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Review Article
A REVIEW ON SUCCESSFUL PROTECTED CULTIVATION OF BANANA (*MUSA*)

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Abstract

Banana is preferably grown under tropical condition where it is well adopted to tropical climate in the warm and humid parts of Asia. A temperature range of 20-35^{0}C is ideal for better banana production and the growth of banana is retarded at temperature below 20^{0}C and above 35^{0}C. In Punjab, banana cultivation is restricted to certain area due to frost injury and adverse climatic conditions during winter seasons and the yield is adversely affected and most of the time whole crop remain damaged. Prolonged prevalence of low temperature during winter prevents the emergence of inflorescence through the pseudostem top due to rosetting of inflorescence. Under such conditions protected cultivation of banana has been advocated. The present review is an emphasis over the feasibility of protected cultivation of banana in comparison to other fruit crops.

Keywords **:** Banana, fruit quality, growth, protected cultivation, yield.

Introduction

Banana is an important tropical fruit and is one of the oldest fruits known to mankind. Banana is one of the dominating fruit crops among majority of fruit crops and is well known as the 'Apple of paradise', so botanically called as *Musa paradisiaca.* Banana name also mentioned in great Indian epics Ramayana and Mahabharata. This is originated in the hot, tropical regions of south-east Asia (Assam, Burma- India, China region). Banana is a good source of vitamin A, Vitamin C and Riboflavin and also a rich source of minerals like magnesium, sodium, potassium and phosphorous and fair source of calcium and iron. Banana contains water-70%, carbohydrates-27%, crude fiber-0.5%, fat-0.3 %, protein-1.2 %, potassium-460 mg, magnesium-36 mg, phosphorous-27 mg, calcium-7 mg, ascorbic acid-10 mg and energy-104 calories per100 gm of fruits (Bal, 1997). Banana is widely grown in countries like India, Mexico, Philippines, Uganda, Tanzania, Thailand, Brazil and China etc. In the world, total area under banana is 5034091 ha having 106847801 MT production with 21.2 MT/ha productivity. In this, India is number one in area and production having total area 802568 ha with production of 29724548 MT with productivity of 37 MT/ha followed by China having 40000 ha area and production 10550000 MT with productivity of 26.4 MT/ha, Philippines having area 454179ha with production 9225998 MT with productivity of 20.3 MT/ha, Equador produces 7012244 MT fruits from 210894 ha area with productivity of 33.3 MT/ha. (Anonymous, 2016).

Banana is well adopted to tropical climate in the warm and humid parts of Asia. A temperature range of 20-35^{0}C is ideal for better banana production and the growth of banana is retarded at temperature below 20^{0}C and above 35^{0}C. The dry matter accumulation in vegetative parts of the plant is maximum at 20^{0}C while the rate of new leaf emergence is highest at 30^{0}C, it ceases when temperature falls below 16^{0}C and growth is completely stopped below 14^{0}C. The respiration rate remarkably reduced and plant becomes susceptible to chilling injury at 10^{0}C and the banana plant is severely damaged at temperature of 3-4^{0}C. The atmospheric temperature above 40^{0}C and a leaf temperature of 47^{0}C causes drying of leaf tissues resulting in blackening of leaves. Sunburn in banana leaves is associated with high summer heat, however it may also occur in winter months due to high day temperature, high light intensity and low humidity. It should not be confused with chilling injury as it only occurs on the western half of the lamina. The optimum soil temperature for maximum root extension in banana is 23.5^{0}C while the root growth stops when temperature falls below 11.5^{0}C.

In Punjab, cultivation of Banana also started successfully from last 3-4 years under subtropical conditions but due to frost injury and adverse climatic conditions during winter season, the yield is adversely affected and most of the time whole crop remain damaged. So, to overcome this problem banana cultivation under net house conditions is needed and so far, there no proper work has been done on protected cultivation of banana under Punjab conditions in relation to different fertigation doses through drip system.

As the world population is growing day by day and urbanization is happening all over, it has resulted into decrease in land holding capacity for growing different crops and due to environmental changes, this is the need of the hour to adopt new cultivation techniques to protect the crops from some biotic and abiotic factors. Protected cultivation provides favorable environment or growing conditions to the plants by providing optimum light, temperature, humidity, carbon di-oxide and circulated air which are suitable for better plant growth, heavy yield and good quality fruits. It also ensures plant protection from various biotic and abiotic factors and reduced gestation period of the crops. Keeping in view the importance of protected cultivation, the current review work emphasized on the study to evaluate the performance of banana cultivation in protected and open field conditions.

Vegetative growth under protected conditions

Prolonged prevalence of low temperature during winter prevents the emergence of inflorescence through the pseudostem top due to rosetting of inflorescence. The

internodes become short and leaf petioles become compact at the top of pseudostem causing 'Choke Throat'. It is major problem in high altitude regions growing dwarf banana cultivars. In case of partial emergence of inflorescence, the orientation remains in upright direction and the phenomenon is called as 'Sun Looker'. In case the inflorescence emerges, the hands remain in vertical positions and the peduncle becomes short. Growing banana under protected conditions improves vegetative growth due to continuous availability of favourable growing conditions.

Saucov *et al*. (1992) worked specifically in Canary Island on the `Dwarf Cavendish` variety of banana and studied the influence of environment variants by using the protected structure on plant morphology and they found that in comparison to open field plants, the plants were superior in terms of all plant growth characteristics under greenhouse conditions. In an experiment on custard apple, Hirokazu *et al*. (2001) conducted a study to determine the influence of various shade levels on plant growth and reported maximum shoot length and leaf number in low shade conditions allowing 64% light interception and maximum shade increased the inter-nodal and specific stem length and in light shading conditions stem diameter, leaf and stem dry weight were found higher. Thinner and larger leaves developed due to suppressed tissue dry weight under more shady conditions. In different varieties of grapes, Kamiloglu *et al.* (2001) conducted an experiment and found enhanced shoot growth under protected cultivation in comparison to open-field conditions. Under both protected and open field conditions "Uslu" variety grew more rapidly as compared to "Yalova Incise" and "Perlette".

Gubbuk and Pekmezci (2004) conducted an experiment on banana (Musa AAA) cultivation in protected and open field conditions and found that there was increase in hands count, fingers count, bunch weight and average annual yield under protected conditions. dos Santos *et al.* (2008) carried out an experiment to observe the growth of papaya and passion fruit nursery seedlings under protected conditions and found that there was uniform height in all treatments upto 31 days after sowing and plant height was maximum under monofilament net and aluminizada shading after 38 days of sowing. Due to low transpiration losses under modified environment, improvement in height occurred.

Medany *et al.* (2009) also reported a significant increase in number of green leaves and average maximum number of total leaves of mango Variety "Keitt" grown under white greenhouse net in comparison to open-field condition. Overall vegetative growth like plant height, number of leaves and stem circumference were also better under white net and this was due to crop favorable environmental conditions like adequate relative humidity, lower maximum temperature, lower light irradiance, lower evapotranspiration, higher maximum temperature and lower wind speed usually prevailed under net house protection.

Casierra-Posada *et al.* (2011) carried out a study on the influence of different shading and light environments on the growth of strawberry plants. On these strawberry plants, different light quantity regimes were maintained using polypropylene films of different colours viz. yellow, green, blue, red, and transparent along with a naked control. Significant difference among root to shoot ratio recorded in green cover conditions only and there was not any significant difference in any parameters in all others cover conditions in comparison to control. Similarly, Schettini *et al.* (2011) carried out a study to determine the effect of two photo selective and three photoluminescent greenhouse plastic films on the plant growth of cherry and peach fruit trees and found that there was significant improvement in shoot growth due to modified spectral distribution of solar radiations under plastic films.

Kaur and Kaur (2017) studied the performance of "Red Lady" papaya under protected cultivation and open field conditions and found maximum plant height (214.05 cm) leaf number (20.46) and leaf area (876.5cm²) under protected cultivation as compared to open field conditions.

Yield and related attributes under protected conditions

The optimum atmospheric temperature for proper fruit growth in banana is 28-30^{0}C. The temperature below 13^{0}C and above 40^{0}C during fruit growth and development causes under peel discolouration. The prevalence of high temperature (40-45^{0}C) during bunch emergence exceptionally reduces the shelf life of banana fruits. The pulp of such fruits collapses to form liquid mushy consistency and the fruits become inedible. This disorder is termed as 'Yellow Pulp'. Further, low temperature is an hinderance in banana plant growth and bunch development. Cracking of fingers have also been reported due to loss of banana peel elasticity during low temperature. Under polyhouse condition, the average size of bunch and finger has been reported to be greater in comparison to open field conditions.

In peach, fruit plants grown under protected conditions showed 13 to 20 days advancement of fruiting as compared to open field conditions. In protected conditions, earliness in anthesis promoted the earliness in fruiting. The overall mean yield was found maximum in open field conditions as compared to protected conditions despite this earliness of fruiting. The assessed yield factor was in terms of yield (Furukawa *et al*., 1990).

Saucov *et al*. (1992) carried out a study to determine the influence of protected structures on banana "Dwarf Cavendish" variety in the Canary Islands and found that there was more bunch weight and finger size ultimately gave higher yield under protected conditions as compared to open field conditions. Similarly, Eckstiin and Joubfrt (1998) studied the performance of banana under protected cultivation and open field conditions and found that due to earliness in anthesis and shooting under protected cultivation, there was shortening in harvesting period. Although there was shorter crop duration from planting to harvest but flowering to harvest duration increased under protected conditions. There was a greater number of fingers per bunch (251), highest fruit circumference (10.9 cm) and fruit length (21.0 cm) under protected cultivation as compared to 185, 8.3 cm and 16.6 cm, respectively under open field conditions. Due to these improvement in fruiting characters, 53 percent increase in yield occurred under protected conditions.

Kamiloglu *et al*. (2011) carried out an experiment under protected conditions and open fields on grape vines and reported that there was earliness in phonologic periods of grape vines grown under protected conditions by advancement of bud break stage, full bloom, veraison and fruit maturity. There was 14 days early blooming than open field grapes due to nine days early bud break of fruiting

vines. Due to sixteen days advancement in veraison stage, fruit maturity occurred 17 days early under protective conditions as compare to open field conditions.

Similarly, in Mango plants grown under white net and open field orchards, there was an increase in fruit yield under white net due to effect of white net on irradiation. Photosynthetic capacity of leaves affected due to reduced radiation under the white net and this resulted in low light saturated photosynthesis rate as compared to the mango plants grown in open field conditions (Medany *et al*., 2009).

Reddy and Gowda (2014) carried out an experiment to determine the influence of protected cultivation on flowering, fruit yield and quality on Red Lady cultivar of Papaya and it was found that under protected cultivation early flower initiation and bearing resulted in higher yield of Papaya. Under protected conditions flowering started in 84.69 days and higher flowers count per plant (48.8%) and greater fruit setting (74.38%) was observed. This earliness in flowering and fruiting resulted in advance maturity. Due to favorable environmental conditions under protective cultivation there was improved hormonal metabolism and photosynthesis in plants resulting in early fruiting and enhancement in harvesting period. Under protected conditions, there was significant increase in fruit size (length x breadth), fruit circumference and total yield per plant as compare to open field conditions. Due to continues availability of healthy, disease or pest free growth and maximum leaf area under protected conditions resulted in promising yield attributes. Similarly, Tyagi *et al*. (2015) carried out an experiment on five different cultivars of Papaya grown under protected conditions and found that there was early harvesting (295 days) in Red Lady cultivar.

Kaur and Kaur (2017) also studied the performance of Red Lady papaya grown under protected conditions and open field conditions. They found that under protected cultivation there was improvement in flowering (51.32), fruiting (49.52 fruits plant^{-1}) and yield (45.39 kg plant^{-1}).

Fruit quality and related attributes of banana under protected conditions

Low temperature during fruiting and maturity of banana fruits prevents yellowing and ripening of fruits due to slow or inhibited conversion of starch to sugar. Under polyhouse conditions, development of sweeter and quality fruits with low acidity at maturity might be due to adequate and timely translocation of carbohydrates accompanied with a greater number of leaves and leaf area.

Furukawa *et al*. (1990) carried out a study to determine the influence of protected conditions on peach plants as compared to open field cultivation and found a significant influence on TSS and pH under protected conditions. Hirokazu *et al*. (2001) carried out an experiment to study the influence of shading conditions on custard apple and reported that there was increase in leaf chlorophyll content due to low light intensity under shady conditions. In pre shade leaves, higher level of chlorophyll content was found and in post shade leaves, the chlorophyll content was found higher at 24% sunlight perception i.e. middle shading conditions. With increased stomatal conductance under light and middle shading conditions they found that leaves performed higher carbon dioxide assimilation rate. Under light shading, this carbon dioxide assimilation rate was uniformly higher all day long except during mid-day when stomatal conductance and leave water potential were minimum. High leaf vapor pressure deficit resulted in low gas exchange rate due to high light perception that caused higher leaf temperature. In this regard they found that under higher shady conditions fruit quality and weight of custard apple were inferior and the maturity was also delayed. Similarly, cherimoya production was also nil while with light environment created by use of 50 to 70% shading this cherimoya production was recorded optimum.

Gubbuk and Pekmezci (2004) studied the effect of protected cultivation on banana production and found that there was increase in bunch stalk circumference and total number of hands per bunch in comparison to open field production. Kamiloglu *et al*. (2011) conducted an experiment on five grapes varieties grown under open fields and protective conditions. He found that overall performance of grapes was better under protective conditions in comparison to open conditions. Different parameters like grape cluster weight, cluster length, cluster width, total soluble solid contents, titratable acidity, pH and maturity index were significantly different among these two growing conditions.

Vool *et al*. (2013) also studied the effect of protective structures and open fields on grapes cultivation. To evaluate the performance of grapes in these two growing conditions different parameters were evaluated like total soluble solids, acidity, phenolics and anthocyanins in grape berries. They reported that total soluble solid contents, phenolic and anthocyanin contents were promising in the grape berries cultivated under protected conditions and maximum value of this is 25.4°brix, 540mg per 100gm and 480mg per 100gm, respectively. Acid content was lowest in the protected cultivation berries as compared to open cultivation i.e. 1.2 gm per 100 gm and 1.6 gm per 100 gm respectively.

Jiang *et al*. (2013) studied the effect of protected cultivation as rain shelter on fruit quality of grape vines and found that there were overall decreases in anthocyanin content of grape berries skin. Lower sunlight availability and risen temperature influenced the accumulation of anthocyanins resulted in reduced pigment contents. The higher levels of air moisture were also found non-favorable for this pigment accumulation.

Reddy and Gowda (2014) carried out a study to determine the influence of protected cultivation on papaya cultivar "Red lady" and found a significant influence on different fruit quality parameters. Under protected conditions, the maximum pulp weight (813.46 g), least peel weight (76.56 g), more pulp:peel ratio (10.63), highest total soluble solids content (13.92 °brix), total sugars (12.64%), reducing sugars (9.53%), non-reducing sugars (3.11%), sugar/acid ratio (15.33), carotene content (2.42 mg/100 g), acidity (0.12%) and ascorbic acid content (96.18 mg/100 g pulp) were recorded in fruits grown under protected conditions. In addition to this, other biochemical characteristics like fruit firmness (2.82 Kg/cm²), shelf life (7.92 days) and organoleptic score (19) were also reported promising under protected cultivation conditions. Under protected cultivation conditions, due to prevailing favorable climatic factors such as temperature, light intensity and humidity, the chlorophyll content was promoted and this ultimately affected the photosynthesis in leaves and due to this, there might be more

translocation of carbohydrates for cell division which ultimately affected the growth of plant and fruits.

Disease and pest incidence under protected conditions

Banana is herbaceous and high-density planting crop which provides habitat to many insect-pests and invites a number of disease-causing microorganisms. Further, poor cleaning practices makes the condition of banana orchard non-productive. Under polyhouse conditions, there is hindrance in entry of biotic agents which are responsible for poor health of banana plantation. Regular cleaning and proper management inside the polyhouse keep the plants healthy which becomes good for high and quality yield in banana.

Jiang *et al.* (2013) studied the effect of protected cultivation as rain shelter on fruit quality of grape vines and found that there was very less fruit diseases incidence under protected cultivation conditions as compared to open field conditions where downy mildew, anthracnose and white berries diseases of grape vines occurred. In open field conditions, these infections were upto the extent of 75% and causing adverse effect on fruit quality and yield.

Reddy and Gowda (2014) also conducted experiment on papaya cultivar "Red Lady" to determine the influence of protected cultivation on incidence of papaya ring spot virus and found that there was no virus incidence in protected conditions whereas in open field conditions, virus occurred with 100% infected plants after 163.23 days. Under protected structure due to presence of insect-net on outer walls of the growing structure there was no any presence of virus vector i.e. aphids.

Conclusion

Overall vegetative growth like plant height, number of leaves and stem circumference have been reported better under protected conditions which might be due to crop favorable environmental conditions like adequate relative humidity, lower maximum temperature, lower light irradiance, lower evapotranspiration, higher maximum temperature and lower wind speed usually prevailed under net house protection.

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