Latest Technologies for Increasing Seed Yield and Quality of Vegetable Crops Grown Under Protected Conditions

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Introduction

The area under protected vegetable crops cultivation in the country has not been documented authentically. However, in India, protected cultivation has been adopted in more than 100000 hectares mostly covering horticulture crops like vegetables, flowers, herbs, mushrooms, plant nurseries and others. Out of this acreage almost half of the area is under vegetables and their nurseries multiplication. The per capita land resources (0.121 hectare) in India are shrinking due to the tremendous pressure of the population growth; therefore, it is very imperative to ensure the higher production and productivity per unit area. Vegetable crops are more productive than other crops, which have potential of providing more food per unit time and land area. India is the second largest producer of vegetables after China in the world. As compared to developed countries India is still far behind in average productivity. The foremost reason for this is the limited availability of quality seeds of released varieties and hybrids for large-scale production and the secondly high cost of hybrid seed of high value vegetables like tomato, cherry tomato, sweet pepper, chilli and green house grown cucurbits. The high cost of seed is mainly due to low seed yield under open field condition. The biotic (viral diseases in tomato, chilli and cucurbits) and abiotic (environmental factors viz. high and low temperature, frost stresses etc.) factors have become a major difficulty in quality seed production in open field conditions because these have direct effect on growth, flowering and fruit set development of these crops (Tomar and Jat, 2015). Growing of vegetables under protected cultivation has got a boost and around 2.0 lakh hectare area is under protected cultivation in India which is largely occupied by vegetable crops. The major challenges in quality hybrid seed production of vegetable crops are lack of sufficient isolation distance, insect's vector, diseases and a virus free environment etc. (Flemine, 2010). The seed production cost of high value vegetables crops could be maximized by growing them in the protected structures and enabling to harvest higher seed yield with better quality as compared to open filed condition (Tomar and Jat, 2015). The seed production of vegetables in summer under open field are affected by sudden increase in temperature under north Indian condition and in rainy season the severe infestation of viruses and other insect pests and unseasonal rains are the major concern. Raising seed crop under insect proof net house can overcome these problems by protecting the crop from various insect vectors and unfavourable climatic conditions. It also provides an option for quality and off-season seed production. Semi-climate controlled green house is suitable for hybrid seed production of indeterminate type varieties and hybrids of tomato, cherry tomato, sweet pepper (red & yellow), bitter gourd and parthenocarpic cucumber varieties. Seed yield in these crops can be 3-4 times more compared to their open field cultivation (Jat *et al*., 2017). In order to enhance the availability of quality seed for high productivity of vegetable, it is necessary to increase the production of quality vegetable seeds (Kaddi, 2011).

Why seed production under protected structure

- To minimize the requirement of isolation distance and facilitate the multiplication of parental lines in vegetable crops requires more isolation distance.
- Raising of healthy, virus free nursery of crops
- Advanced nursery raising of cucurbits for increased crop period and higher seed yield
- To protect the seed crop from environment stress.
- To reduce the application of pesticides
- To enhance the profitability of hybrid seed production

Protected cultivation

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.

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 permit's entry of natural light (Mukherjee, 2016).

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. However, 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

Plastic low tunnels: These structures are commercially utilised for production of off-season cucurbitaceous crops during winter season (Dec-mid-Feb) in north Indian plains. However, these could be utilized for seed production of muskmelon, watermelon, summer 0squash, bottle gourd, bitter gourd etc (Kumar *et al*., 2018).

Soil less cultivation: 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).

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, 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. Commercial production of seed potato by using aeroponics is already progressing (Faran *et al*., 2006). 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). 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 mini tubers in one generation, thus, allowing bulking of large number of potato seeds.

Plug tray nursery: Plug or cell transplants are seedling or small vegetatively propagated plants which are raised in individual small cells, called plugs (Singh, 2017). Technique is capable of vigorous root development, suitable for nursery raising without damage to the seedlings. EL Ghobashy *et al*., (2016)

developed a precision vacuum trays bulk seeder and tested it for seeding single seed in the trays (84 and 209 cells) for cucumber and cabbage seeds under four different suction pressure and four different hole size diameters. Naik and Thakur (2017) mentioned that the automation in the seeder will help in reducing the wastage of the costly seeds, time required for sowing and minimizing the workers expenses.

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 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. 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.

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