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Engineering prospects for off-season fruit and vegetable production: A review

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Abstract

Greenhouse is a controlled environment structure consists of roof, walls, cladding, irrigation, drainage, heating, cooling, ventilation and other controlled engineering system for off-season production of fruits and vegetables. It is clad with transparent material such as glass, fiber glass and polythene. Their size varies from small shed to vast buildings used for international business. Internal environment of greenhouse is much warmer than external as it is exposed to light and protected covering used for temperature control. For plants root support soil, substrates and water-culture may be used. However, to lengthen the growing season, increase yield and for off-season production awareness of engineering prospects required for controlled environment agriculture are vital. Lights enter in greenhouse through windows and transparent covering of glass, fiberglass, and polythene materials during day time. Water conservation, Temperature and humidity control are key factors of a greenhouse production system. Various variables are considered in planning of a reasonable greenhouse framework for creating all year vegetable production are the distance from market, roads, electricity, site area, location, structure outline, shape, geology, soil, wind velocity, rainfall, light hours and atmospheric conditions.

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Introduction

Protected environment for growing crops

Protected cultivation have transformed from basic secured greenhouse buildings to innovative plant processing plants that enhance the efficiency of the crops and labor work. An advanced greenhouse works as a framework, in this manner, it is additionally alluded to as greenhouse condition farming, controlled condition plant creation framework or structure (Ting & Davidson 2016).

These structures utilize common or counterfeit light inside which ideal development conditions is expected to accomplish for delivering green harvests, or for plant inquire about projects. They additionally offer more noteworthy consistency, diminish the expense of creation and increment crop yields (Cuce & Harjunowibowo, 2016).

A few variables is considered in planning of a reasonable greenhouse framework for creating all year yields and vegetables are the structure outline, scene, geology, soil, atmosphere conditions, microclimate control framework, light condition, blocked sun based radiation, windbreaks, the accessibility of power, roadways, and work power. Different conditions that ought to likewise be considered for a proficient huge scale business greenhouse generation are the earth, financial and social variables (Despommier, 2011)

Baudoin *et al.* (2013) prescribed that so as to get a sensible warmth ascent of under 5°C in a greenhouse, the wind stream rate ought to be 0.04-0.05m^3/s of floor region ($1m^2$). Choice of covering material for a greenhouse relies upon its application, the sort of yield to be developed, and the atmosphere state of the area.

El-Gizawy *et al.* (1993) asserted that by expanding covering power, the generation of tomato will increment up to 51%. The dirt surface will lose its dampness in plants quicker by engrossing the more brilliant vitality, at the same time, the high thickness of tomato plants caused less radiation at the dirt surface.

Greenhouse is a closed environment setup in which temperature is controlled by the covering materials that catch sun light and also decreases airflow in the greenhouse frame. The use of greenhouses in agriculture is restricted except the production of horticultural species. But, in some areas, the greenhouses are used for the growth of ornamental plants, though, it is limited in the field of vegetables. Mostly greenhouses, climate control is done by natural ventilation (Gil *et al.*, 2011).

Humidity levels that are so high or very low have an unsafe effect on soilless plants. Low humidity below 60% causes water stresses in crops. Relative humidity 60-90% is important to grow many hydroponics crops i.e. tomato and capsicum etc. (Kittas *et al.*, 2012). Jaleel *et al.* (2008) reported that decrease in dry and fresh weight occur by low humidity.

Many systems worked in a soilless system where nutrients rich water is used to produce fodder and roots immersed in nutrient solution. The greenhouse is a structure enclosed with apparent material by which the crops are grown in the moderately controlled environment. The basic requirements of plants i.e. temperature, water, humidity and light is maintained by different systems i.e. irrigation and heating system and artificial lights controlled automatically (Chandra and gupta, 2003).

Tidwell (2012) suggested that construction materials for system are chosen based on minimizing the impact on the health of plants within the system. It has been found that fiberglass is one of the greatest material for sump and filter tanks because of its durability and nontoxicity. Concrete is a common alternative with a lower price tag, though it decrease the plasticity inherent in fiberglass structure. For the hydroponic plant containers, extruded polyethylene is preferred to makeshift plant containers made of PVC piping.

Low plastic tunnels are least expensive and least difficult: semi round and hollow supporting systems secured with films. The high tunnels that length a few meters are commonly made of steel rods and are settled the longitudinal way with metal wires and little width rods. The further developed and, in this manner, increasingly costly buildings – for crop security – are

single-range and multispan nurseries; that built in different sizes and statures, and accessible with different kinds of rooftops. The most widely recognized rooftop shapes are: (i) gothic (ii) round arch (iii) saw-tooth (iv) saddle (Von Zabeltitz, 2011).

'Parral type' is most widely recognized greenhouse type. The Parral greenhouse is a vertical building of unbending steel or wooden columns, on which a twofold framework of wire is set to convey the plastic movie. This twofold framework course of action is utilized to guarantee solidness of the spread in a district where high breezes are very normal (Céspedes *et al*., 2009).

Normal ventilation is, regardless of area, the least demanding, less expensive and workable methods for producers to change greenhouse microclimate. It likewise includes great blending of the inside and outer air then temperature circulation is as consistent as could be expected under the different circumstances (Bailey, 2000).

Different studies, the vast majority of which were as of late evaluated by Bournet and Boulard (2010), plainly show in warmish atmosphere territories, regardless of regardless of whether the nursery ventilation is obsessed absolutely by the impact of lightness or simply through wind, the most ideal approach to guarantee satisfactory air trade is join rooftop and side ventilation. In any case, considers by Baeza *et al.* (2009) and Kacira *et al.* (2004) founded the proficiency of consolidated ventilation emphatically diminishes when the greenhouse increases (more ranges) and separation between inverse side outlets increments. In this way, the best techniques in heated atmospheres could actualize wall vents not simply in sides that falsehood opposite to predominant breeze.

During two investigations each length with single vent, and the outlets of all areas were situated a similar way. Baeza *et al*. (2006) assessed the impact of various rooftop opening setups on breeze actuated ventilation productivity of a Parral type nursery when the quantity of openings expanded.

The outlet designs examined by Baeza *et al.* (2006) were: a) only opening for every area, windward arranged

b) Only opening for every span, leeward situated

c) Only opening for every span, on the other hand arranged in progressive span

d) Twofold vents in each length.

A portion of the small greenhouse, for example, the Parral, utilized in the Mediterranean region, with an extremely low rooftop incline (10-15°); sufficiently only deplete precipitation. During light spread: when greenhouse edge is situated east-west, an expansion in light show up to 10% throughout wintertime has been estimated in multi-span sheds if the slant was expanded to 30° (Castilla, 2001).

Baeza (2007) investigate that relapse lines relate the ventilation level along with the breeze speed for four tried rooftop slants. It tends to be seen that for low wind speeds. So no expansion in ventilation amount when the slant of greenhouse expanded, yet at higher breeze speeds the impact of incline on ventilation amount turned out to be a lot bigger, particularly as the slant increment from 11.9 to 18.9°. Be that as it may, as the rooftop slant expanded further its impact on ventilation rate turned out to be a lot littler, and there was almost no change as the slant expanded from 25.3 to 31.2°.

Site Selection

All in all, ideal environment circumstances and low generation budgets (great quality) are critical to determination of an area; conveyance charges are likewise a significant thought when marketplaces are far off. Further specialized and financial perspectives (water and power source, work accessibility and so on.) likewise impact creation expenses and intensity (Castilla and Hernandez, 2005).

In certain districts, adjusting plants to problematic domain is the most widely recognized generation methodology. Interestingly, in northern Europe, the favored methodology has been to enhance the nursery condition so as to arrive at greatest potential yields.

These days, showcase globalization has prompted more prominent aggressiveness; it is along these lines important to expand the nature of nursery items through better atmosphere control (Castilla and Montero, 2008).

Temperature requirements

The most ordinarily developed species in greenhouses are vegetables with medium warm necessities (tomato, pepper, cucumber, melon, watermelon, marrow, green bean, eggplant); the point is to expand the developing schedules past the regular outside development season, and in this manner increment gainfulness. These days, the generation of nursery crops in geological territories without reasonable atmosphere conditions, is profoundly flawed since it involves noteworthy and costly counterfeit atmosphere control (Nisen *et al.*, 1988). The term of "all time" and, therefore, the all-out sun powered radiation rely upon the land scope and the time (Nisen *et al.*, 1988).

The central necessities of plant species are popular for off-season developmet are as per slightest worldwide energy of 9.5 MJ/m2/day. Normal encompassing temperatures of 20-30°C in waterfront zones and 15°-20°C in inland regions (a long way from the ocean). This differentiation depends on the way that the day by day warm motions of inland regions (Nisen *et al.*, 1988).

Glass houses

Glasshouses are regularly discovered greenhouse buildings. These buildings are typically worked in huge sections so as to bring down cost per unit territory, advance effectiveness and lessen heat misfortune through the sidewalls in normal glasshouses (Bunschoten and Pierik, 2003).

Semi-closed and closed greenhouses

Throughout the most recent time proceeding with enthusiasm for semi-closed and closed greenhouses, on the grounds that conceivably they expanded CO_2 quantity in the greenhouse, diminished insecticide operation, and give vitality and water reserve funds.

Van't Ooster *et al.* (2008) reported that zero utilization of fossil vitality and therefore a solid decrease in the emanation of CO^2 to the air is conceivable. Different parts of microclimate, production, worth, and activity of closed greenhouses have been depicted as of late. Opdam *et al.* (2005) provided details regarding a framework that comprises of a CHP (joined warmth and control) unit, heat siphon, underground (spring) occasional vitality stockpiling, daytime vitality stockpiling, air treatment components, and air dissemination channels. They detailed a 30% decrease in vitality use, a 25% expansion in tomato production, 85% decrease in insecticide application, and half decrease in water system water usage.

Heuvelink *et al.* (2008) depicted a recreation investigation of the impact of greenhouse atmosphere on tomato production in a fully closed greenhouse; in light of real weather conditions that were estimated in a closed and open greenhouse the re-enactments anticipated a proction increment of 18%.

Wee (2010) showed that accomplishment of Dutch expert was identified with nation's specific climate category, and accessibility of springs – environments that are not constantly establish in other topographical areas. Actually reasoned that to accomplish conservative all time conclusion in territories having bigger climate variety and absence of availability to springs, a superior financial return is normal in semi-closed plans that empower the greenhouse to outlet when the warmth weight moves toward a specific level of pinnacle stages.

An intriguing methodology, wherein a closed greenhouse was utilized for sun based vitality stockpiling, water reusing, and water purification, was portrayed by Janssen *et al.* (2006) and Buchholz *et al.* (2006); they guaranteed that framework that fused in a closed greenhouse empower similar generation of water, vitality, and nourishment. The catch of overabundance warmth can bolster residential warming, particularly in districts with enormous day and night temperature contrasts.

Various greenhouses in Europe are furnished having airing holes to give great microclimatic environments to plant development. Sadly, these openings work likewise as a significant section course in case of bugs, subsequently, cultivators are compelled to protection the openings totally and for all time with fine-work screens to forestall bug attacks. Since the nuisances being referred to might be extremely little. Along these lines, such screens block ventilation and, at times, lessen light spread (Bethke *et al.*, 1994; Teitel, 2001; Klose and Tantau, 2004). Additionally, the focused on creepy crawlies are generally plentiful throughout the hot seasons, if powerful ventilation is basic to forestall distressing environments for both yield plants and laborers (Teitel, 2001), with the goal that issue of inadequate ventilation is disturbed.

Tanny *et al.* (2008) examined the impacts of screen house tallness on a few microclimatic factors; that led estimations in two neighbouring screen houses that were fundamentally the same as separated from their contrasting rooftop statures (4 and 2 m) in which Ornamental Ruscus was developed. The screen houses were secured with 50%-concealing grids to lessen warmth burden on the plants. The accompanying factors were estimated in each screen house, in its middle: wet-bulb air temperatures and dry-bulb air temperatures, net radiation and leaf temperature. The outcomes demonstrated that net heat was practically indistinguishable in two screen houses.

Diffusive films and clear films

Utilization of exceptionally distributing spread ingredients is scattering. In regions with clear skies having high sun powered energy, direct heat can produce leaf consuming in greenhouse yields throughout warm days. To evade such issues, plastic films is built up that expansion the level of energy in the greenhouse. Heat is viewed as diffuse if it goes astray by more than 3° from the immediate episode heat. The level of diffuse energy in worldwide energy is named turbidity. Increment in turbidity builds light consistency and prompts expanded production (Castilla and Hernadez, 2007).

Dueck *et al.* (2009) demonstrated the plant efficiency could be expanded by 9.2% by utilizing a profoundly diffusive (turbidity of 70%) spread, disregarding a general 3% decrease in broadcast. Areas in which the portion of direct heat throughout the year is bigger than the 30% run of the mill of the Netherlands, the possible for expanding efficiency by methods for diffusing spread constituents is considerably bigger; the ideal turbidity rate for greatest yield. However, fundamental outcomes display that a high rate may not be essential. Endeavors to use sunlight based vitality in greenhouse development were accounted for by a few creators.

At the point when Fresnel focal points were joined with warm, photovoltaic (PV) or crossover PV/warm type safeguards to change over surplus sun based heat in the greenhouse into power and warmth, and along these lines to diminish the inside environment of greenhouse. Presumed that straight Fresnel focal points in blend with warm gatherers could diminish the warming requirements by about 30% and the cooling and ventilation prerequisites by about half, and encounter the majority of the electrical vitality requirements. The utilization of dynamic and detached glass optical raster's and different innovations to decrease the warmth burden in greenhouses and to change over direct sunlight based heat to warm which can be either utilized for warming or put away.

Greenhouse movies are made out of polymers and added substances. Polymers are the essential part, while added substances give a wide range of characteristics with ultraviolet assimilation light dispersion. The life expectancy of greenhouse movies has expanded from 10 months throughout the 1960s to approximately 50 months nowadays. Enduring relies upon photograph added substances fused in the film just on geographic area and the presentation of the film to insecticide medications (Cepla, 2006).

Anti-dust films

Most polymers are poor power channels, especially inclined to the amassing of electricity produced via friction when two surfaces are scoured against one another or when there is grating brought about by the breeze.

As an outcome, most plastics draw in dust. To diminish friction based electricity, a few added substances that expansion electrical conductivity can fused into the inside or on the outside of the film (Montero *et al*., 2001)

Blocking UV radiation to control destructive insect movement

The expression "UV blocking" is functional to soft movies made by different producers with several abilities to assimilate daylight beneath 390 nm. The capacity of bugs to move is associated with UV radiation; consequently, by operating soft constituents that assimilate Ultra voilet radiation, infection sickness conduction can relieved (González *et al*., 2003). The focus is managed in the area on creepy crawly verification screens. Nonetheless, diminishing UV radiation additionally constrains the job of advantageous creepy crawlies utilized for fertilization. Field trials shows that creepy crawly fertilization isn't influenced, given that enough time is given to the bee sanctuaries to get acquainted with the low Ultraviolet stages inside a greenhouse. It should likewise be called attention to that delaying UV-radiation effect sly affect optional digestion, for example plant barriers and micro nutritional nature of items. Photograph specific screens, shading impacts and different alterations

Removal of insects screen

Ideal environmental situations in greenhouse are regularly kept up by shutting and opening vents.

Notwithstanding, bug windows and vents are not managed because of danger of attack by bothers (Ben-Yakir *et al*., 2008). When the fly populace tops, more than 97 percent of whiteflies entered the greenhouse somewhere in the range of 8.00 and 12.00 hours (Teitel *et al*., 2005).

Consequently, danger of fly in greenhouses toward the evening and around evening time is insignificant. Large portion of the year, around 80% of the thrips trapped toward the beginning of the day and 10% at sunset (Ben-Yakir and Chen, 2008).

Notwithstanding consequences for creepy crawly infiltration and the drying level, screens decrease light show in greenhouse by making segments of shadow on the harvest. If they are introduced on rooftop outlets. In sandy districts the shadow impact can exacerbate with time because of the amassing of residue on the screens. Klose and Tantau (2004) reported that in spite of the fact that screens with the biggest separation between neighbouring strings had the most noteworthy light transmission, screens with the littlest separation didn't really have the least.

Climate control

The absence of atmosphere control in numerous greenhouses in Mediterranean nations brings about a deficient microclimate that contrarily influences yield segments and information use proficiency (Shanchez-Guerrero *et al*., 2005).

Well mechanism of greenhouse elevated condition can increase attractive production and value, and broaden the developing period (Baille, 1999).

The low proficiency of ventilation frameworks in minimal effort greenhouses combined with utilization of creepy crawly verification nettings (Muñoz *et al*., 1999), clarifies the generally huge amount of carbon dioxide consumption (Lorenzo *et al*., 1990).

Potential arrangements are: Increment the drying speed by constrained air; Advance structure and the executives of the ventilation framework; or Give carbon dioxide enhancement. The last is generally received in greenhouse business in to upgrade crop photosynthesis in low emission circumstances that win throughout winter. Advancement apparently expands crop production and class under a CO_2 grouping of 800-900µmol mol^{-1} (Nederhoff, 1994).

In any case, a few creators prompt providing CO_2 in any event, when ventilation is working so as to keep up a similar CO_2 focus both inside the greenhouse and external environment, improving to ranks of around 800-900µmol mol^{-1} if the greenhouse is kept shut (Nederhoff, 1994).

Ideal CO_2 advancement relies upon the edge between the expansion in crop esteem and the expense of giving the CO_2. Endeavouring to set up the ideal fixation by try isn't practical in light of the fact that the financial estimation of enhancement isn't consistent however differs with sun based radiation through photosynthesis rate (Bailey and Chalabi, 1994).

The ideal carbon dioxide set argument relies upon a few impacts: the impact of CO_2 on the photosynthetic digestion rate, the dividing to products of the soil vegetative structure, the circulation of photosynthetic in consequent harvests, and the cost of organic product at harvests and notwithstanding the measure of carbon dioxide utilized. Machine-driven ventilation is functional to trade dry external air with damp internal air, trading hotness between the two wind streams (Campen *et al.*, 2003),

Humidity control

On an all year premise, a significant part of the vitality move by regular ventilation. In moderately low heat and modest surrounding temperatures, characteristic or constrained ventilation is commonly used to avert high dampness. Thus a significant division (10-25%) of the all-out vitality utilization is identified with stickiness control. Albeit high mugginess is for the most part connected with expanded danger of contagious infections and diminished quality (for example Botrytis, bloom end decay), it might likewise be sure for crop generation. Decreasing the degree of dampness of the air is exorbitant because of the vitality required and ought to be evaluated against the additional estimation of the yield. An expansion in the stickiness set purpose of 5 percent diminishes the vitality utilization by roughly 6% (Montero, 2006).

Crop selection

From a monetary perspective, it ought to be noticed that glasshouse vegetable are always expanding (Tuzel and Leonardi, 2009), whereas cultivators' earnings are diminishing, in spite of endeavors to bring down generation prices and increase competitively (La Malfa and Leonardi, 2001).

Harvest decision may turn out to be progressively imperative to save the monetary manageability of the set up greenhouse industry and improve the presentation of homesteads presenting secured developments in new territories. Harvest decision must consider species and genotypes equipped for giving explicit produce typologies, assessing market and monetary conditions, crop qualities and necessities, similarity among crop and climate, and soil attributes and soil ailments.

Greenhouse generation is a unique monetary segment and should adapt to quick changes in advertise patterns and purchaser inclinations. Therefore, picking the correct cultivar in greenhouse creation is a basic step in the generation procedure (Tuzel and Leonardi, 2009). Before, creation systems in Mediterranean greenhouses have been founded on adjusting harvests to an imperfect situation because of constrained greenhouse atmosphere control. Throughout the years greenhouse atmosphere control frameworks have been created, bringing about enormously improved production and item quality (Castilla *et al.*, 2004).

Cultivars impervious to significant pathogens and nuisances have been presented in ensured development and progressively speak to a significant segment of the generation procedure (Tuzel and Leonardi, 2009).

The presentation of strong cultivars permits a critical decrease in compound medicines, ecological contamination and creation costs, while giving new potential outcomes to the execution of coordinated development procedures and greenhouse natural preparations. Be that as it may, while embracing safe cultivars, so it is important to study the security of the particular obstruction under various climatic and agronomic environments. With specific organic product typologies (for example neighbourhood cultivars), protection from soil sicknesses is definitely not an essential necessity, since it tends to be overwhelmed by utilizing appropriate rootstocks and well-created uniting systems; the genotype ought to be picked (Leonardi and Romano, 2004).

It is critical that pick cultivars in explicit regions may valorise the ecological situations and specialized variables engaged with the creation procedure. Late headway because of quickly creating rearing innovations has prompted a generously more extensive arrangement of new cultivars with hereditary qualities for improved malady obstruction, versatility to problematic temperature and light, and other explicit characteristics, for example, partenocarpy and appropriateness for joining. Notwithstanding standard quality parameters (size, shading, Brix, % dry issue, timeframe of realistic usability and so on.), specific consideration has been given to subjective characteristics characterizing the wholesome profile of crisp leafy foods (Lenucci *et al.*, 2006).

It is essential to create, in an agent greenhouse zone, a nearby screening system to assess and evaluate as of late discharged cultivars (with the help of neighbourhood organizations and research foundations), so as to help ranchers and underwrite the advancement of vegetables i.e. Lettuce, Cucumber and tomato (Williams and Roberts, 2002). Another expansion program of this sort ought to likewise give specialized exhortation to ranchers on social perspectives to arrive at the production and class capability of explicit types. The feed-forward-criticism circle between ranchers, augmentation administrations and seed organizations may produce a viable framework to protect and valorize underexploited hereditary assets.

Conclusion

To control price of vegetable and fruit during offseason education, research and extension work on engineering prospects of greenhouse production system should be initiated at different agriculture academia, provinces and federal agriculture research organization to train student, officials, extension workers and progressive farmers. Collaboration of different universities, national and international research organization NGOs may be developed for promotion and extension of off-season production technology through social media, print media, radio, television, projectors, exhibition and fair on the progressive farmer filed.

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