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Aqleema Banoo
KVK Kargil-II Zanskar, SKUAST-K, Jammu and Kashmir, India

Shabber Hussain
KVK Kargil-II (Zanskar), SKUAST-K, Jammu and Kashmir, India

FA Shah Khan
KVK Kargil-II Zanskar, SKUAST-K, Jammu and Kashmir, India

Shahnawaz Rasool Dar
Research Center for Residue and Quality Analysis, SKUAST-K, Jammu and Kashmir, India

Rinchan Dolkar
KVK Kargil-I, SKUAST-K, Jammu and Kashmir, India

Rovidha S Rasool
Division of Plant Pathology, Faculty of Horticulture, SKUAST-K, Jammu and Kashmir, India

Corresponding Author:
Aqleema Banoo
KVK Kargil-II Zanskar, SKUAST-K, Jammu and Kashmir, India

A review on economic aspect of protected cultivation in Ladakh

Aqleema Banoo, Shabber Hussain, FA Shah Khan, Shahnawaz Rasool Dar, Rinchan Dolkar and Rovidha S Rasool

Abstract
Ladakh is a cold arid desert at an altitude of mostly 3000 m above the sea level. Cold arid Ladakh region experiences more than 300 cloud free sunny days. This solar energy is an asset that can meet all energy needs of Ladakh region. The implementation of the protected cultivation offer immense scope and support small-scale farmers of this cold arid region and also help to improve their livelihood security. Protective cultivation practices adopted in Ladakh regions is a cropping technique wherein the micro climate surrounding the plant is partially/fully controlled, as per the requirement of the plant species grown, during their period of growth and has an ability to produce variety of fresh vegetables even in harsh winter. Different protected cultivation techniques exist and among these protective cultivation practices, greenhouse/polyhouses are extremely useful for round-the-year vegetable cultivation in the Ladakh region.

Keywords: Protected cultivation, cold desert, green house, off-season vegetable production

Introduction

The westernmost tip of the Tibetan Plateau is home to Ladakh, a cold, dry desert with an elevation of more than 3000 metres. Ladakh has a different agro climate than the rest of the country (Mishra *et al*., 2010) [15]. As a result, the enormous Himalayas create a desert in the rain shadow, with most areas receiving only approximately 300mm of precipitation per year, blocking the moisture-rich clouds from the south. Due to the high elevation and exposure to winds from Central Asia, the winters are lengthy and quite harsh. From October through April, this limits agricultural operations in the open field. Ladakh's agriculture is mainly dependent on other parts of the country and there is a serious lack of fresh vegetables during the off-season. (Kunzang Lamo *et al*., 2020) [12]. Due to their high perishability and need for long distance transportation, it is challenging to import vegetables from other regions of the country to Ladakh in order to meet the requirements. Every year from November to May, the areas are cut off by thick snowfall on the road passes (Srinagar-Leh and Kargil-Zanskar highway). Fresh veggies must be airlifted, which incurs high costs that the general public cannot afford. The development of agriculture has led to the development of numerous protective farming techniques appropriate for different agro climatic zones. There are currently two practise methods used: one uses a fully controlled environment, while the other uses a partially controlled setting. In regions where the climate is constantly on the extreme side, such as the Ladakh region, the technology of employing greenhouses to cultivate plants is crucial. For agricultural cultivation, a variety of greenhouse structures are available. Since each style of greenhouse structure has benefits and drawbacks depending on the application, no certain type of greenhouse are thought to be the best. In order to suit the various needs, several greenhouse designs based on function, shape, material, and construction are available. (Singh *et al*., 1999) [24].

The salient features of region are

1. Temperature extremes (-30 °C in winter and 30 °C in summer).
2. Low amounts of precipitation, especially snow (80 to 300 mm).
3. The thin atmosphere brought on by the high altitude exposes more biologically harmful UV and infrared rays from the powerful sun radiation.
4. Wind that is moving quickly.
5. The region's altitude spans from 2500 to 8000 metres.

6. The cropping season is brief (120-150 days).
7. Irrigated agriculture is the only option.
8. Young, coarse-textured, and highly permeable soils.
9. There is typically no greenery or vegetation throughout the winter.
10. There is very little relative humidity (20 to 40%).

Protected cultivation: Protective cultivation techniques are described as cropping methods where the microclimate surrounding the plant body is partially or completely controlled, depending on the needs of the plant species farmed during their growth phase (Mishra *et al*., 2010) [15]. Protected farming refers to a comprehensive system of controlled environmental agriculture in which all parts of the natural environment are adjusted to maximise plant growth and financial advantage. Consequently, it is feasible to regulate the temperature, humidity, light and other factors in accordance to the requirements of the crop (Maitra *et al*., 2020) [13]. This results in a bigger and healthier harvest. However, without considering the greenhouse effect, it is challenging to imagine growing vegetables in the winter when the temperature drops below -20 °C (Singh, 1999) [24]. Protected cultivation techniques like forced ventilation greenhouses, naturally ventilated polyhouses, insect resistant net houses, shade net houses, low tunnels, trench tunnels, mulching, and raised beds are a few of the regularly employed techniques (Chandra, 2001) [6]. These techniques can be employed separately or together to create a favourable environment that will protect plants from harsh weather and lengthen cultivation times or off-season agricultural production. Different types of greenhouses exist depending on their shape (lean-to, evan-span, ridge-and-furrow, etc.), utility (temperature and humidity controlled), construction (wooden, pipe, or truss framed), and covering material (glass, fibreglass, plastic-film). Acrylic, polycarbonate, fiberglass-reinforced polyester, and polyethylene film are just a few examples of the various varieties of plastic film covering materials (Montero *et al*., 2005) [16]. Mishra *et al*. (2010) [15] reported that among these protective cultivation practices, greenhouses/polyhouses are extremely useful for round the year vegetable cultivation in the Ladakh region.

What is green house?: A greenhouse used to be a building made of glass (Joudi and Farhan, 2014) [10] or plastic film (Sonneveld *et al*., 2010) [25], with a heating (or cooling) system that was used all year round, but mainly in the winter (Mishra *et al*., 2010) [15]. Because of their endurance, resilience and transparency, polycarbonate sheets are commonly utilised nowadays. In greenhouse applications, polycarbonate sheets are highly favoured because they can reduce energy use by up to 30% without affecting the quantity of light that enters the greenhouse (Fabrizio, 2012) [8]. Polycarbonate is light weight, easy to install and allows abundant natural light into interior spaces. Furthermore, polycarbonate has the highest fire rating of any plastic material and great insulation qualities, all of which contribute to the design and construction of secure and energy-efficient agricultural structures. Because of better thermal efficiencies and greater diffusion of natural sunlight, twin wall polycarbonate is likely the product of choice. The greenhouse covered with simple plastic sheet is termed as polyhouse (Chandra and Panwar, 1987; Singh and Balraj, 2014 and Mehdi *et al*., 2104) [7, 21, 14].

Principle of green house: For optimal plant growth, greenhouse environmental control comprises managing day time and night time temperatures, relative humidity, and carbon dioxide (CO_2) levels (Mishra *et al*., 2010) [15]. Controlled environment plant production systems offer the possibility to provide large numbers of high quality crops with greater predictability. Solar radiation, air temperature, water vapour, carbon dioxide concentrations and solar radiation are the key determinants of the glasshouse environment (Mishra *et al*., 2010) [15]. The indoor environment is significantly impacted by variations in external air temperature and solar radiation because of the glass cover's great transparency and low thermal resistance. Consequently, to produce commercial crops with acceptable yields and quality the internal conditions have to be controlled (Ummyiah, 2017) [26].
Furthermore, the greenhouse effect occurs when short wave radiation from the sun enters the greenhouse structure, refracts off the surface and gets change into long wave radiations. These long wave radiations do not escape the greenhouse in entirety, thereby trapping the heat and thus, continually increase the temperature inside. The greenhouse effect is responsible for this. As a result, the enclosed compartment becomes warmer than the surrounding air. Though, it begins losing heat by conduction, convection and radiation after sunset (Jones and Henderson-Sellers, 1990) [9].

Advantages of Greenhouses: The following are the different advantages of using the green house for growing crops under controlled environment (Patniak and Mohanty, 2021) [17]:
1. Crops that cannot be grown in open fields are successfully cultivated in greenhouses.
2. The productivity of the crop is increased considerably.
3. Superior quality produce can be obtained as they are grown under suitably controlled environment.
4. Gadgets for efficient use of various inputs like water, fertilizers, seeds and plant protection chemicals can be well maintained in a green house.
5. Effective control of pests and diseases is possible as the growing area is enclosed.
6. Percentage of germination of seeds is high in greenhouses.
7. Crop production timetables for the horticultural and agricultural sectors can be arranged to capitalise on market demands.
8. Using a greenhouse also makes it feasible to raise vegetable seedlings earlier and increase food supply.
9. Cultivation of vegetables during winter months at sub-zero temperature when it is not possible to grow in open field.
10. Vegetables like cucurbits, capsicum, brinjal, okra, etc. are rare in Ladakh but these crops can be grown in greenhouse during summer.
11. Self-employment for educated youth
12. Greenhouse is ideally suited for farmers having small land holdings.

Disadvantages
1. Initial cost is very high.
2. Knowledge of various factors is required to effectively control climate inside the greenhouse.

Common available Solar Greenhouses in Ladakh: Though Ladakh is predominated by Ladakhi polyhouses, however studies carried out by Field Research Laboratory-Leh recommends trench type of greenhouse for the region (Mishra *et al*., 2010) [15].

Common greenhouses available in Ladakh are

1. **Glasshouse:** Perhaps this is the first and oldest among all types of greenhouse structures. Wani *et al.* (2011) [27] reported in their review that glasshouse is the glazing material with glass panels fitted with the help of wooden or metal frame and due to high temperature during summer it becomes unfit for cultivation. However, it is high in initial cost, difficulty in construction and frequent damage of glass panels by strong winds are certain discouraging factors. Such structures are not common in Ladakh.
2. **Ladakhi Greenhouse:** The most common greenhouse in Ladakh is Ladakhi greenhouses. It is small to medium having mud walls on three sides (north, east and west) with polyethylene cover on south facing side (Kunzang Lamo *et al*., 2020) [12]. As a consequence, most of the farmers follow single cropping, while double cropping is not possible in many parts of Ladakh. Modification has been made in ladakhi greenhouse by various agencies such as GRERES greenhouse, LEHO greenhouse, SKUAST etc., a passive solar greenhouse for local farmers. Accordingly, polyethylene sheet replaced with polycarbonate sheet as cladding material (Fig. 1) (Angmo *et al*., 2019) [3]. This structure increases temperature at night during the winter season since polycarbonate has much better insulating properties. Inside the greenhouse, the maximum temperature recorded is 45 ºC during summer month and minimum 1 ºC during peak winter month. Department of Agriculture has providing farmers with 75% subsidy for the construction of this greenhouse. The most growing vegetables during summer season under Ladakhi polyhouses are Tomato, Capsicum, Brinjal, Cucurbits (Cucumber, Bottle gourd, Long melon, Muskmelon, and Watermelon etc.) and during autumn and winter (like cabbage, cauliflower, broccoli and all leafy vegetables) (Singh and Ahmad 2005 [22]; Angmo *et al*., 2020 [2] and Kunzang Lamo *et al*., 2020 [12]).

Fig 1: a) A Ladakhi greenhouse in Kargil, Ladakh b) Vegetables cultivated inside green house

3. **Trench (underground greenhouse):** This is a very simple, cheap and useful greenhouse structure for Ladakh and, thus, has unlimited potential in the region. This may be of any convenient dimensions (10 x 6 x 1.5 ft). Wooden poles are utilised to support UV-stabilized polyethylene film in this pit-like construction. When it is extremely cold outside, this is once more covered by a second polyethylene sheet at night to prevent heat loss so as to lessen wind-related damage (Angchok and Srivastava, 2016 and Angmo *et al*., 2017) [1, 4]. The structure does not require much skill in its construction and management. Its cost is lowest among all other greenhouses and being an underground structure heat loss is minimum and temperature retention is high (Singh and Daulakhandi, 1998) [19] and thus yields good crop. Trench type green house is thus most suitable for the region and vegetables were cultivated round the year (Angmo *et al*., 2017) [4]. However, is most suitable to produce off-season potato (Singh and Ahmad, 2007) [23], vegetable nursery and certain leafy vegetables during March-May (Singh and Dhoulakhandi, 1998) [19].

Fig 2: A Trench (underground greenhouse) in Kargil, Ladakh

4. **Low Tunnel:** Also called miniature greenhouses, low tunnels generally cover rows of plants in field and, therefore, they are also known as row covers. Clean plastic films are stretched over low wire hoops (arcs up to 1.0 m high) to protect plants against frost, wind, insects and pests (Mishra *et al*., 2010) [15]. The hoops are made of steel wires or bamboo strips or cane. These hoops are covered by polythene sheets of about 50 microns thickness and are provided with ventilation holes on the side opposite to the solar movement. Low tunnels provide a passive control of plant micro climate, *i.e.*, use of specific plastic material to control radiation and provision of natural ventilation (Mehdi *et al*., 2014) [14]. Plastic mulches and drip irrigation may be used in conjunction with low tunnels. The crops which have been generally grown commercially under low tunnel conditions are melons, cucumber, tomato, strawberry, pepper, beans, squash and sweet corn (Kunzang Lamo *et al*., 2020) [12]. The trench may be 20-40 cm deep. The polyethylene is removed from the trenches when the plants start flowering to enable pollination facilitated by insects. Plastic low tunnels provided 30-45 days protection from low temperature to the crop during winter months and the grower could harvest the crop 45-60 days earlier compared to its normal season (Singh and Sirohi, 2004) [20]. Such technology are showing excellent results under the cold desert conditions of UT Ladakh, as moisture is also conserved to a great extent. Furthermore, it boosts the economy of farmers.

Fig 3: Low Tunnel greenhouse

5. **Mulching:** Mulching is one of the potential protected cultivation approaches. It is a protective ground cover that can include manure, saw dust, seaweed, litter, stubbles, sands, pebbles, black polythene (Fig. 4) and other natural products. While covering the soil surface with these materials to retain moisture and maintain a stable soil temperature particularly in the root zone is known as mulching (Peera *et al*., 2020) [18]. Major function of mulching is to limit first stage of drying which helps in optimum moisture status, reduced soil temperature, also containing seedling mortality and improving crop stand. Additionally, it overcomes weed-flora and reduces weed competition with crops for nutrients and water making more of these resources available to crop plants ultimately increasing overall crop production (Awasthi *et al*., 2006) [5].

Polyethylene mulches: The use of plastic mulch in agriculture has increased dramatically in the last 10 years throughout the world and last 2-3 years in Ladakh. Mostly this type of mulching is used in Ladakh. Mulches made of non-organic materials typically don't have the soil-improving qualities needed to improve soil particle aggregation, structure creation, and response control. Among the various mulch materials, the use of these mulches is most popular due to their abilities to control the hydrothermal regimes of crop microclimates, have a positive impact on weed control, guard against crusting and dryness of the soil, regulate soil moisture by preventing evaporation from the surface, and prevent erosion, nutrient loss, reduced weed pressure, reduction of certain insect pests and higher crop yields (Kasirajan and Ngouajio, 2012) [11].

Fig 4: Black Polythene Mulching in Kargil, Ladakh

Disadvantages: Mulches do have a few drawbacks, which are as follows:

1. Large scale mulching is cost intensive.
2. Non-availability of mulching materials.
3. Use of high C:N mulching materials viz., saw dust, straw results in temporary immobilization or starvation for nutrients in crops.
4. Change in the soil reaction due to continuous use of same mulching material.
5. Application of top-dressed fertilizers is difficult.

Site selection and Suitable crops for protected cultivation: While protected cultivation practices such as drip irrigation, raised bed farming, mulching can be practised on any site, even where cultivation is still being done. The criteria for site selection in case of protected cultivation structures like shade net houses and greenhouses are as follows:

1. Exposure to adequate sunlight: The site should not be close to tall trees, buildings or by the leeward side of hills.
2. Appropriate distance from a low-lying area: The site should not be in a place vulnerable to waterlogging.
3. Levelled ground surface: A slope of 0-2% is usually recommended. Levelling is required to be done in case the slope is beyond the recommended range. For steep terrains, it is usually recommended to construct several separate greenhouses with axes parallel to contour lines.

During summer, crops like Eggplant, Capsicum, Cucumber, Bottle guard, Tomato, Watermelon and Muskmelon were cultivated under protected structure and during winter leafy vegetables like Beet leaf, Spinach, Karam, Saag, Fenugreek and Coriander were cultivated.

Conclusion

The use of above basic structures was found more economical and justified as along with year round production and these also enabled variety availability in vegetables. For early yield production nurseries can be raised under polygreen house. It has been estimated that the yield under polyhouse or greenhouse farming can be achieved at a higher level about 4-5 times as compared to open field. Hence farmers must think of setting up a polyhouse rather than just working on open fields. Mulching depth of less than 2 inches is recommended for shallow-rooted vegetables growing on poorly-drained soils (clays) and 3-4 inches for deep rooted growing on better-drained loams or sandy soils. Polygreen houses are usually being used on a large scale in most area of Ladakh. However, lacks of awareness are major limiting factors in the adoption of several other technologies.

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