TRENDS IN AGRICULTURE SCIENCE
ISSN:2583-7850

Popular Article
Domain: Agriculture Science
Vol 5 Issue 4, April 2026, 404-409

Increasing Seed Yield and Quality of Vegetable Crops Under Protected Conditions

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doi.org/10.5281/TrendsinAgriculture.19570459

Abstract

Protected cultivation in India has expanded to over 100,000 hectares, largely focused on horticultural crops such as vegetables, flowers, herbs, mushrooms, and nurseries, with nearly half the area dedicated to vegetables and their propagation. With increasing support from government agencies and agricultural missions, this area has grown rapidly. Protected cultivation offers significant potential for enhancing productivity and reducing input use through controlled environments and improved technologies. It is particularly valuable for quality hybrid seed production in vegetables, where challenges such as inadequate isolation distance, insect vectors, and disease-free conditions limit open-field production. Growing seed crops under protected structures can reduce production costs while improving seed yield and quality, and also enables off-season production. Although limited comparative studies exist, available evidence indicates a clear advantage of protected conditions over open fields in terms of seed yield and quality. Therefore, expanding protected cultivation is essential to ensure the availability of high-quality vegetable seeds and improve overall productivity.

Introduction

Protected cultivation is the modification of the natural environment to achieve optimum plant growth (Pattnaik and Mohanty, 2021). Modification can be made to both the aerial and root environment to increase crop yield, quality, extend growing season, quality seed production.

Importance and Scope

- ✓ Open field production encounters with many production constraints therefore protected cultivation is sustainable approach toward vegetable production.
- ✓ The production is higher than the open field conditions due to congenital inside microclimate and provided a better price.

- ✓ Protected cultivation enables producers to produce several folds of good quality products which is difficult in normal conditions.

Principle of Protected Cultivation

The sunlight comes in the greenhouse and is absorbed by the crop, floor and other objects which in turn emit long wave thermal radiation. The solar energy remains trapped in the green house. This condition of natural rise in greenhouse air temperature is utilized in the cold regions to grow successfully (Tarara, 2012).

Technologies Under Protected Cultivation

Greenhouse Structures

A greenhouse is a special constructed structure like a building for growing plants under controlled condition. It is covered with a transparent material as such permits entry of natural light.

Different Types of Polyhouses

Naturally open ventilated Poly house: There is no mechanical or electrical device for ventilation in the green house. It is naturally ventilated through insect proof netting mainly at the top and sides also. There is no requirement of energy to regulate temperature inside the green house. Being less costly such greenhouses are liked by farmers.These structures can be used for seed production of tomato, sweet pepper, parthenocarpic cucumber and muskmelon etc. both under south and north Indian conditions. However, the duration of growing period and seed yield are less compared to climate controlled or semi climate-controlled greenhouses (Singh and Tomar, 2015).

Insect proof net-houses: These structures are suitable for seed production of sweet pepper, slicing tomato, cherry tomato, brinjal, chilli, parthenocarpic cucumber, summer squash, muskmelon, bitter gourd etc. These structures provide the protection against viruses and other insects like fruit borers during rainy and post rainy season. These structures are well suited in north India, insect proof net house could be utilised for production of parental lines seed and hybrid seed production during summer and kharif successfully as per the need of crop and demand. Shade house conditions are more favourable for higher seed yield and quality (Yadav and Malabasari, 2014). Highly significant differences in seed yield/fruit, seed yield/plant under IPN were due to higher number of filled seed/fruit and number of matured fruit/plants

Soil Less Cultivation: Soilless production is the cultivation of crops in a medium other than soil. Soilless cultivation can be conducted within protected environment virtually anywhere because it does not rely on soil suitable for vegetables and other crops production. Generally soilless cultivation is used for seed production of potato. Soilless seed production techniques play an important role in these activities, and the critical in vitro and semi-in vivo phases almost invariably rely on the use of one or more of the range of soil-free techniques that have been developed

(Millam and Sharma, 2007). These soilless techniques transformed the conventional production capacity of mini-tubers under screen house pots from 43,773 to 433,742 under screen houses (Lemma *et al*., 2018). The overall clean mini-tuber production capacity increased from around 43,000 to 650,000 and consequently the productivity was improved due to quality seed source. The use of soilless propagation techniques provides distinctive opportunities for producing seed potatoes at enhanced rates in a controlled environment with no, or a minimal incidence of pests and diseases.

Hydroponics: Cultivation of vegetables in nutrient solutions is known as hydroponic vegetable cultivation whereby a very thin layer (film) of nutrient solution flows through watertight channels (also known as gullies, troughs or gutters), wherein the bare roots of plants lie. The thin water stream (1–2 mm deep) ensures sufficient oxygenation of the roots, as the thick root mat which develops on the bottom of the channel has its upper surface continuously exposed to the air. (Sardar and Admane, 2013). More than 10,000 high quality seed potato can be produced in hydroponics (Tessema and Dagne, 2018).

Aeroponics: In aeroponic systems the roots hang in the air and are misted with nutrient solution.The misting are usually done every few minutes. Because if the roots are exposed to the air they will dry out rapidly if the misting cycles are interrupted. In aeroponic, growing medium is primarily air.The aeroponic system is probably the most high-tech type soilless agricultural syste (Otazu, 2010). Commercial production of seed potato by using aeroponics is already progressing (Faran *et al*., 2006). The cost of production and serious disease transmission was also reduced as well as enabled the mass production of quality seed with this approach (Abebe *et al*., 2014). The technology is also space efficient compared to field multiplication. With aeroponics technology, an individual potato plant can produce over 100 mini-tubers in a single row as opposed to conventional method that create approximately eight daughter tubers ((Otazu, 2008). Quality seed of potato production was also increased by 206,566 mini-tubers, while it was nil before the establishment of the technology (Lemma *et al*., 2018). The technology is also space efficient compared to field multiplication. With aeroponics technology, an individual potato plant can produce over 100 mini-tubers in a single row as opposed to conventional method that create approximately eight daughter tubers only in the course of a year while only five to six tubers per plant are produced using soil in the green house (Otazu, 2008). Aeroponics technique is a rapid multiplication technology (RMT) able to produce large numbers of minitubers in one generation, thus, allowing bulking of large number of potato seeds

Grafting: Vegetable grafting reduces the agrochemicals dependence on organic production. Grafting is used to improve the efficiency of production and resources of vegetable crops, mainly in protected crops. In part, the adoption of grafting depends on the establishment of appropriate grafting methods

and the vigorous development of rootstock through breeding (King *et al*., 2010).Grafted vegetables are very popular and widely used among farmers in Asian and European countries and are increasing in the US, especially with tomatoes. In Japan, almost 95 per cent of watermelon, oriental melon, eggplant, greenhouse cucumber and tomato are grafted before being transplanted to the field or greenhouse. In South Korea, the use of vegetable grafts is increasingly popular in the production of many vegetables. An increase in plant purchases and shortage of skilled workers has made it necessary to automate grafting in Japan. Grafting robot produces 815 plants per hour (about three to four times more than manual grafting) with a success rate of 97.1 per cent. Numerous vegetable crops face the problem of soil borne fungal diseases (Fusarium wilt, verticilium wilt, damping off and nematodes) which cause severe damage to the seed crop and reduce the seed production. Therefore, the grafting of seedlings on resistant rootstocks can play a vital role to overcome these problems of soil borne fungi and nematodes (Sakata *et al*., 2007).

- **Internet of Things (IoT):** The term "Internet of Things (IoT)" refers to a mass system which is connected to numerous sensors, embedded controllers, decision-making platforms, Internet, and a cloud server. The sensors collect the data and automatically feed them to the cloud server. The cloud servers store and allow the data to be accessed remotely (Wiangtong and Sirisuk, 2018). Therefore, IoT systems are implemented mainly to monitor and take intelligent actions without human intervention, such as cooling, heating, lighting, irrigation, on and off of the motors and actuators by analyzing the sensor data (Jeaunita *et al*., 2018), making the farm smart. Smart greenhouse farms can also aid the farmers to gain knowledge about the season or the most suitable time for harvesting, quality of the soil, amount of nutrients needed for healthy plant growth, quality of water and many other important factors. Smart greenhouse farming can make farming reliable, cost-effective, and maximize the yield of the crops with the minimum number of labors (Daga *et al*., 2018**)**. This can help the farmers to manage the farms and optimize the resources efficiently. It is envisioned that in the future the growing of crops inside a smart greenhouse (or at least part of the process) can be fully automated and remotely controlled. The IoT technologies comprise of sensors, actuators, cloud computing-based data amenities, drones, navigation and analytical system, which allows the architecture to make intelligent decisions to increase the crop yield. IoT devices can provide information about the environmental variables including, humidity, temperature and climatic conditions, and also about the field variables such as soil and plant bio-masses (Pang *et al*., 2017). It can be employed to predict and monitor the quality of the crops for the consumers. Additionally, IoT can be used to collect data and store them in cloud computing devices to create alert and send short messages services (SMS) to the farmers. The data stored in the cloud can also be used to develop predictive models which can prognosticate the variables that affect the crops. One of the

most indispensable parts of the IoT architectures is the sensor systems which provide information about the environment and plants in the greenhouse. The most common sensors that are deployed in smart greenhouses are humidity, temperature, soil moisture, and light intensity, heat and gas sensors.

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 region. Protected cultivation provides the required environment to overcome the biotic and abiotic stress and enhance yield as well as the quality of seeds. Protected cultivation offers very congenial environment for producing healthy, virus free, and genetically pure hybrid seed with higher seed yield per unit area. Enterprise establishment in the form of vegetable seed production under protected conditions can be the future of the country.

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