REVIEW ARTICLE

Cultivation of tomato, capsicum and cucumber under protected cultivation: Extensive analysis

Mahendra Kumar Yadav[1*], Satyendra Kumar[2]

Yadav MK, Kumar S. Cultivation of tomato, capsicum and cucumber under protected cultivation: Extensive analysis. AGBIR.2024;40(2):996-998.

Protected cultivation is a method of growing crops in a controlled environment, allowing for the regulation of factors such as temperature, humidity and light based on the specific requirements of the crop. The overall production is increased and healthier plants are encouraged in this regulated environment. Protected farming methods come in a variety of forms, such as plastic tunnels, raised beds, trellising, mulching, insect-proof net homes, naturally ventilated polyhouses, insect-proof net houses and shade net houses. These techniques can be applied singly or in combination to develop a good growth environment that protects plants from extreme weather, lengthens the growing season or permits the production of crops during the off-season. Tomato, capsicum and cucumber protected culture is an important technique that can greatly improve crop production quality. It has several benefits, including increased yield, improved quality, extended season and defense against pests and unfavorable weather.

Key Words: *Protected cultivation; Tomato; Capsicum; Cucumber; Yield*

INTRODUCTION

Vegetable crops grown under protection is a novel technique that guarantees the production of vegetables of superior quality. This method creates a controlled environment that protects crops from harmful weather, pests and diseases by using buildings like greenhouses, polytunnels and net houses. Vegetable growth conditions can be optimized using this method's exact control over temperature, humidity and light [1]. These days, forward-thinking farmers are growing high-value vegetables and flowers under commercial protected cultivation [2]. In comparison to open fields, shielded structures yield more flowers and vegetables and also have higher output. These configurations produced larger net and gross profits when compared to open settings. Most farmers use open-field cultivation methods, but because these methods don't provide the right temperature, humidity and other conditions, they eventually lower land value, water availability and farmer revenue. Thus, in terms of enhancing agricultural production, soil fertility, profitability and sustainability, among other aspects, protected structures-based farming (also known as protected cultivation) technology is superior than open field agriculture/conditions [3]. Because agriculture still has economic value due to increasing production levels, protected technologies are opening doors not only for higher level growers but also for smaller-scale growers. Protected cultivation can be thought of as a kind of precise, progressive, parallel agriculture that involves almost every aspect of agriculture but is subject to extra examination for technical applicability to circumstances as well as grower and market economics. A suitable microclimate has been created by greenhouse farming and other forms of controlled environment cultivation, allowing for crop production to occur all year round or only during certain periods of the year as needed. The most advantageous and cost-effective polyhouse technology for India's plains and subtropics is the naturally ventilated, low-cost polyhouse. A greenhouse can be used to grow high-value off-season vegetables such as tomatoes, capsicum, cucumbers, bottle gourds, early cauliflower, coriander, cabbage and others for an extended period of time. In addition to being bug proof, these net buildings offer perfect conditions free from viruses and insects for the development of those vegetables, especially during the rainy season. According to a number of research findings, the production of vegetable crops grown in enclosed environments can rise three to five times when compared to open environments [4]. Numerous horticultural crops, such as the following, can be cultivated under protected cultivation: Vegetables include lettuce, leafy greens, zucchini, melon, tomatoes, capsicum, cucumbers and eggplant [5]. Fruits: According to Granatstein et al., [6], grapes, apple, pear, peach, plum, cherry, strawberry and other berry crops, Flowers: Chrysanthemum, anthurium, lilium, carnations, gerberas and roses [7]. Tomatoes were the first vegetables to be produced in greenhouses out of all the crops. In comparison to other vegetables like cucumbers and peppers, it is very simple to cultivate and when grown under protection, the fruit output is quite great. The three fastest-growing states are Karnataka, Andhra Pradesh and Odisha. The tomato or *Lycopersicon esculentum*, is widely regarded as a "Protective Food" and is sometimes referred to as the "poor man's orange". Tomatoes come in two varieties: Indeterminate or vine tomato and determinate or bush tomato. Indeterminate varieties are primarily utilized in greenhouse settings to optimize crop yield and elevate vegetable quality. As they grow, they continuously generate fruits and flowers along the main stem [8]. Protecting against biotic and abiotic stressors is the primary goal of growing capsicum in covered structures, particularly in the off-season. Despite being extremely profitable, capsicum production in India is still in its early stages of transfer and expansion into farmer's fields. To achieve optimal development, productivity and quality, growing tomatoes, cucumbers and capsicum under protected conditions-such as in greenhouses or polyhouses-requires careful consideration of a number of parameters. It is imperative for farmers to select appropriate cultivars, offer optimal growing conditions, regulate environmental elements like humidity, temperature and sunlight and execute efficient irrigation and nutrient control strategies.

LITERATURE REVIEW

Designs, construction and operation of protected cultivation

Vegetable cultivation in greenhouses is a labor-intensive process that requires meticulous planning and multiple stages of operation to be successful. Whether a greenhouse is located in a desert, the tropics or a moderate climate, its design changes accordingly [9]. The earliest greenhouses were highly controlled because it was impractical to grow vegetables in freezing temperatures [10]. In contrast, simpler greenhouses offered minimal climatic control and contributed to the production of an economically viable yield of vegetable crops [11]. Glasshouses are more popular in temperate climates around the world, but greenhouses also give a "windbreak effect" and "shading effect" in other subtropical and tropical areas. While the temperature and humidity within a greenhouse create a "oasis effect" in dry locations relative to the scorching, dry heat outside, rain shelters are the typical protective constructions in wet tropical regions to prevent flooding [12]. Protected cultivation buildings come in a range of forms, from basic net

[1]*Department of Agriculture, RNB Global University, Bikaner, Rajasthan, India;*[2]*Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India*

Correspondence: *Mahendra Kumar Yadav, Department of Agriculture, RNB Global University, Bikaner, Rajasthan, India, E-mail: mahendra.yadav@rnbglobal.edu.in*

Received: 27-Feb-2024, Manuscript No. AGBIR-24-130170; **Editor assigned:** 29-Feb-2024, Pre QC No. AGBIR-24-130170 (PQ); **Reviewed:** 14-Mar-2024, QC No. AGBIR-24-130170; **Revised:** 21-Mar-2024, Manuscript No. AGBIR-24-130170 (R); **Published:** 28-Mar-2024, DOI:10.35248/0970-1907.24.40.996-998

huts to intricate greenhouses. The crop being cultivated, the environment and the available funds all influence the sort of structure that is selected. The simplest and least expensive kind of covered construction are net dwellings. They are constructed from a net mesh that keeps birds, illnesses and pests away from the crop [13]. Compared to net houses, polyhouses are built of a plastic sheet that offers superior weather protection. In order to have a more regulated atmosphere, they can also be heated and cooled [14]. Gardens: The most advanced kind of covered structure is a greenhouse. They can be fitted with a range of environmental control systems and are constructed of glass or polycarbonate [15].

Tomato, capsicum and cucumber grown under protected cultivation

Tomato: Tomatoes are one of the most popular crops for protected cultivation. Compared to open field farming, greenhouses offer better growth conditions, which results in larger yields and higher-quality fruit [16]. In addition to increasing yield, using drip in conjunction with mulching resulted in a 62% irrigation water savings when compared to the conventional approach, which had the highest Water Use Efficiency (WUE) (58.19 kg m^{-3}). This helped to achieve the main goal of "more crop per drop" [17]. The earliest treatment examined, treatment 125% Recommended Daily Allowance (RDF) at four-day intervals, was taken at least eight weeks before the first harvest (84.97 days) [18]. The findings indicate that a decrease in irrigation frequency was followed by a decrease in all of these variables, including the weight of the single fruit, transverse and vertical diameters, total soluble solids, total soluble sugar, soluble solid content, sugar-acid ratio, soluble protein, vitamin C, lycopene and WUE [19]. According to Shenda et al., [20], tomato cultivation in poly houses was found to have a higher B:C ratio of 3.73 (B:C ratio-1.85). Although the cost of labor, seed and other inputs was greater in poly house cultivation than in open farms, the yield of tomatoes produced there was three times higher and the market price of high-quality vegetables from the poly house was likewise higher than that of produce from open fields [21]. Tomato production in greenhouses has the potential to enhance tomato quality and productivity, potentially resulting in a more favorable market price for farmers [22]. Plant height (246.31 cm), number of branches (74.82), rind thickness (5.69 mm), fruit diameter (51.16 mm), chlorophyll content (72.15%), number of fruits per plant (56.31) and yield per square meter (7.63 kg) were all higher in the tomato cultivated under shade net [23]. The usage of colored net houses has a favorable influence on tomato output in terms of improvement in morphometric parameters, such as plant height and leaf area and nutritional content such as lycopene [24].

Capsicum: Protected cultivation of capsicum provides a sustainable and efficient approach to meet market demands for high-quality produce. For pepper plants, greenhouses provide the best growing environments, enabling longer growing seasons and higher yields [25]. In light of the lower use of water and fertilizers for improved growth, higher productivity and profitability of capsicum produced under polyhouse conditions, the overall performance demonstrates that capsicum at second irrigation (60% of crop Evapotranspiration (ETc)) and fertigation (75% RDF) regime were noteworthy [26]. Growers of chillies shown a greater degree of adoption of all vegetable growing procedures in covered buildings, particularly with regard to land preparation, manures and fertilizer, seed treatment and sowing timing [21]. We can conserve water by up to 25% by switching to 0.75 ETc irrigation and we can grow more veggies with the water we save. Raju et al. [27], 45 cm × 30 cm spacing was judged to be the best. Furthermore, compared to open settings, a noticeably larger yield gain was observed in a low-cost naturally ventilated polyhouse [28]. Due to its high yield and high cost of high-quality produce, the benefits of growing capsicum under protected structures outweighed those of open field cultivation (B:C ratio: 1.3:1) [29]. According to Aruna et al., [30], growing capsicums in polyhouses is thought to be more profitable than growing them in other protected buildings.

According to Singh et al. [31], improved insect pest management using nonchemical methods results in capsicum var. Bharat fruit produced under net houses with a high fruit production and uniform fruit size. Maximum plant height, flower count, fruit count, fruit set percentage and yield per plant or per square meter are all achieved in covered capsicum production when fertigation and black polythene mulching are used, according to research by Kumar et al., [32]. Kurubetta et al., [33] reported that capsicum var. Indra produced under Net house with Ventilated Polyethylene (NVP) exhibits early flowering, maximal flowers and fruits set and early first fruit harvest. Kanwar et al., [34] studied the best-performing hybrid in the cold, dry Ladakh region under greenhouse circumstances, specifically focusing on the Bharat hybrid of capsicums, which produced a longer fruiting period and a marketable yield. Under protected cultivation, capsicum hybrid Tanvi showed the largest fruit diameter, fruits/plant, fruit weight and total fruit yield [35]. In a low-cost polyhouse cultivating capsicum cv.

Cucumber: Protected spaces are ideal for cucumber growth, particularly greenhouses and high tunnels. Cucumbers grown under protection are more productive and of higher quality than those grown in the open. Higher yields and better fruit quality are a result of the regulated climate and defense against pests and illnesses [36]. Malini under polyhouse had the greatest Total Soluble Solids (TSS) level (4.06°B), highest total sugar (3.46%) and highest reducing sugar (0.58%). Das et al., [37] discovered that Sedona had the highest maximum TSS concentration (4.22°B), total sugar 3.51% and reducing sugar 0.61% in an open environment. The white polyhouse had better light intensity and solar incident radiation than the blue polyhouse. However, plastic mulch produced unfavorable findings under polyhouse cultivation while producing favorable results under open conditions (control) for growth and yield parameters [38]. For year-round cucumber cultivation, the less expensive naturally ventilated greenhouses are more practical and cost-effective [39]. As evidenced by the high water productivity among common passively ventilated low-tech greenhouse structures, the naturally ventilated polyhouse was a more effective protected structure for producing high yields and high-quality greenhouse cucumber fruits, with an optimal use of scarcely available water [40]. One of the most widely grown vegetable crops in the world, cucumber (*Cucumis sativus* L.) is grown in plastic greenhouses for higher economic value during off-season farming [41,42].

RESULTS AND DISCUSSION

Future prospects of protected cultivation

The benefit of protected cultivation is its ability to flourish under a variety of adverse agroclimatic circumstances. It makes it possible to cultivate some vegetable crops year-round, guaranteeing a steady and consistent supply. Notably better produce quality is obtained and increased input usage efficiency is attained by the system. In this regulated setting, controlling weeds, illnesses, pests and insects is much easy. Consequently, there is typically a large rise in agricultural income per unit area. This technique offers a great chance to regularly grow vegetables of the highest caliber, enhancing the general sustainability and financial success of farming operations.

Constraints of protected cultivation

A number of obstacles prevent protected cultivation from being widely used. For many farmers, high initial basic and operating costs are a major deterrent. The functioning of greenhouse systems is further complicated by the erratic power supply. There is a lack of access to high-quality materials and the necessary technical expertise, which makes it difficult to successfully apply protected cultivation techniques. One significant obstacle is the lack of hybrids or types that are suited for greenhouse growing. The cost of exotic seeds exacerbates this problem by limiting their accessibility to a wider variety of farmers. Adding to the limitation is the underperformance of native cultivars, which limits the options available to individuals who want to engage in protected farming. Strategic interventions are required to address these issues. These include increased technical information dissemination, upgrades to the power infrastructure for a more dependable electricity supply and financial support or incentives to lessen the burden of early costs. Furthermore, it will take coordinated efforts to create and distribute high-performing, reasonably priced cultivars that are appropriate for greenhouse production if protected cultivation techniques are to be widely used and successful.

CONCLUSION

In conclusion protected cultivation offers a controlled and favorable setting that empowers farmers to overcome environmental challenges and extend the growing season, ultimately leading to a more sustainable and efficient tomato, capsicum and cucumber production. Protected cultivation is a new method for growing vegetables, such as tomatoes, capsicum and cucumber in controlled environments. This method ensures superior quality and yields by controlling temperature, humidity and light. Protected structures offer better soil fertility, profitability and sustainability compared to open-field cultivation methods. Protected cultivation ensures a consistent supply

of vegetables, despite adverse agroclimatic conditions, enhancing produce quality, efficiency and financial success in farming operations.

REFERENCES

1. Kushwaha PP, Anjum R, Kumar A, et al. Protected cultivation of vegetable crops-a way to get quality veggies. Vigyan Varta. 2023;4(12):188-191.
2. Maitra S, Shankar T, Sairam M, et al. Evaluation of gerbera (*Gerbera jamesonii* L.) cultivars for growth, yield and flower quality under protected cultivation. Indian J Nat Sci. 2020;10(60):20271-20276.
3. Debnath A, Deb P. Advances of protected cultivation of vegetable crops in India as well as global scenario: A review. Pharma Innov J. 2023;SP-12(9):2512-2518.
4. Yadav KS. High-tech horticulture: Protected vegetables production in subtropics under changing climatic scenario. Int J Curr Microbiol App Sci. 2018;7(8):1115-1122.
5. Castilla N. Current situation and future prospects of protected crops in the Mediterranean region. Acta Hort. 2002;582:135-147.
6. Granatstein D, Kirby E, Willer H. Current world status of organic temperate fruits. Acta Hort. 2010;873:19-36.
7. de LC, Singh DR. Floriculture industries, opportunities and challenges in Indian hills. Int J Hortic. 2016;6(13):1-9.
8. Pavani K, Jena C, Vani DV, et al. Cultivation technology of tomato in greenhouse. Prot Cult Smart Agric. 2020:121-129.
9. Jensen MH. Controlled environment agriculture in deserts, tropics and temperate regions-a World review. Acta Hort. 2002:19-25.
10. Albright LD. Controlling greenhouse environments. Acta Hort. 2002;578:47-54.
11. Enoch HZ. Climate and protected cultivation. Acta Hort. 1986;176:11-20.
12. Garnaud JC. A survey of the development of plasticulture: Questions to be answered. Plasticulture. 1987;74:5-14.
13. Singh HP, Dhankhar SS, Dahiya KK. Horticultural crops. Stadium Press. 2009.
14. Kanwar MS. High-altitude protected vegetable cultivation-a way for sustainable agriculture. Appl Agric Prac Mitigat Clim Cha. 2019:51-68.
15. Dalai S, Tripathy B, Mohanta S, et al. Green-houses: Types and structural components. Prot Cult Smart Agric. 2020:9-17.
16. Peet MM, Welles G. Greenhouse tomato production. Tomatoes. 2005:257-304.
17. Devi KL, Panda J, Yadav SR, et al. Effect of drip and mulch on growth, yield and wue of tomato under low cost polyhouse in Sikkim condition. J Curr Microbiol App Sci. 2020;9(1):193-198.
18. Ameta KD, Dubey RB, Kaushik RA, et al. Fertigation schedules and NPK doses influence growth and yield of tomato under polyhouse conditions. J Appl Hortic. 2021;23(2):111-114.
19. Zhang M, Wang L, Wang H, et al. Exploration of water-saving and high-yield irrigation model for tomato under microsprinkler irrigation with plastic film in a greenhouse based on spatial analysis. J Sens. 2022;2022.
20. Shende NV, Meshram RR. Cost benefit analysis and marketing of tomato. Am Int J Res Form Appl Nat Sci. 2015;11(1):46-54.
21. Bhanwaria S, Vatta L. Protection cultivation: Need, status and challenges. J Agric. 2021;2(3):58.
22. Sharma A, Singh KK. Protected cultivation of tomato (*Solanum lycopersicon* L) under polyhouse. Biotica Res Tod. 2020;2(7):562-564.
23. Ramesh G, Maheshwara Babu B, Ajithkumar K, et al. Significance of protected structures on growth and yield of tomato (*Solanum lycopersicum*) in semi-arid region and its influence on blight of tomato. The Pharma Inn J. 2022;11(2):800-805.
24. Cardona SP, Lin MY, Srinivasan R. Growing tomato under protected cultivation conditions: Overall effects on productivity, nutritional yield, and pest incidences. Crops. 2021;1(2):97-110.
25. Boswell VR. Pepper production. US AgricRes Ser. 1964.
26. Dhotre M, Mantur SM. Response of capsicum to different levels of irrigation and fertigation under polyhouse. Adv Life Sci. 2016;5(16):6074-6077.
27. Raju JT, Krishna GM, Kumar HV, et al. Influence of deficit irrigation on biometric parameters of capsicum crop under polyhouse conditions. Int Res J Pure Appl Chem. 2020;21(24):341-347.
28. Brahma S, Phookan DB, Kachari M, et al. Response of capsicum to different plant density under polyhouse and open conditions. Indian J Hort. 2012;69(2):292-294.
29. Sreedhara DS, Kerutagi MG, Basavaraja H, et al. Economics of capsicum production under protected conditions in Northern Karnataka. Karnataka J Agric Sci. 2013;26(2):217-219.
30. Aruna P, Sudagar IP. Evaluation of capsicum varieties under polyhouse conditions. Asian J Hort. 2009;4(2):336-337.
31. Singh D, Kaur S, Dhillon TS, et al. Protected cultivation of sweet pepper hybrids under net-house in Indian conditions. Acta Hort. 2004;659(68):515-521.
32. Kumar M, Verma V. Bell pepper (*Capsicum annuum* L.) production in low cost naturally-ventilated polyhouses during winters in the mid hills of India. Acta Hort. 2008;807:389-394.
33. Kurubetta YK, Patil AA. Performance of coloured capsicum hybrids under different protected structures. Karnataka J Agric Sci. 2009;22(5):1058-1061.
34. Kanwar MS, Sharma OC. Performance of capsicum under protected cultivation in cold arid region. J Hill Agric. 2010;1(1):88-89.
35. Singh AK, Singh B, Gupta R. Performance of sweet pepper (*Capsicum annum*) varieties and economics under protected and open field conditions in Uttarakhand. Indian J Agric Sci. 2011;81(10):973-975.
36. Pal A, Adhikary R, Shankar T, et al. Cultivation of cucumber in greenhouse. Prot Cult Smart Agric. 2020:139-145.
37. Das T, Saikia L, Kumar V. Comparative quality analysis of cucumber grown under polyhouse and in open condition. Int J Biochem Res Rev. 2018;22(1):1-11.
38. Reddy DM, Lalitha R, Kannan SV, et al. Effect of different cladding material and mulching on the growth and yield of cucumber (*Cucumis sativus*) under forced ventilated greenhouse system. Int J Environ Clim. 2021;11(3):115-125.
39. Singh B, Kumar M, Sirohi NP. Techno-economic feasibility of year-round parthenocarpic cucumber cultivation under naturally ventilated greenhouse in Northern India. Acta Hort. 2007;731(38):277-280.
40. Kumar P, Khapte PS, Singh A, et al. Optimization of low-tech protected structure and irrigation regime for cucumber production under hot arid regions of India. Plants. 2024;13(1):146.
41. Soleimani A, Ahmadikhah A, Soleimani S. Performance of different greenhouse cucumber cultivars (*Cucumis sativus* L.) in southern Iran. Afr J Biotechnol. 2009;8(17):4077-4083.
42. Chandra P, Sirohi PS, Behera TK, et al. Cultivating vegetables in polyhouse. Indian Horticulture. 2000;45(3):17-25.