

Seed Production of Vegetable Crops Under Protected Environment

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ABSTRACT

Protected cultivation offers an effective approach for producing high-quality vegetable seeds by providing a controlled environment that protects crops from climatic variability, pests and diseases. Structures such as greenhouses, insect-proof net houses and polyhouses help maintain favourable conditions for seed production. Practices like raising healthy seedlings, through plug tray technology, proper training and pruning and efficient pollination management improve seed yield and quality. Compared to open-field conditions, protected structures can significantly enhance seed production in crops like tomato, cucumber, pepper and muskmelon making it a promising strategy for sustainable hybrid seed production.

INTRODUCTION

India is the second-largest vegetable producer in the world after China. The country's total production has reached about 214.56 million tonnes from 11.43 million hectares, with an average productivity of 18.77 tonnes per hectare during 2024-25 (NHB, 2024-25). Yet, this productivity level remains considerably lower than that of many developed and even several developing

nations. The primary cause of this low yield is the limited availability of high-quality seeds of improved open-pollinated varieties and hybrids. Also, the high cost of hybrid seeds especially for high-value crops such as tomato, sweet pepper, chilli and major cucurbits, which further restricts productivity. These high seed costs are largely attributed to poor seed yields under open-field seed production

systems. Areas suitable for producing high-quality vegetable seeds are limited and even in these regions, climate change along with various biotic and abiotic stresses has created significant obstacles to seed production under open-field conditions. The growing impact of climate change on agriculture is becoming increasingly evident each day, making the production of quality vegetable seeds a serious challenge. Under such circumstances, it becomes essential to develop advanced technologies and innovative methods that can improve both seed quality and yield, particularly, as climatic variability and the incidence of new viruses, insect pests and diseases. In response to these challenges, there has recently been a technological shift towards producing high-quality hybrid seeds of important, high-value vegetables under protected cultivation systems. Protected conditions for vegetable cultivation are created by using different types of structures, which are season- and location-specific. These structures are designed as per climate modification requirement of the area. Temperature, humidity, wind velocity, soil conditions, etc. also play a major role in the design of protected structures for growing vegetable crops.

Principle of Greenhouse cultivation

The principle of greenhouse cultivation is based on the greenhouse effect, where solar radiation enters the structure and creates a warm, controlled environment suitable for plant growth. The transparent covering of material of the greenhouse which is commonly made up of glass or polyethylene allows short-wave solar radiation from the sun to enter the greenhouse. The incoming solar radiation is absorbed by plants, soil and internal surfaces and is converted into long-wave infrared radiation. The covering material allows short-wave radiation to enter but blocks the escape of long-wave radiation, trapping heat inside

the structure. It raises the temperature inside the greenhouse and creates a controlled microclimate where temperature, humidity, light, CO₂ levels can be regulated through ventilation, heating and cooling systems.

Selection criteria of structures suitable for seed production

There are several types of protected structures available for seed production, including climate-controlled greenhouses, semi-climatic controlled greenhouses, naturally ventilated greenhouses, insect proof net-houses, walk-in-tunnels, low-cost poly-houses and plastic low tunnels etc. The choice of structure depends upon climatic conditions of the area, climatic requirements of the crop and challenges in seed crop and season of seed production under Indian conditions (Tomar *et al.*, 2019).

Seed production practices of vegetables under protected structures

1. Raising of healthy nursery for quality seed production

Healthy and virus-free seedlings are crucial for producing high-quality seed and hybrid seed. Plug tray nursery technology has been standardized for many vegetable crops under greenhouse conditions. In cucurbits, off-season nursery raising methods have also been standardized for the major crops (Singh *et al.*, 2007). Research on tomato showed that plug cell size, shape and cell volume significantly affect seedling quality. Seedlings grown in round cells with a volume of 68.2 cm³ gave the best results in terms of shoot fresh weight (12.8 g), root fresh weight (5.2 g), root length (3.8 cm), leaf area (25.6 cm²), stem diameter (3.1 mm), true number of leaves (3.0) and seedling dry weight (156.0 mg). Seedlings are generally raised in multicelled plug trays using a soilless medium made of coco-peat, vermiculite and perlite in a 3:1:1 ratio. (Singh *et al.*, 2005).

2. Training and pruning

Tomato: Indeterminate tomato varieties are staked and trained vertically and side branches are pruned to maintain one or two stems. For hybrid seed production, emasculation is usually carried out on flowers from the first to the fourth cluster. For single-stem plants, terminal shoot is pinched after 6-10 clusters to limit vegetative growth.

Sweet pepper: In sweet pepper, pruning involves removing shoots below the first branching point. Because the stem is usually not strong enough to support fruit load, plants are trained upright. After the first terminal bud is removed, two main branches are allowed to develop so the canopy receives better light exposure and support for fruit development.

Cucumber: Cucumber is trained vertically with the help of tendrils, usually on wires fixed at a height of 1.5-2.0 m. In short-fruited varieties, fruits and lateral shoots are removed up to 40-50 cm on the main stem. In long-fruited varieties, this pruning is done up to 60-70 cm along the main stem.

Summer squash: Summer squash has short main stems and branches which gives them a naturally bushy growth habit. Hence, they do not require training or pruning. In contrast, winter squash produces long, trailing vines that require vertical training. The main stem is pinched off at 4th node to promote the development of two strong branches. Two fruits are allowed to set on each branch between 12-16 nodes.

3. Pollination management

Protected structures lack natural wind, self-pollinated crops like tomato, brinjal and chilli need pollination using vibrators or air blowers. In hybrid seed production, hand emasculation and hand pollination is carried out, with a female to male ratio of 4:1 for tomato and 3:1 for cucumber, bitter gourd, muskmelon and

summer squash. In tomato, the female parent is planted earlier to synchronize flowering and pollination is best done around at 9:00 a.m and 5:00 p.m for higher fruit set and seed yield. (Manjunath *et al.*, 2010).

Major advantages of vegetables seed production under protected conditions:

1. High seed yield (generally 2-4 times more) compared to open field in major vegetables.
2. Seed Quality is high compared to open field produced seed.
3. The isolation distance in cross pollinated vegetable crops can be reduced.
4. The issue of synchronizing flowering between parental lines can be minimized.
5. Maximum plant population can be maintained along with appropriate ratio of male and female parents for higher hybrid seed yield.
6. Under adverse climatic conditions seed production is possible which is not possible in open field conditions.
7. Healthy virus free seed crop can be grown, which is very difficult under open field conditions.
8. Seed production practices like training, pruning and hand pollination are easily manageable when compared with the field seed crop.
9. More number of seed crops could be taken under protected conditions.
10. Protected conditions provide the best opportunity for organic seed production in vegetables.

11. Judicious use of water is possible for seed production under protected conditions.
12. Seed crops not damaged by un-seasonal rains at the time of their maturity unlike open field seed crops.
13. Quality seed production of vegetables could be undertaken by agri-entrepreneurs; this in turn could generate employment opportunities in rural areas.
14. Seed production cost of vegetables could be reduced under protected conditions.
15. In hybrid seed production, emasculation of female parents is not required as there are no insect pollinators inside the protected structures.

Expected seed yield (kg/ha)

Crops	Protected condition	Open field condition
Tomato	150-200	60-70
Brinjal	200-400	150-200
Pepper	150-200	100-150
Cucumber	400-500	150-200
Squash	500-700	150-200
Muskmelon	250-300	150-200
Watermelon	200-300	150-200

(Centre for Advanced Faculty Training, Solan, 2017-18)

CONCLUSION

Protected cultivation creates a controlled environment that helps overcome both biotic and abiotic stresses, thereby improving seed yield and quality. It provides highly favourable conditions for producing healthy, virus-free and genetically pure hybrid seed with higher

seed output per unit area. However, to achieve a high success rate with this technology, proper management and regular maintenance of the protected structures are essential.

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