

Protected vegetable cultivation for climate resilience and nutritional security in Eastern Ladakh (UT)

Sonam Spaldon*, Anwar Hussain*, Kunzes Angmo*, M.S.Kanwar*, Jigmet Laskit**,
Phunstog Tundup* and Diskit Dolker*

*High Mountain Arid Agriculture Research Institute, **KVK-Leh, SKUAST-K, Leh

Corresponding author email: sonamphdscholar@gmail.com

Abstract

Eastern Ladakh is having harsh climate with temperature dropping below zero restricting agricultural cultivation for short period. Hitherto, makes them completely dependable on dairy products, packed and processed foods. Traditionally farming practiced here is purely indigenous and by default organic system. Therefore, the region has potential to produce organic products under protected structures which will be the source of income generation. The present study was conducted *via* Front line demonstration at 3 different locations *viz.*, Nyoma, Mudh, and Tsaga for 2 consecutive years from 2019 under protected structures *viz.*, local greenhouse and low tunnel. Comparison of productivity levels between demonstrated variety and local checks were also studied. A significant outcome is that the farmers have learned to produce quality vegetables not just to increase their income but also for the nutritional security. There are positive attitudes among locals toward the importance of protected cultivation as self-sustainable technology, nutritionally secure, and uplifting socioeconomic conditions with climate-resilient features that will be a boon for this region despite extreme climatic conditions.

Keywords: Cold arid, *Changthang*, *Changpa*, nutritional security, protected cultivation, tribal

INTRODUCTION

Changthang, the eastern part of Ladakh is known for its wide rangeland, having harsh climatic conditions with temperature -22°C to -28°C at an elevation ranging between 4200-4500 amsl, restricting agricultural cultivation for short period (3-4 months) in the summer season and very few vegetable crops like turnip, spinach beet (locally known as *Mongol*), and potatoes are commonly grown by the farmers in their kitchen garden. Food and nutritional security are a concern and receiving attention in developing countries like India but Ladakh's cold arid region in particular has been neglected and yet not received due consideration to date. *Changthang*, eastern Ladakh is a cold arid highland, situated at an altitude of 3400-4500asml in Trans-Himalayan India and this tribal population is known as *Changpas*¹. The inhabitant' lifestyles are mainly nomadic, semi-nomadic, and sedentary and their economy is driven by the rearing of livestock population², as agriculture is unsustainable in the cold high deserts (above 4,000 MSL), people have adapted to a pastoral mode of life, rearing sheep, goats, and yak for their survival³. Although harsh climatic conditions and resources scarcity, pastoralists have been able to manage the environment until recently⁴, the scenario is now changing rapidly in response to socioeconomic changes. The area suffers from hostile climatic conditions characterized by high wind velocity, dryness, intense solar radiation, and precipitation in the form of snow, and freezing stress.⁵

During winters, the region remained barren and isolated due to adverse climatic conditions. The major determinants are remoteness due to the topography of the region, hostile climate, market access restrictions, and an often limited agrarian resource potential⁶. Food consumption is primarily based on locally stored produce like potatoes, carrot as well as pulses, dried meat, dried leafy vegetables, and tinned foods in winter.^{7,8} Local peas and oats are grown as fodder

species. In winter, the temperature drops down to -3 to -5.94 °C even during day time⁹ with high wind speed. With the rise in altitude, there is a huge gap in vegetable production with the lowest recorded in changthang (251 MT) as compared to Leh with 452 MT¹⁰. The chilling temperature extends up to the month of May, leading to the frozen streams (*khuls*)¹¹ in night hours, due to which the transplanted vegetables are not able to withstand freezing stress in the early growth stage. Therefore, Protected vegetable cultivation is solution for climate resilience and nutritional security in Eastern Ladakh, Changthang (Table 2).

Research Gaps

Lack of R&D is the main factor that remained neglected owing to its remoteness and harsh climatic condition. Earlier, vegetable production scenario of Changthang has been almost negligible as compared to other regions of Ladakh. Locals revealed that underexploited wild vegetables like *zatsot* (*Urtica hyperborea*), *skotchche* (*Allium przewalskianum*), *Nyungma* (*Brassica spp*), *Kosnyot* (*Carium carvi*) were consumed and very few vegetables like turnip, silver beet (*Mongol*), potatoes, kale and local pea were grown in their kitchen garden especially during summer season on limited scale. Vegetables are highly sensitive to freezing and cold stress¹² which is prevailing throughout the year in this region. Mostly these fresh vegetables are purchased from market at high rate for their daily needs. Another reason was less consumption of vegetables and more consumption of meat. This leads to malnutrition in these region¹³. The highest prevalence of anaemia is observed in Ladakh with 92.5, 92.8 and 96.9 percent in children, women in reproductive age and adolescent girls respectively¹⁴.

Present scenario in Changthang

The present scenario in vegetable production is completely different as today thirty different types of vegetables are grown with Research and Development (R&D) as well as extension initiatives by highest altitude Krishi Vigyan Kendra (KVK) established in 2013 in the region for improving the livelihood opportunities and to combat the nutritional security among the tribal population of this high altitude remote region (*Changthang*). After conducting baseline survey, farmer's needs were assessed. Research areas were prioritised and technologies were developed, assessed and refined according to the micro farming situations of the region. All the extension methods like on-campus, off-campus training programmes, film shows, exposure visit, method demonstration, FLDs and OFTs have been conducted to provide ultimate benefit to farmers of this region. The impact of training programme on protected cultivation is shown in Fig 6. Sensing the benefit of scientific method of cultivation for improving the nutritional security for this region, farmers were motivated for scientific method of cultivation through training, method demonstrations, providing technical Know-how and distribution of improved seeds and seedlings. The defunct protected structure have been made functional with suitable modifications. Regular inspection and monitoring were made throughout the growing season. Women are encouraged for various skill development training programmes on protected vegetable cultivation. Special events like breast feeding and nutritional week are conducted for a week in different villages with special focus on improving their nutritive value of daily diets. A number of high value crop like broccoli, Chinese cabbage, Swisschard under low tunnel are newly introduced in this region which were highly accepted by *Changpas*. Similarly, summer vegetables like Cucurbits and Solaneaceous vegetables are successfully introduced in three-sided walled polyhouses.

Protected structures technology, as key factors to meet the nutritional security among *changpas*.

To fulfil the aim and objective of combating the nutritional security various steps have been taken.

- **To supply quality seedling to the farmers of Changthang region**

Nursery raising under greenhouse has a huge potential to fulfil the needs of this remote region and it can earn handsome return to enhance the living standard of a farmers. Otherwise, they are totally depend on lower region (Leh) for seedlings where the seedling mortality rate is high due to long distance transportation and lack of suitable varieties recommended for the region. The hamlets in the region are sparsely located where in, villages are at the distance of 35 to 45 km from one another. Therefore, vegetable nursery sowing is needed to be encouraged in every village in the month of mid-April under greenhouse condition for easy availability of quality seedlings. Simultaneously, the owner of the polyhouse can fetch a good income through the sale of nursery seedlings and it can be a handsome source of income among rural communities in a short time span.

- **To meet the nutritional security through proper balanced diet**

Vegetables are known as protective foods and are essential source for the micronutrients needed for healthier body and mind. Under protected structures, all types of vegetables can be successfully grown resulting in the improvement of nutritional security of every household. To alleviate micronutrient deficiency, there is urgent need to create awareness regarding nutrition gardens among farmers and farm women in order to grow fresh and clean vegetables for daily consumption diet. An adult requires 500g vegetables, 100g fruits and 60 g pulses for normal maintenance of health¹⁵ which was completely missing among these communities. In Ladakh, particularly in *Changthang* region majority of the farmers are buying vegetables from the market at high prices to meet their family requirements. These vegetables are loaded with pesticides and insecticides, which can cause health problems. Therefore, creation of nutrition gardens is considered as a significant step to mitigate these problems. Several studies by KVK Nyoma have shown that small holder and farm women can play a key role to achieve nutritional security.

- **To empower *Changpa* tribal women through protected vegetable cultivation**

Women in general, plays a major role in agrarian community in Ladakh ultimately leading to what scholars in this region deem the “feminization of agriculture”¹⁶⁻²¹. *Changpa* Tribal women of this region needs to be encouraged for vegetable cultivation which can be the source of income. In addition to this, the produce of this region is scrumptious and of high quality due default organic farming system. Therefore, to improve their living standard and to get reorganization of their produce, mud or mud brick poly house are required where different vegetables can be grown throughout season to generate their income and uplift their standard of living through protected vegetable cultivation.

POTENTIAL SUITABLE PROTECTED STRUCTURES FOR CHANGTHANG

1. Low tunnels: The most compatible and cheapest and portable protected structures suitable for growing vegetables in *Changthang* condition at altitude of 3400-4400 amsl in summers. This structure provides protection from cold stress during night hours in early growth stages of cole crops. For instance, temperature is key factor in early growth and curd formation in cauliflower. Similarly, cabbage head size has been considerably improved if grown in low tunnels along with recommended genotype²². This technology led the successful introduction of broccoli in *Changthang* highlands²³. Therefore, this technologies is beneficial in raising cole and leafy vegetables (Table 2) in changthang region²⁴. In lower belt of Ladakh at 3000amsl it is

used for nursery raising and cucurbits cultivation. This structure is highly adopted by all types of farmers.

2. Three side walled poly house

This type of double wall greenhouse (32 x 16 ft) made up of local bricks insulated with saw dust and plastered with mud on both sides are most suitable throughout the year. Most of the villager owned this type of greenhouse but it remain defunct due to unavailability of quality polythene and technical knowhow. Therefore, to make it functional, high quality polythene (150 gsm) are provided and demonstrations on cucurbits cultivations are given to the farmers.

3. Trench technology:

This is underground low cost technology rectangular structured (10 ft × 6 ft × 2 ft:: L×W×D) in North-South orientation with stone wall on four sides. It is covered with polyethylene sheet at ground level during winter months and is the first protected structures developed in Ladakh²⁵. This structures is suitable to raise crop throughout the season in Leh region²⁶. Whereas, in *Changthang* it is suitable for nursery raising and summer crop like summer squash, Cole crops, solanecous vegetables. During peak winter, the crop gets freezing stress therefore it is mainly confined to spring, summer and autumn season.

RESPONSE OF INDIVIDUAL SUMMER CROPS UNDER MUD TYPE POLYHOUSE

1. **Cucumber** : It is newly introduced under greenhouse and many varieties like JLG, SH-1, SH-2 and Gynoecious variety Aviva have been evaluated. Among these the variety Aviva is performing well and recorded 1270 qtl /ha with long harvest duration from mid July to first week of October (Fig 4). This crop is highly remunerative due to continuous production per plant. At present, cucumber of *Changthang* is gaining popularity due to its distinct taste and quality. On the other hand, long melon is also grown for salad purpose due to its earliness and more fruits/plant but being a new crop, it will take time for the acceptability among local.

2. Cucurbits :

It set new record in the farming system at an altitude of 4200amsl where fruits like watermelon and muskmelon is coming up well under greenhouse condition. The watermelon varieties like *Kalia* and *Rasdar* are performing well with average fruit weight recorded between 3 to 5 kg. Similarly, muskmelon *var. Apsara* is performing best as compared to other varieties. (Fig 4). The average fruit weight ranging from 700g to 1 kg with high TSS (8 to 10 brix). Others cucurbits Crop like squash, bottle gourd, bush squash are performing well but the acceptability among local is low due to their different taste habits. Therefore, to popularise these crops, value addition or their use in local delicacies can be promoted.

3. **Tomatoes**: These can be grown under open condition at 10500ft amsl in lower belt of Ladakh region using black mulch during summer season with ease. But the scenario in *Changthang* is completely different. Here, most of the locals were hesitating to grow tomatoes in even in greenhouse due to short summer and lack of technical knowhow. And in many cases, they used to broadcast seed directly resulting small fruit size due to dense crop geometry resulting in continuous vegetative growth with poor yield. Therefore, various genotypes have been evaluated under green house in *Changthang* region with proper staking and pruning to get quality fruits. Among all varieties Millar (2.240 kg/plant) and Tapan (2.111kg/plant) performed well.

4. **Capsicum:** It is emerging high value crop in whole Ladakh under greenhouses²⁷ and its cultivation at 4200 amsl is another milestone in Changthang. Nine varieties collected from different sources have been evaluated under greenhouses and average yield per plant(1.309kg) recorded in hybrid Koti followed by Solan Bharpur (1.120kg). The demand is rising with more awareness among nutritious food. And its cultivation will bring more revenue to farming community of this region. Like-wise, other solanaceous crop like brinjal is also performing well in protected structures.

WINTER PRODUCTION IN MUD TYPE PROTECTED STRUCTURES

The freezing stress in open field observed in the last week of September which is atleast one month earlier as compared to other region of Ladakh. The *khuls* freezes which hampered irrigation system. Therefore, greenhouse cultivation is only answer to have fresh vegetables in lean winter months. To encourage winter cultivation, variety of leafy vegetables have been tried in greenhouse condition. Crops like Siberian kale, Kale- Khanyari, Chinese cabbage, swiss-chard, lettuce are introduced for winter cultivation. During peak winter, the growth process is stunted and freezing injury are commonly observed²⁸. Among leafy vegetables, Swiss chard is performing best followed by Chinese cabbage. Therefore, to boost the fresh vegetable production in winters, cultivation of the recommended crops and varieties under protected cultivation in Changthang play a key role in achieving nutritional security.

Conclusion

There is positive attitudes among locals towards the importance of protected cultivation as self-sustainable technology, nutritionally secure and socioeconomic conditions. It is the only climate resilient technology which will be boon for this region despite extreme climatic conditions and to fulfil the requirements for consumption and to maintain healthy diet. Sensing the nutritional power of vegetables, more area under protected cultivation can be expanded in adjoining hamlets also. The produce from this cold arid region will be unique and distinct due to the usage of organic inputs. Market oriented vegetables not only create vegetable business opportunity among youth but also helps the small farmers to overcome external risks and enhance the living standard of their family. Thereafter, through this intervention, agro climatic risk will be reduced and crop duration will expand. Apparently demand for local produce will rise and proper marketing channel will be developed. The major impact will be seen in socioeconomic, health and over all development of a society.

Erstwhile, the cropping season is hardly for 3-4 months in open field conditions but climate resilient technologies like protected structures (low-tunnel, trench, mud wall greenhouse) is boon for the region as it make it possible to grow more than 30 types of vegetables (cole,solanaceous,cucurbits,leafy). This which not only extend the cropping period but also enhance the nutritional security. Hence, these technologies have immense scope to increase the farmer income and play an important role in uplifting the rural livelihood of cold arid Ladakh, combating the nutritional deficiency among these tribal communities.

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Table 1. Crop duration in open field Vs Different protected structures in Changthang region

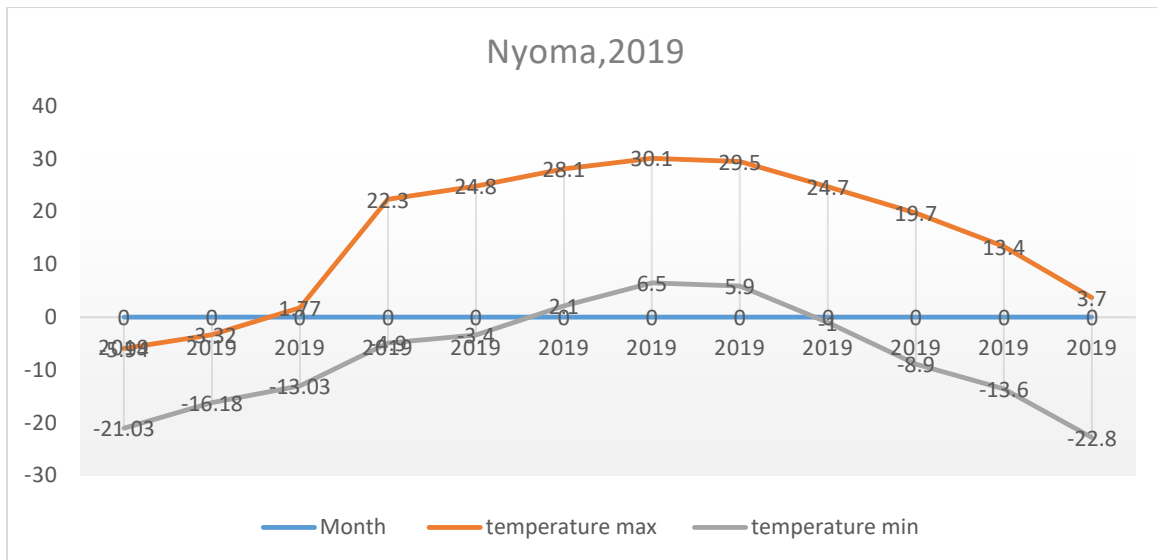
S.No	Field condition	Crop duration	Crop duration in open and different Protected structures	Temperature (°C)
1	Open field	June to August /september	Field Pea, Garden pea, Oats, Barley, potatoes, Turnip	15-30
2	Low tunnel	April to September	Vegetable seedling , Cole crops, bulb crops and leafy	18-42

3	Trench	March - October	Vegetable seedling, cole crops, bulb, solaneaceous, cucurbits	20-44
4	Greenhouse (mud type)	Throughout	Vegetable Solaneaceous, Winter: Leafy	seedling, cucurbits, -10 to 50

Table 2. Potential vegetable crop recommended for changthang region under low tunnel during summer season (Mid-May to September) (Qtl/Ha)

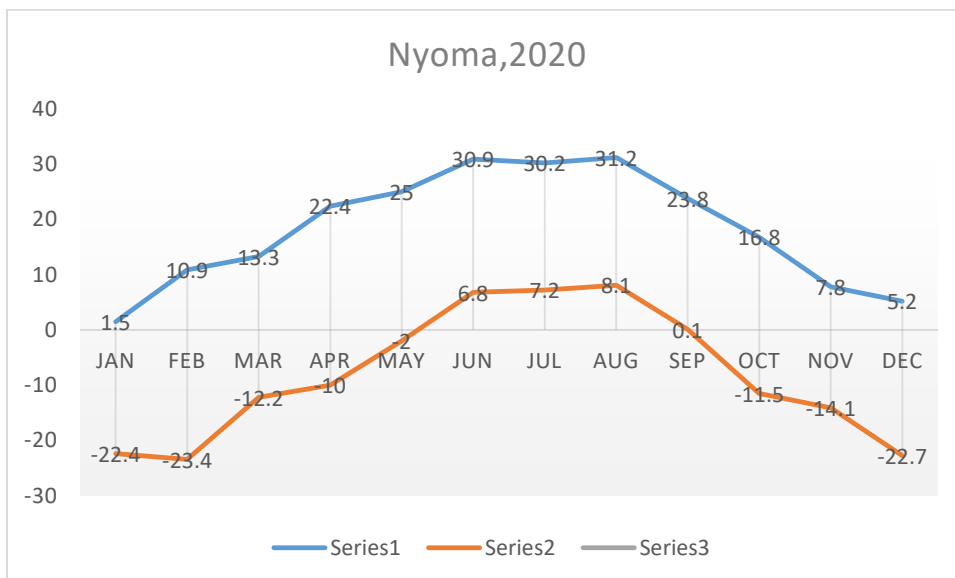
Crop	Recommended varieties	Yield practice (qtl/ha)	Local Yield practice (qtl/ha)	Improved practice (qtl/ha)
Chinese cabbage	Palampur green	151.09		352.06
Cauliflower	PSB-1	350		650
Cabbage	Mitra	266.67		833
Broccoli	Lucky	NA		350
Swisschard	CITH Red & Green	200		428

Figure 1. Agroclimatic data in Nyoma (4200m) under open conditions (2019)



(Source :KVK Nyoma,2019)

Figure 2. Agroclimatic data in Nyoma (4200amsl)under open conditions (2020)



(Source : KVK Nyoma,2020)

Figure4. Performance of summer vegetables under mudtype greenhouse under changthang conditions at 14000ft AMSL



a) Green house mud wall, Mudh village b) Variety Aviva Cucumber c) Musk-Melond) Watermelon weight 7 kg e) Bush Squash (Paty-pan variety f) Okra

Figure 5. Performance of Cauliflower, broccoli and swisschard in open conditions under lowtunnel at 14200ft Amsl.



Figure 6. Training on protected cultivation and number of beneficiaries in Changthang (2017-2019).

