



Prospects of Protected Horticulture in Arid and Semi-Arid Regions of India

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Protected cultivation in arid and semi-arid regions sounds uncomfortable at first sight looking to it in a very narrow sense, but technology is productive if implemented in a planned manner as just copying a technology as such can't justify its relevance. The subject of protected cultivation was initiated in western world in the form of glass houses which were established to cultivate crops in colder regions. Eventually, the modification of the glass houses has taken the shape of protected structures using plastic and polymer sheets in various forms like plastic covered green houses, high tunnels, walk-in-tunnels, plastic covered low tunnels, insect proof net houses, mulching, shade nets etc. Horizons of the any development are vast if applied in the context of its needs and its uniqueness. The present article is a vision for application of protected cultivation technology in harsh climate of western India.

It is imperative to know the strength of the protected cultivation in and around the globe and also to know its applicability in arid and semi- arid regions. The following text will cover the general view of protected cultivation, followed by its future prospects in arid and semi-arid region of India.

Protected cultivation: an overview

It has been clearly proved that protected cultivation is a sound technology to enhance productivity and quality of horticultural crops by providing a logical and technical solution to manage major biotic and abiotic stresses usually encountered under open field cultivation of some high value crops. The effectiveness of this technology has been proved in various parts of the world. In the last two and half decades, the area under protected cultivation in various parts of the world like countries in and around Mediterranean region, China, South-East Asia, Africa has increased exponentially in different forms of adoption like plastic mulching, temporary plastic walls, plastic low tunnels, plastic-covered walk-in tunnels, plastic-covered high tunnels, temporary and permanent insect-proof net houses, shade net houses and different kind of greenhouses etc.

Presently, China is the world leader in protected cultivation with an area of around 3.5 million hectares out of which nearly 96% is only being used for commercial cultivation of fresh vegetables and hybrid seed production of vegetables. Although, a simultaneous growth like China, has also been observed in other developing countries of Indian and African sub-continent for the use of protected cultivation technologies, but the success rate varied significantly. It was because of poor agreement between the designs of protected structures and prevailing agro-climatic conditions of the regions. Although, the experience of greenhouse production or protection cultivation which has emerged from Northern Europe stimulated its development in other parts of the world including Mediterranean region, Northern America, Oceania, Asia and Africa with varying rates of success. But, now, it has been clearly established that mere adoption of a technology as such from other parts of the world without understanding the local agro-climatic conditions of the regions of adoption is not turns into success. Every technology requires further research, development, extension, training, procedures and methods of adoption to adept to local agro-climatic and socioeconomic conditions and protected horticulture technologies are not exception.

India with its diverse agro-climatic conditions have shown an overall growth of around 75,000 hectares area under protected cultivation in different forms in the last two and half decades. But the success rate of these technologies varied significantly depending upon the prevailing climatic conditions of various regions and seasons. In North Indian plains, protected cultivation technologies faced a tough challenge against the harsh climatic conditions whereas, other regions like Bangalore, Pune and some parts in North-Eastern States with mild climatic conditions has achieved high success rate. Basically, the growth of protected cultivation technology in India occurs due to favorable Government policies in terms of subsidies under various schemes with various State Governments like MIDH (previously known as NHM), TM (Technology

Mission), NHB, RKVY etc. but merely, due to the technical beauty of the technology. The technical know-how for adoption of protected cultivation technology under Indian conditions was not up to the level from the time of inception. With time, research and development work carried out by various public sector institutions in collaboration with developed countries gradually reflected in terms of modifications in technical designs of different protected structures suitable to the region's specific needs of prevailing climatic conditions of India which led to expansion in the area and production under protected cultivation.

Future prospects of protected cultivation in arid and semi-arid regions

An Agro-climatic condition of a region is a highly significant factor for the success of any protected cultivation technology. The basic purpose of protected cultivation in arid and semi-arid regions is to address high temperature fluctuations, low soil fertility coupled with low biomass, high wind velocity and high solar radiation peculiar to these regions. Water being the most limiting factor in these regions increases the level of constraints for promoting protected cultivation in these regions. Now the question arises, Why protected cultivation in these areas full of climatic constraints? The basic advocacy in favour of the answer of the aforesaid question would be that in spite of several climatic constraints these regions offer opportunity to grow high-quality and high-value horticultural crops. The low humidity in these regions is also not favorable for disease and pest epidemics to occur. Taking the advantage of the climate, the existing protected cultivation structures can be modified with respect to the crops and resources available in these regions. Local availability of any produce is the first preference compared to a product which is transported from distant regions as they are cheaper, fresh and also have a local taste beside cultivation familiarity of farmers. With time the socio-economic developments in urban and peri-urban areas and creation of transport facilities has increase both the market as well as access of quality produce produced under protected cultivation.

As far as the prospects of protected cultivation of horticultural crops are concerned, following important challenges and opportunities are lies under arid and semi-arid regions.

Major Challenges

1. In arid and semi-arid regions extreme temperature being the major challenge only limited crops can be cultivated in summer months and crops grown have to withstand scorching heat of sun with heat storms. During winter month's high diurnal temperature differences is the challenging situation.

2. Extreme levels of radiations encountered in the region reduce the adaptability of new crops in these regions. High radiation increases the temperature and also encourages water stress in several crops.
3. The available ground water for irrigation is limited and is of varied quality. The ground water quality is normal to saline and brackish and in most parts it is still underutilized due to lack of suitable technologies.
4. The soil stratum of the region is characteristically known for very low level of organic carbon (i.e. < 0.2% only) and sandy loam to loamy structure having low water holding capacity becomes less productive for crops.
5. The high temperature and low vegetation cover in these regions increases the chances of having very frequent dust storms of high wind velocity causing significant loss to crop.
6. Erratic and very low rainfall is a usual phenomena and average rainfall is below 200-500 mm in the arid/semi arid region. In every 4-5 years of span a drought like conditions occurs. Harvesting rain water and its utilization in best way to manage is other challenging situations in these naturally water deficit areas.

Opportunities

Low humidity and low vegetation cover

In the region the prevailing low humidity is unfavorable for major disease and pest survival. Low vegetation cover also restricts the space for pathogen survival on alternate hosts during non crop season. Since the arid and semi-arid areas are less prone to major fungal, bacterial and viral diseases, it becomes supportive for protected cultivation of horticultural crops.

National-international market access

In western part of the country which falls under the arid and semi-arid regions major development are happening in favour of market access for the region. The recent advancements which are highly favorable for protected horticulture are as under

- **Local Network of Roads:** An excellent network of roads is available in these regions for fast transportation of the commodities either to sea ports or to international airport located at Jaipur and Ahmedabad.
- **Dedicated Freight Corridor:** A dedicated corridor of road and rail network is under progress starting from National Capital to western coast lines of Kandla and Mumbai. This will prove highly favorable for export promotions of high quality produce from western India.

- **Proposed Dry Ports in Arid Region:** A dry port near Jodhpur and one proposed in Chitalwania tehsil of Jalore district is going to become a backbone is brining a boom in agriculture enterprise specifically for commodities grown in arid/semi arid regions. Sanitized cultivation under protected cultivation is need of hour for meeting the global demand of high quality safe produce of horticultural crops.

Vast Availability of Eroded/degraded lands: A large chunk of eroded / degraded land available in arid and semi-arid regions can be used for cultivation of horticultural crops through protected cultivation technologies by making horticultural interventions on case by case basis depending upon the type of land, micro climate and water availability as major factors.

Suitable protected cultivation structure for arid/semi-arid regions

Looking to the above mentioned points with respect to the challenges and opportunities for protected cultivation in arid/semi arid regions the best structure which can fit well for successful hi-tech horticulture can be as mentioned below:

- **Shade Net-house:** As the region encounter high radiation, use of shade net houses covered with different shading intensity shade nets (40-75% shading intensity depending upon different crops) of different colours can allow us to grow different vegetable and ornamental crops which are affected adversely by high radiation and high temperature. Large-scale use of shade net houses during harsh summer months is advised for cultivation of different horticultural crops these regions.
- **Modified Insect Proof Net-houses:** Insect proof net-houses are preferred structure for several vegetables and some fruit crops like papaya etc. which have more problems of pest or viruses. Insect management by use of these structure will reduce the load of pesticides in the crop and will increase the demand in market as consumer prefer no/low pesticide exposed crop specifically vegetables and fruits. These insect proof net houses can be erected by providing an aluminum coated shade nets (aluminet) approximately 1.0 meter above the roof top of the net houses with movable facility and with two door waiting area facility. These structures can be used for year round cultivation of vegetables like tomato, seedless Cucumbers, Capsicum, Okra, Brinjal and some cucurbits with optimum pollination management.

- **Naturally Ventilated Green-houses:** Regions which are having a suitable micro-climate wherein the soil type and available water are suitable can be brought under commercial horticulture, green house cultivation needs expertise and skilled manpower, and the need will generate employment also in the region. These naturally ventilated green houses are required to be equipped with mini sprinklers on the roof top for lowering down the temperature during peak summer months by using solar power. These green houses are required to be mandatorily clubbed with rain water harvesting and solar power for making their use sustainable.
- **Walk-in Tunnels:** These are temporary and low-cost structures erected on half-inch GI pipes covered with transparent plastic with 200 micron thickness and the height of the tunnel is around 6 feet with a width of around 4 meters. Walk-in tunnels can be used for off-season cultivation of vegetables by protecting them against extreme low temperature during the peak winter months. Mainly, cucurbitaceous vegetables are mainly grown under these structures, but these structures can also be used for other crops like coriander seed crop etc. for advancing the crop by 30-40 days in comparison to open field cultivation.
- **High Tunnels:** These are temporary and low-cost structures erected on 3/4th and 1/2 inch GI pipes covered with transparent plastic with 200 micron thickness and the height of the tunnel is around 9 feet with a width of around 6 meters. Walk-in tunnels can be used for off-season cultivation of vegetables by protecting them against extreme low temperature during the peak winter months. Mainly, cucurbitaceous vegetables are mainly grown under these structures, but these structures can also be used for other crops like coriander seed crop etc. for advancing the crop by 30-40 days in comparison to open field cultivation.
- **Plastic Low Tunnels:** Winter cold breezes and low temperature both are causing significant loss to Rabi or late Rabi crops in the region. A physical barrier in way of the air flow and use of plastic sheet can reduce the extent of loss to the crop. The concept of using plastic low tunnel is very effective in early crop stage when the crop is having low strength to face low temperature stress. It can be used in some parts looking to the range of minimum temperature for a limited period for off-season vegetable cultivation mainly in areas like Bikaner, Sri Ganganagar, Churu, Sikar, Jhunjhunu etc.

- **Temporary Plastic Walls:** Like plastic walk in tunnels, these physical barriers are also effective in reducing the frost and heat stress damage caused during peak winter and summer months. It can be used in various parts of the country for growing crops just to protect the crops against frost/ heat storms for a very short period usually from mid December to mid January or in the months of May and June.
- **Plastic Mulches:** The use of plastic sheet as cover over the crop not only reduces the evaporation loss from the soil upper layer but it also acts as a barrier for emergence of weeds, hence providing a chemical free weed management technique. It is useful not only useful for large-scale cultivation of vegetables but are also equally suitable for fruit orchards in these regions.



Figure 1



Figure 2



Figure 3



Figure 4



These models are well known and are preferred structures for protected cultivation but now the point is in arid and semi arid regions there should be a clear cut definition of structure and suitable crop required to be grown under these structures (Table 1).

Water management is the most crucial part of the protected cultivation. Drip and micro-sprinkler system fits well in the model, moreover harnessing of solar power for operating the irrigation

system is the most added advantage in promoting protected cultivation in western regions. Like design modifications irrigation systems can also be modified e.g. to have white colour drip lines and laterals in place of existing black colour as white coated will have more life and will be least affected by high temperature and high radiation and will not allow to rise in the temperature of irrigation water running through lateral during peak summer months.

S. No.	Protected Structure	Suitable Crop	Season
1	Shade Net house	Leafy and root vegetables; tuberose and green fillers among flowers	Peak summer months (April to August)
2	Modified insect proof net houses	Tomato, cucumber, capsicum, okra, brinjal, other cucurbits etc.	Throughout the year
3	Naturally ventilated green houses	Tomato, cucumber, capsicum etc.	September to March
4	Plastic low tunnels	Mainly cucurbits, strawberry, French bean etc.	December to February
5	Temporary plastic walls	Vegetables, seed spices like cumin	Mid December to mid January
6	Plastic mulches	All kind of vegetables and fruit orchards	Throughout the year

Table 1: Suitable Protected Structures for Different Horticultural Crops in Arid and Semi-Arid Regions.

Diversified use of protected structure in arid/semi-arid regions

Post Harvest Management: Plastic high tunnel can be used for better post harvest drying, as it acts as a protected site under plastic and operates like a solar dryer with ventilation. The open sun drying under field reduces the face value of the produce by loss of excess moisture and discolouration besides chances of microbial contaminated if done on *Kachcha* platforms. Looking to the benefits of high tunnel the following are the potential uses in arid/semi arid regions:

Drying of Nagauri methi

For drying of Nagauri methi use of high tunnels can be very quick and clean process wherein the leaves can be dried 2-3 days earlier than sun drying and it is also safe from damage caused due to unusual weather situations like winter rains. This technology is more effective to have a clean and green produce of Nagauri methi leaves especially for export lot.

Drying of vegetable crops

Introduction of high tunnels is a cheap and clean process for drying vegetable like chilli, mint, spine gourd, aswagandha etc. with maintaining quality for better consumer acceptability.

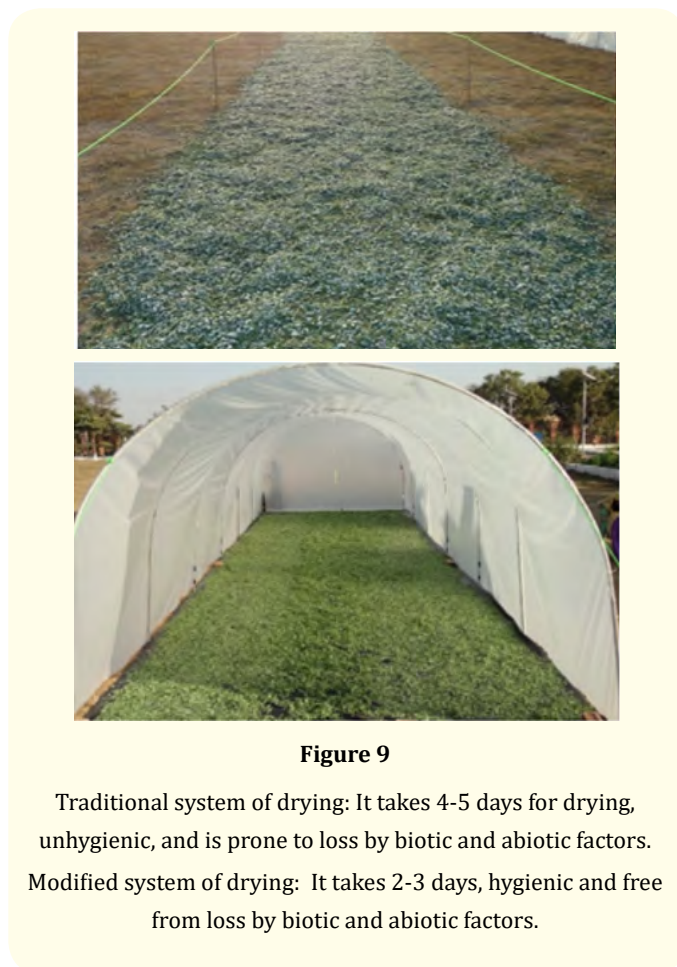


Figure 9

Traditional system of drying: It takes 4-5 days for drying, unhygienic, and is prone to loss by biotic and abiotic factors.
 Modified system of drying: It takes 2-3 days, hygienic and free from loss by biotic and abiotic factors.



Figure 10

Traditional system of drying chilli is unhygienic and that creates the problem of Aflatoxins which is a major barrier in export of chilli but drying under walk-in tunnels is hygienic and a part of GAP. This kind of technology can also be used for drying mint, Nagauri methi, moringa leaves, and several other vegetables which are used in dried form.

Drying of specific commodities

Some products like *Panchkuta*, *kachri* etc. which are unique to arid ecologies are sun dried by farmers. The use of high tunnel can be innovative approach in drying of these commodities for better quality and fast drying

Drying of plantation crop products

In the region of Sojat and Pali the cultivation of heena leaves holds special identity as a Geographical Indicator. The drying of henna leaves under high tunnels will be very useful in producing better heena powder for local and international market.

Conclusion

Protected cultivation of some specific agricultural commodities is an innovative agriculture idea. The application of these technologies in warmer regions of India as compared to their regions of origin i.e. colder regions of the world creates a doubt in their application feasibility. Gradually the protected cultivation technologies got modernized with developments in polymer science. The present scenario of global marketing and local growing is the key to promote these technologies for the benefit of the farmers of the resource scarcity regions. The arid and semi-arid regions are having their uniqueness for producing commodities which are very much specific to prevailing agro-climatic conditions. Hence, intervention through protected cultivation will reduce the risk of climatic vagaries and will also expand its cultivation duration. The prospects

of protected cultivation in these regions are very high not only for production of certain specified crops on normal lands but these technologies can also be performed on eroded and degraded lands besides its potential use in post harvest management if applied in a planned manner. It's because just area expansion under protected cultivation without proper technical assessment will leads to technology failure and it may end up with causing losses to farmers. Protected cultivation for arid regions needs to be expanded under proper technical guidance and also to be carried in a phased manner. The success of technology is solely depends upon the profit which it can produced to farmers. Hence in view of the strength of protected cultivation technologies there is immense scope of increasing farmer's income of arid/semi arid region by promoting protected farming in an innovative way.

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