria* Druce), Phalsa (*Grewia subinaequalis* DC.) and Drum stick (*Moringa oleifera* Lam), etc. In addition, some cucurbits and other vegetables also have wide scope for production in hot arid regions. There is also a tremendous scope for expanding the Indian fruit industry by introducing several fruit species from the iso-climatic regions of the world. Recently, new infra-structural and technological development through the functioning of Central Institute for Arid Horticulture, Bikaner (Rajasthan), All India Co-ordinated Research Project on Arid Fruits (located in 18 centres of the different parts of the country), progress made by SAUs, etc. enhanced the scope of horticultural development in hot arid regions to make them blossom. Due to the existence of above strength in context of horticultural development in hot arid regions, some of the important strategic considerations to escape the negative effect of the existing constraints in adoption of arid horticultural crops narrated here.

(i) Adoption of potential crops and agro- techniques

(a) Selection of ideal crops: The crops selected for arid region must have xeric characters like deep tap root system (ber, bael, aonla), summer dormancy (as in ber), high water bound tissues (cactus pear, fig) reduced leaf area (aonla, tamarind), leaf surface heaving sunker stomata, thick cuticle and waxy coating (ber, phalsa, tamarind) and ability to withstand in poor degraded and marginal soil conditions. While selecting the crops due consideration should also be given on the flowering and fruiting period time. The crops selected should be such that it completes its maximum vegetative and reproductive phase during the period of maximum moisture availability.

(b) Selection of standard cultivars: Cultivars differ in their adaptability according to climatic conditions. The important cultivars identified for ber - Gola, Seb, Thar Sevika, Thar Bhubharaj, Mundia, Banarasi Karaka, Umran; for Aonla - NA 6, NA 7, Krishna, Goma Aishwariya, Chakaiya and Kanchan; Bael - NB 5, NB 9, Goma Yashi; likewise for Pomegranate- Jalore Seedless, Ganesh, Muskat and Dholka; Khejri – Thar Shobha, for Jamun- Goma Priyanka, in tamarind PKM-1, No. 263, Pratisthan, Yogeshwari, Goma Prateek, for Moringa PKM-1 and for Fig - Pune Fig, Daultabad, Black Ischier are the suitable cultivars for cultivation in hot arid and semi-arid regions of the country. Identification of suitable cultivars for crops like Ker, Lasora, karonda is in progress at Central Institute for Arid Horticulture, Bikaner and other co-ordinating centres of AICRP on Arid Zone Fruits. In case of vegetables improved varieties of mateera(AHW-19, AHW-65, Thar Manak), Snapmelon(AHS-82, AHS-10), Kachri (AHK-119, AHK-200), Cluster bean (Goma Manjri, Thar Bhadavai), bottle gourd (Thar Samridhi), etc. have been developed by Central Institute for Arid Horticulture, Bikaner which can be adopted by the farmers for better production in wet arid conditions.

(c) Planting specifications: The planting system in hot arid regions depends on location and topography of land, fruit species and soil type, etc. In the plains crescent shaped or semi-circular bunds with a diameter of 6-3m (depending on the spacing requirement of individual fruit trees) are prepared, while catchments pits are also dug on the upper side of the slope. The trees should be planted in centre of the crescent. On sloppy lands, fruit trees should be planted on contour terraces, trenches, bunds and micro-catchments. The trenches and bunds made across the slope are staggered. In a micro-catchments, which may be triangular or rectangular, trees should be planted at lowest point where run off accumulates. The spacing between rows and trees in such a run off harvesting has to be suitably varied and adjusted. The budded or grafted plants prepared in polyethylene bags in the nursery should be planted in the field at their age attaining 4 – 6 months at depth of 30 – 50 cm on the onset of monsoon. It should be taken care that polyethylene bags be removed without disturbing the soil block of root or exposing the roots of the plant. If available, a litter of water may be provided to the newly established plant. The planting is better in bored holes than the planting done in broad holes with the help of a spade . Newly established plant should be irrigated lightly by weekly, fortnightly, monthly, depending on the climatic conditions.

(d) Propagation considerations: Seeding plants have better and well developed root system. Therefore, it is advisable to sow the seeds of rootstock in pits (in-situ) prepared according to layout or transplant the seedlings grown in polybags or polytubes. Budding or grafting with scion shoots, raised from promising cultivars may be done in the appropriate season. This practice results in establishment of healthier and uniform orchards. Rootstocks growing in abiotic stress should be preferred as it imparts resistance against stress environment, e.g. boradi (*Zizyphus mauritiana* var. *rotundifolia*) and jharber (*Z. nummularia*), seedling of Chakaiya for Aonla (*Emblica officinalis* Gaertn), ramphal (*Anona reticulata*), etc. Top working (frameworking) is another technique by which the inferior trees of ber, aonla, bael, etc. can be converted into superior ones.

(ii) Enriching the physiographic and fertility status of the aridisol

In hot arid regions enough land is available for crop cultivation but it is poor in fertility and gets deteriorated due to various reasons like soil erosion, shifting sand and sand dunes, water logging, salinity/alkalinity, unscientific cropping system and cultivation practices, over tilling, improper choice of implements & machines, faulty irrigation and drainage system, etc. The major effect of the above factors is degradation of physical and chemical properties of the soil and loss of plant nutrient. It has been reported that about 6000 million tones of soil are eroded annually in rainfed areas of the country which carry away 8.4 million tones of major plant nutrients. In such fragile conditions, the following soil management practices/activities are essential to improve fertility and physiographic conditions of sandy soil for horticultural crop production in hot arid regions.

(a) Land Planning and Mapping: Land planning and mapping here refers to land levelling, categorization of land according to land capability and capacity, put the land in use under different horticultural crops according to its capacity and nature, rotational and judicious use of land, mapping and classification of land for different uses, crops and cropping system etc.

(b) Soil Conservation: The soil of arid regions are highly eroded by action of wind and water. The soils of these regions are very light/sandy and undulating which leads to high wind and water erosion processes. In such conditions soil conservation is pre-requisite for sustainable development of arid horticulture. Soil conservation measures which can be applied in arid sol may be classified in two major groups i.e. biological measures and mechanical measures.

Biological Measures: Biological Measures for soil conservation help in intercepting rain drops and reduce splash effect, reduce wind velocity and suspension, saltation and surface creeping of soil particles, a better intake of water by soil through improving the content of organic matter and soil structure, reducing the over land run-off. These biological measures are : contour cultivation, strip-cropping, mixed cropping, cover cropping, multiple/relay cropping , appropriate tillage practices and mulching, improved crop management practices, vegetative water ways, wind breaks, mixing organic matter in soil, etc.

Mechanical Measures: Mechanical Measures which are also known as engineering measures, usually involves creating mechanical barriers across the direction of flow of water and wind which may retard or retain the run off and wind velocity. The important Mechanical measures to control the soil erosion are (a) Basin listing (b) sub-soiling (c) contour banding(d) graded banding (e) bench terracing (h) inter band area management (i) vegetative barriers (j) grassed waterways and diversion drains (k) water shed & water harvesting structures, (l) retaining walls, etc. which are essential for sustainable management of sandy & undulating soil of the arid regions for horticultural development.

(c) Securing the nutrient status of the soil: The soils of arid regions are very poor in fertility status. Therefore, the application of an appropriate management practices to improve the nutrient status and fertility of arid sols are very essential. For this purpose, the plant nutrient cycle amongst the soil, crops and livestock, organic cycling, balanced combined use of organic manures and chemical fertilizers, exploitation of biological nitrogen fixing potential, and taking holistic view of crop management system etc., are necessary. The sustainable nutrient status of the arid sols may be developed through integrated nutrient management approach

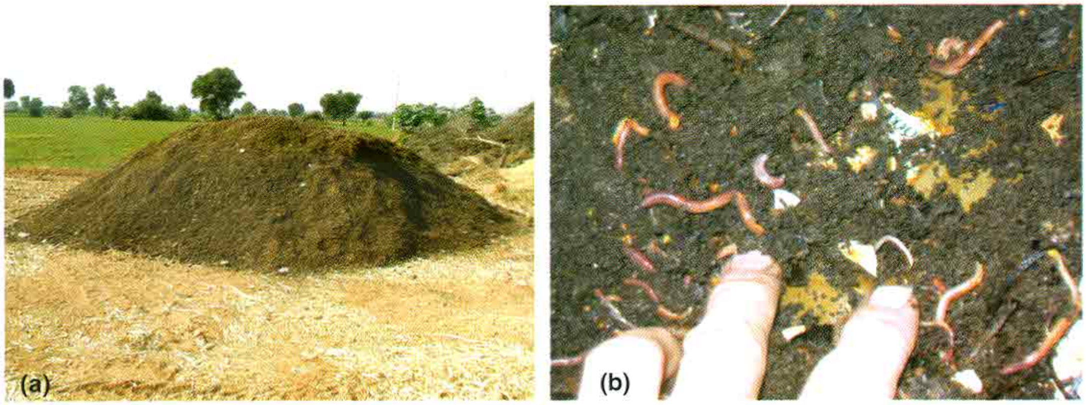

Fig. 10. (a) Sheep manure (b) Vermicompost

viz,: application of FYM/ sheep/goat manure in the soil, application of vermicompost, crop residues, green manures, green leafy manures , biological nitrogen fixation, chemical fertilizers, appropriate crop combination and cropping systems, growing suitable crops and their varieties, crop rotation, soil conditioning through soil amendments, etc.

The other processes like compaction of excessively permeable soil, deep tillage for hard soil, no tillage/zero tillage practices, organic mulching for poorly structured soil, neutralization of saline and alkali soils, etc. can also help in improving the fertility of the sandy soils for good production of horticultural crops.

(d) Approaches for rehabilitation of sand and sand dunes: In western part of India, the area affected by moving and semi-stabilized sand dunes of different degrees is about 128028 Km^2 and in Haryana about 13712 ha area are subject to dune formation.

The dunes are derived from the English word 'Dun" which means "hilly topographical feature". Thus, the sand dunes means hilly topography of sand which formed by the wind. The process of sand dune formation is only pronounced in desert area like western Rajasthan. The moving wind dislodges the soil particles and transports them to a considerable distance and accumulated at the end point on the land surface which is known as sand dunes. Due to different shape, size and stability, the sand dunes are known by different names (a) Active sand dunes e.g. crescent dunes (Barkhanes, parabolic), linear dunes, pyramidal dunes and fixed dunes.

Rehabilitation / Stabilization:- Most suitable methods to stabilize the sand dunes are raising of micro-macro wind breaks & shelter belts , retreating the dunes, growing grasses and plant saplings including horticultural crops, like *Prosofipis juliflora, Prosopis cineraria,Zizyphus spp., Cordia myxa, Capparis deciduas, Carissa carondas, Ricinus communis, Acacia spp.* and grasses like *Lasiurus sindicus, Sccharum spp.,* etc. on the sand and sand dunes. Other methods for sand dunes stabilization are spreading of organic material & crop residues on sand, fencing and making walls (mud/bricks/stone) against wind blowing sands, compacting and conditioning the sand/soil surface and use of other soil conservation practices.

(e) Management and reclamation of degraded soils: Majority of the soils of the arid regions are saline / alkaline in nature. The saline and alkaline soils are the major drawback (constraint) in development of horticulture in such regions. Thus, reclamation and proper management of these soils is must for the sustainable development of arid horticulture. These soils may be reclaimed to a reasonable extent by improving drainage system, use of salt free irrigation water, proper use of irrigation water, furrow sowing, pit planting, maximum use of organic manure and composts in soils, deep ploughing and levelling of land, retardation of water evaporation from soil surface, growing salt tolerant crops and crop varieties, application of gypsum, sulphur, iron sulphate, iron pyrite, acidic fertilizers, etc., in the soil.

(f) Land v/s crops planning: The efficient planning and management of cropping or farming system as per available land resources and their rational utilization leads to protection and conservation of land resources. Crops and cropping systems of arid horticulture should be selected according to land capability, nature of land and its physical and chemical properties so that sustainable use of land may be made. As slightly salty soil may be used to grow ber, date palm, aonla, mateera, snapmelon etc. while good soil may be used for less self tolerant arid horticultural crops. Likewise, vegetable crops may be grown on undulating soils of arid zone using sprinkler system of irrigation. Cover and leguminous crops should be included in horticultural cropping system which may be helpful in reducing soil erosion and increasing soil fertility.

(iii) Water use planning and soil moisture conservation

Water crisis is a very big problem in hot arid region, which has become most challenging constraint in adoption of horticultural crops in these regions. The following strategic planning and techniques can be helpful in boost up the growth and development of the horticultural production in hot arid regions.

(a) Micro-irrigation system: Micro-irrigation system can save irrigation water up to 40-60 % in horticultural crops. The irrigation efficiency of traditional methods is merely 30-50% while irrigation efficiency of sprinkler and drip irrigation system is up to 70-75 % and 90-95%, respectively. Development of multi-irrigation system will further help in optimal allocation and utilization of water resources.

Fig. 11. Drip irrigation system in arid (a) fruits and (b) vegetable crops

For efficient utilization of water, drip irrigation is gaining more importance in arid regions. It ensures uniform distribution of water, perfect control over water application, minimizes water losses during conveyance and seepage, reduces the weed population, keeps the harmful salt below the root zone and minimizes labour cost.

(b) Collecting of rain water and in-situ use: Watersheds are very good devices for collecting rain water and recyclic use of it for growing horticultural crops in water scared areas. For arid horticulture development, both in-situ water conservation as well as harvesting of water in watersheds are equally important measures to ensure efficient use of rain water.

Current strategy for arid horticulture should be based on integrated management of watershed and promotion of horticulture based farming system with a view to evolve methods for sustainable horticulture in hot arid regions. The water harvesting techniques like- construction of contour bunds on catchment areas, construction of semi- circular hoops, trapezoidal bunds, graded bunds, construction of storage tanks, dugout ponds, embankment type reservoirs, etc. are the structures which are advocated for sustainable management of water in arid regions for horticultural development.

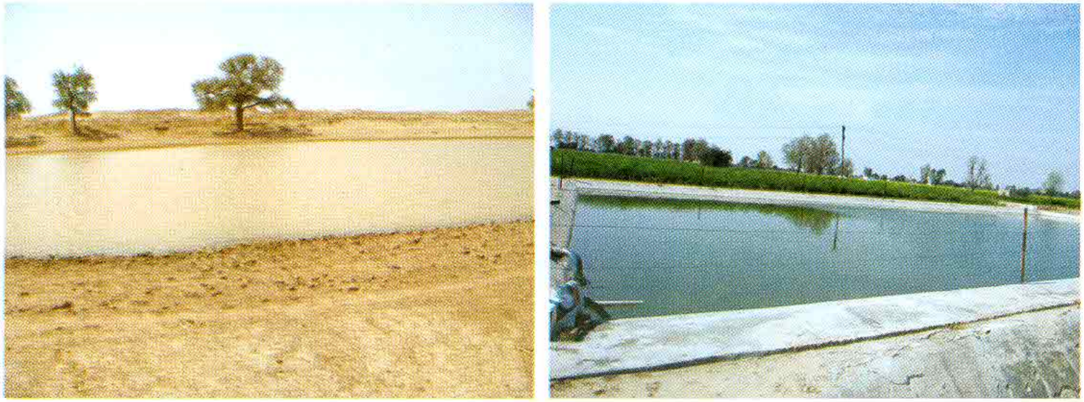

Fig. 12. Water harvesting for recyclic use in horticultural crop production

(c) Construction of in-situ micro-catchments: The free rain water can be harvested / collected directly in – situ (in root zone of the fruit trees) by preparing the small circular micro-catchment around each fruit tree to meet its water requirement in later growth stages. Microcatchment systems are relatively effective for use in growing trees and shrubs in semiarid and arid regions. Annual crops may also be planted in the catchments. Microcatchment or micro-watersheds are constructed by digging multiple small, U-shaped, sloping shallow depressions (approximately, 1m x 1m) or other suitable forms on sloping land.

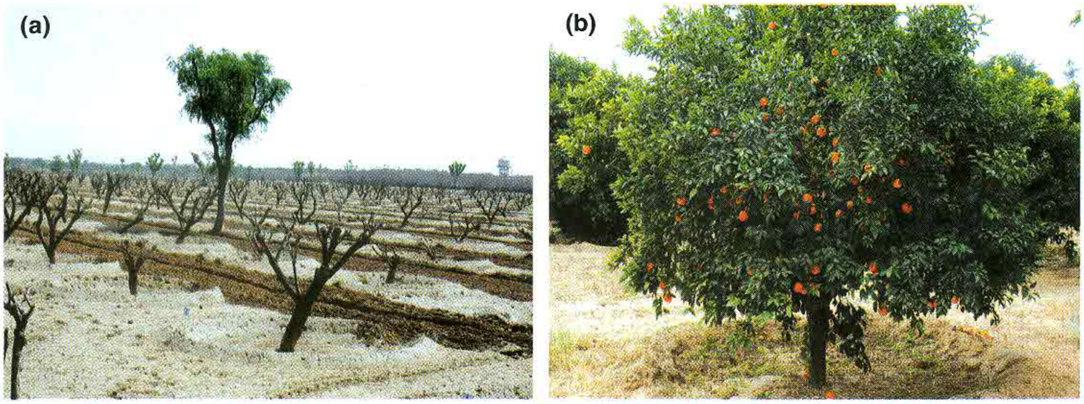

Fig. 13. Small circular micro-catchment around fruit tree: (a) ber and (b) kinnow

Generally, this technique involves the construction of compacted circular catchments of 1.5 m radius with 5 to 10% slope around the transplanted plants. Gupta (1992) reported that even during low rainfall years from 1986 to 1988, circular water storage (circular micro-catchments) increased by 10 to 30 mm/m profile and improved the growth and fruit yield of ber plants.

(d) Mulching: Mulching is defined as a process of covering the soil surface with organic or synthetic materials with a primary aim to conserve soil moisture and to maintain an optimum temperature in the rhizosphere of the plant. The loss of soil moisture through evaporation in arid regions can amount to 50% or more of total precipitation (Hillel, 1998). This much evaporation losses can be reduced by modifying the albedo of the sandy soil through mulching. However, to a certain

Fig. 14. Mulches in brinjal crop
(1-a) Black polyethylene mulch (1-b) FYM mulch (1-c) Cluster bean straw mulch.
2. Maize straw mulch in aonla plantation

extent sandy soil itself act as a good mulching material in the hot arid regions. Mulching with crop residues during the summer fallow can increase soil water retention capacity. Saur *et al.* (1996) found that the presence of crop residue on the surface reduced soil water evaporation by 34-50%. Straw mulching can be easily implemented by local farmers and can be extended on regional scale because the low cost straw is easily accessible and does not contaminate the soil. The crop residue mulches also improve soil moisture storage and prevent crop drought stress during dry spells, especially during the early stage of crop growth. Plastic mulch is commonly used to reduce evaporation, improve soil moisture storage and suppress weed growth for horticultural crops (vegetables and flower crops) planted on raised beds.

Comparative evaluation of synthetic and organic mulches with control in brinjal (*Solanum melongena* L.) grown in aonla-based multi-storey cropping indicated that synthetic mulches (black and white polyethylene of 75 micron thickness) conserved 108 to 122% more moisture in comparison to control under hot arid ecosystem of Bikaner (Awasthi *et al.*, 2006). The effect of synthetic mulches (300-500%) was more pronounced on fruit yield than the organic mulches (200%) as compared to control. Similar effects of straw mulch on increased mean yield of tomato (107%) and okra (388%) have been also reported by Gupta (1986).

Evaporative water losses are very high in arid tracts. Covering soil surface with organic waste material, emulsions or black polyethylene and use of anti transpirants have been found very effective in reducing the evaporation losses. In case of organic mulches as a matter of common experience, incidence of termites are very high, hence these mulches (organic) should be sprayed with 2ml chloropyriphos/litre of water. To minimize water losses through transpiration, anti transpirants which have radiation reflectant/stomatal closing properties can be used. Spraying of 4-6% kaolin, 0.5-1.0% liquid paraffin and 1.5% power oil, after occasional rains in low rainfall areas and after the post monsoon in high rainfall areas, considerably reduces plant water losses. Chemicals such as Phenyl Mercury Acetate (PMA), Decinyl Sucinic Acid (DSA), Abscisic Acid (ABA), and Acetyl Alcohol causes stomata eclosure and thereby reduces transpiration.

(iv) Horticulture based ideal cropping and farming systems

(a) Cropping system: The in hot arid regions, the resources are poor and climatic conditions are very hostile and harsh. In such regions, the adoption of single cropping system, sole cropping/monoculture system is dangerous for the farmers. In these regions, the rainfall is very low and droughts occur very frequently along with heavy disease and pests attack due to which any single crop may be failed or damaged. Therefore, rational horticultural cropping system like, ber based / khejri based multistory cropping system, inter-cropping system, diversified cropping system,mixed cropping system, guard cropping system, multiple cropping, agri-horti-pastoral system, agri-horti-silviculture system, horti-silvipastoral system, etc. should be developed and provided to the farmers of arid regions so that they can sustain their livelihood with rational use of their available scare resources.

(a) (b)

Fig. 15. (a) Khejri based multistory cropping system (b) Ber based multistory cropping system

(b) Farming system: Due to the harsh/hostile climatic conditions of arid region, it is not worthy to grow only horticultural crop. Rearing of animal husbandry with horticultural cops production, will certainly, be profitable and safe for the farmer's livelihood point of view. Horti-based farming system like vegetable-based farming system, fruit-based farming system /horti-pastoral system, horti-silvi-pasteral system, horti-patoral system, mixed farming system etc., will be more economical and safer in adverse climatic conditions of the arid hot regions Therefore, appropriate horti-based farming should developed and promoted amongst the farmer's of arid regions for sustainable horticultural development.

Now a days, horticultural crop production is leading towards crop specialization rather the crop diversification, which induces agro-ecological imbalance. At present arid horticultural system is ruled over by a certain group of crops. More than 80 percent of our arid fruits and vegetables comes from about 10 crops species only. The farming practice adopted particularly in irrigated area is monoculture. Under such circumstances crop diversification will be boon from ecological as well as nutritional viewpoint. Integration of horticulture with other farm enterprises viz. livestock production, dairying, fisheries, poultry, agro-forestry, bee keeping, goat & sheep rearing, etc. will certainly be helpful in achieving the goal of horticulral development in hot arid regions.

(c) Protected horticulture: Protected cultivation is intended to mean some level of control over plant microclimate to alleviate one or more of a biotic stresses for optimum plant growth. The microclimatic parameters being referred here are temperature, light, air composition and the nature of root medium. The protected cultivation includes greenhouses / net houses, mulching, low tunnels & cloches, nutrient film technique (NFT), plant protection nets, row covers/ floating covers and soil solarization. Important consideration needs to be given while going for greenhouse cultivation is the selection of crop which can give more produce over a

Fig. 16. Protected cultivation (a) Chilli (b) Summer squash

longer harvesting period under sub-normal conditions of light and carbon dioxide and high humidity prevalent in the greenhouses, if they are not monitored properly. Besides, the choice of crops to be raised in a greenhouse is made on the basis of the physical size of the structure and the economics of crop production. As a result, high value horticultural crops have been more popular for cultivation in greenhouses. Besides, the crop should be preferred by a large mass.

Another consideration for the viability of greenhouse technology is the higher return per unit area per day. The commonly grown greenhouse crops include tomato, cucumber, lettuce, cabbage, beans, peas, spinach, eggplant, peppers, squash, capsicum, okra, turnip, melons and radish among the vegetables; and roses, poinsettias, chrysanthemum, carnation, gerbera and potted plants among the ornamental crops. Taking into consideration the adverse agro-climatic conditions of the hot arid regions, there is vast scope for popularizing protected cultivation to provide high value vegetables and flowers under extreme of the conditions. Further, capsicum, tomato, cucumber, among the vegetables, carnation, chrysanthemum, and gerbera among ornamental crops hold the great promise for greenhouse cultivation.

(d) Organic horticulture: It means production of horticultural crops in the spirit of organic relationship. It is also gaining importance day by day. It is a production system, which avoids use of synthetically compounded fertilizers, pesticides and other agricultural chemicals. Thus we can say that future green revolution will have to rely on sound, equitable and ethnic farming system.

(e) Precision horticulture: It envisages a systematic approach to experimental design and agronomic practices. It needs multidisciplinary approach and scientific land and water use planning. Through precision farming, we can ensure most efficient use of inputs and production practices. According to this concept, it is always beneficial to apply fertilizers on the basis of soil test values as it will not only minimize cost of fertilizers, soil deterioration but also have less toxic effects on plants. Similarly land levelling, surveying and development of micro irrigation system will be helpful in coping with scarce land and water resources. Inclusion of legumes in crop rotation will try to compensate nutrient loss up to an extent.

(v) Conservation and utilization of biodiversity

The conservation of natural and biological diversity in plants is a matter of insurance with respect to crop improvement and sustenance of life. It is necessary to sustain and improve production of horticultural and related enterprises. Conservation of biodiversity is a matter of securing the future option against hazardous environmental changes and as the new material for scientific and industrial innovation.

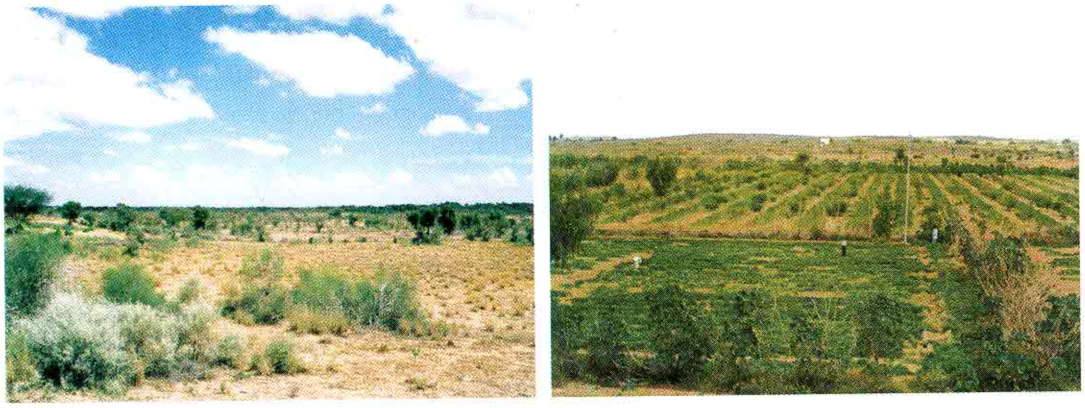

Fig. 17. Protection of natural biodiversity

The conservation of biodiversity is not only a matter of security against hazards but also a matter of moral of all citizens. The conservation of biodiversity is very much essential to :

1. Maintain crucial ecological process and life support system.
2. Preserve of genetic diversity and species.
3. Ensure the availability of biological materials (Gene, species, natural chemical, alkaloids, etc.) for crop improvement and animal up-gradation.

Therefore, natural biological biodiversity should be conserved at any cost to sustain the horticulture, agriculture and living being as a whole in hot arid regions.

(vi) Conservation and utilization of Indigenous Technical Knowledge (ITKs)

The farmers are very intelligent and they have long practical experience of their crop production techniques, systems, climatic changes, plant nutrient management, soil and water management, pests and diseases management, drought management, post harvest management, etc. They have developed various indigenous technologies for better production of horticultural crops in hostile and adverse climatic conditions of arid regions. They use various ITKs like application of tobacco water, spraying of Kerosene oil and ash mixture on crops, dusting of cow-dung ash and FYM mixture, burning of mustard/ seasemum oil in crop fields, spraying of cow dung/goat/sheep excreta and kerosene oil solution on crops / seedlings, smoking and dusting of dry ash on fruit and vegetable crops. Application of butter milk or curd in individual pit of fruit plants, application of *neem* kernels powder in the soil, spraying of *hing* (asafoetida) solution over vegetable crops and so on to protect their horticultural crops/ seedlings from the attack of insect and pests in nurseries as well as in fields. These techniques may be of great importance for horticulture development in hot arid regions. Such kind of indigenous technological knowledge of farmers should be collected, refined, standardized and must be used for sustainable development of arid horticulture.

(vii) Advance techniques for mass multiplication of plants and generation of neo-plants

For the horticulture development in hot arid regions, the following bio-techniques like- *tissue culture*, *embryo culture, cloning,* micro-propagation, *genetic engineering,*

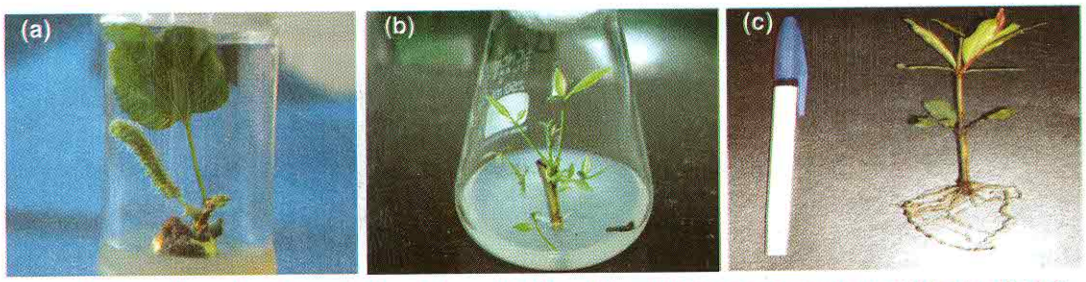

Fig. 18. Growing plantlets of (a) mulberry (b) Bael through tissue culture and (c) plantlet of pomegranate generated through micro-propagation technique

etc. are very important and potential techniques which can be exploited for plant multiplication/propagation , developing new varieties, transgenic plants , etc. in the field of horticulture to encourage the same in hot arid regions of the country.

(viii) Development of basic infra-structural and support system

In arid region, the basic facilities for arid horticultural development are not available which leads to under development of horticulture in such regions. To speed up the horticultural development in arid regions, the following infra structural and support systems are quite essential.

- The reliable source of advocated inputs (seeds, planting materials, fertilizers, insecticide/pesticides, etc.)
- The availability of improved inputs in localities at right time with reasonable cost.
- Reliable guidance/advisory source for horticulture crop production technologies
- Appropriate transportation and communication facilities
- Generation of local markets to sale horticultural produces at reliable cost and time
- Generation of horti-based value addition / processing industries in local areas.
- Creation of subsidized credit or loaning facilities.
- Providing power/electricity and essential mechanical mean, at rational cost & time to farmers for horticultural crop production etc. The important basic infrastructural and support system needed for the growth of horticulture in hot arid regions are being mentioned in detail as below:

(a) Value-addition-cum-entrepreneurships: For sustainable development of horticultural in arid regions, the development and promotion of horti-based

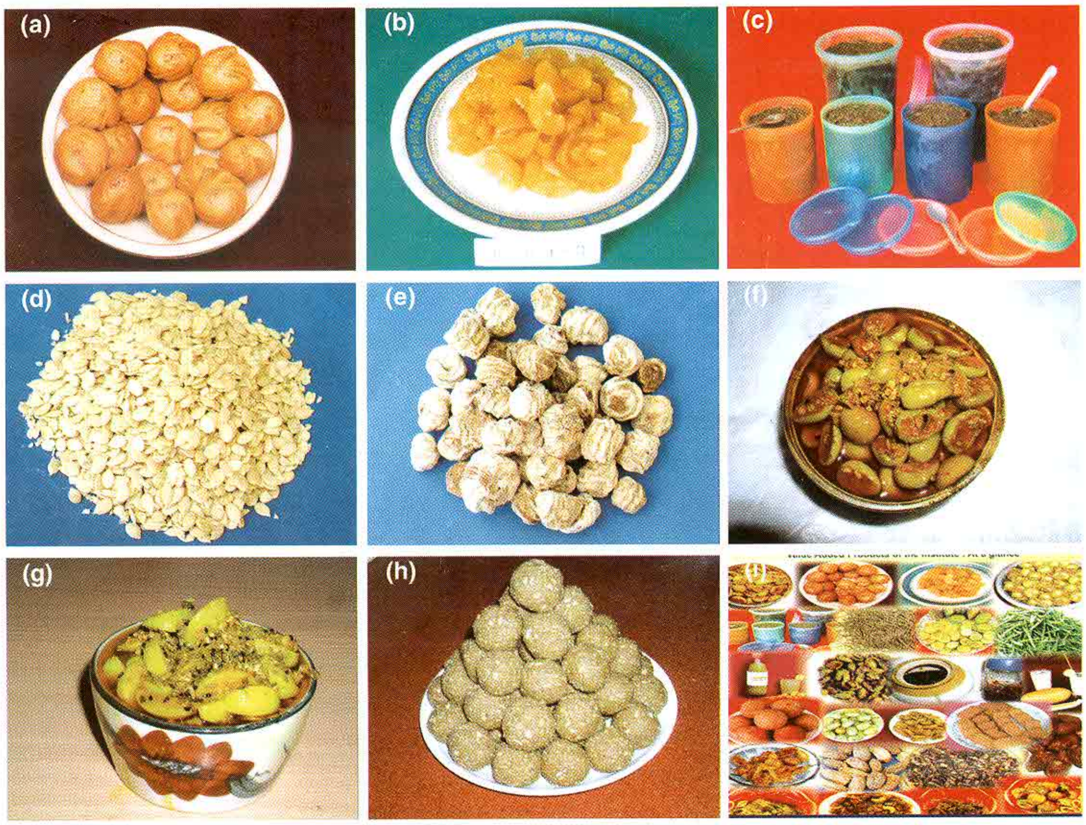

Fig. 19. Value added products (a) Khejri sangari biscuits (b) aonla candy (c) Chawanprash (d) Mateera magaz (e) Dehydrated kachri (f) Karonda pickle (g) Aonla pickle (h) Aonla laddu (i) PHT products at a glance

entrepreneurial activities and value-addition practices in rural area are of paramount importance. These activities may generate employment opportunities and extra-source of income for the farming communities/rural people which will lead to more adoption of arid horticultural technologies.

The value addition practices and entrepreneurial activities like preparation of Chawnprash, aonla murabbah, candy, dry ber, kachari powder, drying of cluster bean pods, drying of sangari of khejri, bael squash, aonla slice, pickles, vegetable seed processing and selling, development of nurseries of fruit plants, transportation and selling work of arid horticultural products, etc. should be initiated and promoted to encourage the horticultural development in hot arid regions.

(b) Horticultural marketing system: Horticultural marketing is a process which starts with a decision to produce a saleable horticultural commodity and it involves all the aspects of market structures or systems, both functional and institutional, based on technical and economic considerations and including pre and post-harvest operations, assembling, grading , storage , transportation and distribution.

The horticultural marketing system is very poor, particularly, in rural areas of arid regions of the country. Lack of local markets is a major constraint in the development of arid horticulture. The farmers are very eager to grow the arid horticultural crops but no body or institution /organization is ready to purchase their surplus horticultural produces at reasonable cost on time. Hence, the farmers are reluctant to adopt arid horticultural crops. Since, most of the horticultural commodities/produces are highly perishable in nature and the farmers can not store preserve them on their own level for long period of time due to lack of proper storage facilities like cold storage. On the other hand, there is no local markets where such surplus produces may be sold at any time. Hence, lack of marketing facilities are major problem of the arid horticultural development. Therefore, the development of local markets and other marketing facilities in arid regions to sell the horticultural produces are very important and very high need of the time.

(c) Ideal net work for transfer of technologies: In existing socio-economic and constraints of arid regions, the transfer of any improved arid horticultural technology is a very difficult job. In such conditions a proper planning, developing and selection of suitable approach for transfer of improved horticultural technologies is the crucial issue of today. The following mechanisms / phenomenon may be quite helpful in transfer of technologies to farmer's field.

- Report building with farmers
- Creating awareness and knowledge amongst farmers about the technologies.
- Publicity of improved technologies through different means & methods of mass media etc.

- Informal technological discussions and interactions amongst the scientist and farmers.
- Arranging-farmers fair, exhibition, field days/ field trips.
- Regular training of farmer's.
- Selection and adoption of potential areas/villages to conduct front line / field demonstration of the innovative arid horticultural technologies.
- Personal meetings/discussion with farmers.
- Regular visit of scientists to farmer's field.
- Making self-help groups of the horticultural farmers.
- Gating feedback of the farmers about technologies and refining the same as per need of the farmers.

(ix) Considerations to escape adverse climatic conditions

The arid regions of the country are active treasures of adverse climatic conditions like very frequent occurance of drought and frost, erratic rainfall, very high and low temperature, very hot and high wind velocity, scarcity of water and soil moisture, etc. The adverse climatic conditions can be managed to some extent for horticultural crop production by taking some precautions and pre-event management practices like :

- Management of high and low temperature through making protectional structures like- green houses, poly houses , thatches, (Jhonpa), artificial cool chambers, live fencing and wind breaks, smoging, heavy irrigation, sprinkler irrigation, growing high and low temperature resistant crops & their varieties, etc.
- Management of very hot and high wind velocity through establishment of windbreaks, shelterbelts, border fencing , brick walls, generation of cool micro-climate in the fields, etc.

- Crop management practices like- growing short duration drought hardy horticultural crops and their varieties, use of protected cultivation practices, soaking of seeds and planting materials before sowing / planting, foliar application of plant nutrients, use of drought hardening chemical compounds (like – calcium chloride, boron, agrosan, purine and pyrimidine, caffeine, xanthenes, etc.), mixed cropping, intercropping, cover cropping, horti - silviculture system, etc. can play a vital role in escaping bad effect of adverse climatic conditions on horticultural crops grown in hot arid regions.

4. CONCLUSION

The arid horticulture is a new area of the horticultural development and it has a great potential for the future development. In last two decades, considerable knowledge has been generated in the field of arid horticulture and it has already assumed of great importance for the development of the vast drought prone arid regions of India. Arid horticulture has a great and wide scope in future in developing unproductive soil to productive soil of the arid regions. It provides tremendous opportunities for employment, income generation to the poor people of arid regions and reducing soil erosion and aridity. For the better and fast development of horticulture in arid zone of the country, there is utmost need of genetic manipulations and efficient management of natural resources like soil, water, nutrients and germplasm. To develop appropriate crop combination/cropping system with the available agro-climatic resources would assume great significance. Since the horticultural produces and products are perishable in nature, therefore the value addition by suitable processing technologies will have to be developed for horticultural enterprise such as post harvest handling of produces and processing for gainful employment to the rural people. There is great need to explore and conserve the fast eroding indigenous plant genetic resources of fruits, vegetables, and other horticultural species and introduction of useful plants from isoclimatic regions of the world. Other practices like nutrient management, cropping system etc. may be carried out as per the recommendations for the regions. A complete understanding of crops and their cultivars, root stocks in relation to propagation, agro-techniques, water balance/water harvesting can make the arid region blossom, thereby resulting in assured food and nutrition security, income security and ultimately ecological balance. The technology dissemination is a back bone of any research development. If any new technology is not reaching to the farmers field, then the time, funds and efforts spent on research are not gainfully utilized. Thus, for the efficient and fast development of arid horticulture in future, a appropriate technology dissemination system is of a vital importance.

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