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Review Article

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Protected Cultivation of Fruit Crops- A Review

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ABSTRACT

India is second largest producer of fruit crops in the world, still we are lagging in export potentiality, productivity and quality of fruits, because of low land holdings, rain fed farming, improper utilization of natural resources, over emphasis on chemical fertilizer and pesticides. These chemicals are also causing environment pollution and fruits produced by using chemicals are not preferred for export due to residual accumulation. Physiological disorders, pests and pathogens also causing adverse effect on production of quality fruit crops. In order to overcome disadvantages caused by local climatic conditions, one has to go for protected cultivation to produce desired quality fruits. It also promises the yield and quality improvement with good benefit cost ratio.

Key words: *Yield, Quality, Economy, Biotic and Abiotic.*

INTRODUCTION

High-density planting is a way to get high yield in short time. The increase in area, easier harvest and pest management, and high yield in short time for high profit can be listed for the reasons for approaching to high-density planting[1,13]. Enabling the yield in a shorter time when compared to standard cultivation, high density cultivation is getting more popular in fruit production. This method has encouraged dwarfing the trees by different applications and developing of dwarf trees under protected cultivation. The advantages of such systems include easier cultivation (e.g., irrigation, weed control, pest management and harvest), decrease in yield lost by ecological factors, possibility of working in all weather conditions, increase in marketable fruits, consistent high yield, and most importantly, earliness and higher profitability[4,5]. India is second largest producer of fruit in the world but the productivity and quality was inferior due to influence of biotic and abiotic factors which will also hinders the export potentiality. The yield, quality, off season cultivation and export potentiality of fruit crops can be promoted by greenhouse fruit cultivation. In Japan, protected cultivation was initiated to compete with fruit import during out of harvesting period as improving the fruit quality[8].

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In Italy, the protected culture was established as the fruit import from South Africa has increased during 1960s and now becomes a common technique as it increases the earliness[2]. The fruit crops will mostly influence by the abiotoc and biotic factors, therefore, obvious choice to regulate/manage these factors by greenhouse/protected cultivation. Therefore, this review article is about the cultivation fruit crops.

Effect of protected cultivation on field environment

In mango

Medany *et al*[11]., conducted study on suitability of white greenhouse net cover for growth of mango (*Mangifera indica*. L.) cv. Keitt cultivar they found that, Maximum temperatures tended to be lower under the nets (2°C), due to the interception of radiation which is greater than the gain of temperature caused by the use of nets due to their role in the interception of air circulation or "greenhouse effect". Bigger differences were recorded on the growing seasons. Minimum temperatures tended to be lower in the control by 1°C than in the nets because of the greenhouse effect and the low radiation at this time of the day. Average relative humidity increased by the use of white net by 4-8% compared with open field, the increase in humidity associated with the use of nets. These authors also reported a decrease in evaporation associated with the use of nets and a significant reduction in wind speed.

In banana

In summer the green houses were cool in greenhouses it was reduced the by 8^{o}C compared with under canopy temperature levels outside the greenhouse. Before turning the overhead cooling system, the humidity was already up to15 per cent higher inside the greenhouse than outside. After turning over head cooling system the humidity was increase up to 18% per cent[3].

In grape

Jaing *et al*[9]., the impermeable plastic covering above the grapevines rows increased the air temperature and decreased the photosynthetic radiation and wind speed. The covering interfered with the quality of the incoming solar radiation, mainly by reducing the irradiance in the ultraviolet band and also by reducing the ratio between the irradiance in the red and far-red bands.

Effect of Protected Cultivation On Vegetative Growth

In mango

Regarding number of leaves per plant, white net condition significantly increased number of green leaves in both seasons, number of total leaves was also significantly increased in the both season. They found that vegetative growth of the plants under white net cover were bigger than those plants grow under higher open field conditions. The improved vegetative growth evidenced as plant height, number of leaves, and stem diameter per plant under the greenhouse levels may be due to the favorable weather conditions, *i.e*., increase in relative humidity, lower maximum temperature and light irradiance, higher minimum temperature and finally lower wind speed in comparison with open field conditions[11].

In banana

Gubbuk and Pekmezci[6], in 'Dwarf Cavendish' the height Average pseudo stem circumference was 68.5 cm in open-field and 78.3 cm in protected cultivation. Mean pseudo stem height was 1.7 m in open field and 1.8 m in protected cultivation. The total leaf number was found to be higher in protected cultivation (28.2) than in open field (20.8). The plants grown in the greenhouse had up 5.4 leaves at flowering. It was found that the no. of leaves produced before flowering was more (35.00-39.40) in outside because of faster rate of senescence of leaves whereas in greenhouse less no. of (<35) leaves was produced. Number of leaves present at flowering was more (17.2) the crop grown in greenhouse in outside was less (11.80-13.30). The highest plant height (2.55-2.84), pseudo stem circumference at flowering (76.30-81.90) and the lowest values were noticed in outside[3].

In Custard apple

Shoot length and leaf number at light shading condition (64% sunlight) were larger than at

the other shade levels. Inter-node length and specific stem length were increased with shade. Stem diameter and leaf and stem dry weight were greater at light shading condition. Although tissue dry weights were suppressed at deep shading condition (10% sunlight), stem dry weight was less affected by shading than leaf dry weight. The thinner and larger leaves developed under the heavier shade environments. Single leaf area was increased by heavier shading, although the total leaf area per shoot was reduced. Specific leaf area became larger as shading level increased, indicating that leaves at heavier shade reduced leaf thickness[7].

In grape

Based on the means of the 2 years, the shoot elongation of plants in protected cultivation was greater than that of plants grown in open fields. Additionally, based on the shoot measurement in the last period, 'Uslu' was the most rapidly growing cultivar in both open field and protected production. The shoot development of 'Yalova incisi' and 'Perlette' cultivars in the open field were found to be the lowest[10].

Effect of Protected Cultivation On Flowering

In banana

The period from shooting to harvest was 41.4 days shorter in protected cultivation[6]. The plants grown in greenhouse was found to flower 6.9-7.0 months after planting but the plants grown outside the flowering was started 9.2-10.10 months after planting. But long duration (5.3-6.5 months) was taken for flowering to harvest in greenhouse condition whereas, day from planting to fruit harvest was lowest (12.7-13.4 months) in greenhouse grown banana but in outside 4.4-5.3 months from flowering to harvest and 14.5-14.9 months from planting to harvest[3].

In peach

Full blossoming was 1–12 days earlier in protected cultivation than open field. The differences among cultivars in harvest dates ranged from 1–15 in protected cultivation and 2–7 days in open field. In general, protected cultivation showed 13–20 days' earliness when compared to open field[5].

In grape

The phenologic periods were observed earlier in protected plants than in those grown in an open field, the vines under cover reached bud break 9 days early, full bloom 14 days early, veraison 16 days early, and maturity 17 days early[10].

Effect of Protected Cultivation On Yield

In mango

The higher yield associated with the use of the white net in comparison with open field conditions. The reduction of radiation is responsible for down-regulation of photosynthetic capacity of leaves and consequently a lower light saturated photosynthetic rate compared to the control[11].

In banana

In open-field and protected cultivation, finger number, finger circumference, and finger length were measured as 185 fingers/bunch, 8.3 cm, and 16.6 cm respectively compared with 251 fingers/bunch, 10.9 cm, and 21.0 cm, respectively. In protected cultivation, bunch weight was heavier by 14 kg compared to open field[6]. The quantitative parameters clearly indicate that bananas grown in protected cultivation are superior to those grown in open-field cultivation, with a yield increase of 53%. Banana grown in green house shown that, finger length was increased by 14 mm, the no. of hand per bunch was increased by 10%, the overall bunch mass was increased from 8-26%, the annual yield was increased 37% over outside grown banana[3].

In peach

The mean yield was higher in open field than protected cultivation for yield/unit trunk cross-sectional area and yield/unit of canopy volume of trees[5].

Effect of Protected Cultivation On Quality Parameters

In banana

Gubbuk and Pekmezci[6], The bunch stalk circumference as well as the number of hands also varied significantly; 22.2 cm in open field and 25.4 cm in protected cultivation for bunch stalk circumference and 10.6 in open-field and 12.9 in protected cultivation for number of hands.

In peach

Protected cultivation had lower values for soluble solids and acidity, and higher values for pH than open field. These differences between cultivation systems were significant for soluble solids and pH, but not significant for acidity[5].

In grape

The highest cluster weight and width values were observed in 'Ergin cekirdeksizi' (322.42 g and 10.27 cm, respectively) and the longest cluster length was observed in 'Uslu' (22.39 cm)[10]. Vool *et al*[14]., the content of soluble solids ranged from 24.1 and 25.4 ^{o}Brix but under open condition it was ranges from 17.9-21.8^{o} brix, the lowest titrable acidity (1.2-1.2 g/100g) was noticed in protected cultivation of grape cultivars (Hasanski Sladki and Zilga respectively) and maximum TA (1.5-1.6 g/100g) noticed in open condition, highest total phenolics and anthocyanins (540 and 480 mg/100g and 160 and112 mg/100g) was noticed in protected cultivation of grape cultivars (Hasanski Sladki and Zilga respectively), the lowest total phenolics and anthocyanins (326 and 222 mg/100g and 133 and 64mg/100g) noticed in open condition. TSS contents were 14.68% and 14.82% in open field and protected cultivation, respectively. The pH means were similar for open field (3.08) and protected cultivation (3.09). The acid content was higher in protected cultivation (0.74%) than open field (0.65%). This may be caused by the fact that the maturity index of protected cultivation (20.62) was less than that of open field cultivation (23.21)[10].

Effect of Protected Cultivation On Economics

In mango

Annual costs of using nets White net was superior of fruiting by two years comparing with control treatment, and the total benefit during the first two years after cultivation was 19160 L. E[11].

Cost accounting for Keitt Mango The costs of the constructing of a new greenhouse on 4200m2 area with local material, such greenhouse model was used to planting both navel orange and Keitt mango. Thereat, the previous costs used for establishing a greenhouse are reused to estimate the same feature for Keitt mango. The total costs of the cultivation for feddan of Keitt mango under protected cultivation during the first seven years of cultivation was L.E 72331. The agricultural operations such as "irrigation, fertilization and hoeing, etc.", ranked first with L.E 31500, which represent about 43.55% of the total production costs, while the value of screen net came in the ranked second being on average 21.29% of the total costs. As for the costs of the cultivations of Keitt mango in open field, Table 8 shows that the costs of cultivation one feddans of Keitt mango in open field during the first seven years of agriculture, was L.E 52900. The agricultural operations value such as "fertilization, hoeing etc." came in ranked first with L.E 35000, which represent about 66.16% of the total costs. On the other hand, the value of seedlings transplant ranked second representing about 18.53% of the total costs, whereas the value of drip irrigation system depreciation came in the third rank representing 10.59% of the total costs. The comparison between Keitt mango total production, total cost, total revenue and net return per feddan in the open field and protected cultivation during the first seven years of cultivation. The total production during 2007- 2013 under screen net reached 33.075 tons/ feddan, while that in the open field was 16.100 tons/ feddan. The results also show that the total cost was L.E 52900 in open field compared to L.E 72331 in screen net. Moreover, during the same period, the total revenue reached L.E 128800 for the open field, and L.E 264600 in screen net. Consequently, the net return per feedan within first seven years in screen net cultivation within 7 years reached L.E 192269, while the net return per feddan in the open field reached L.E 75900. Results in Table 10 show the comparison between Keitt mango and navel orange profitability for one year under open field and screen net. Total yield per feddan for Keitt mango under screen net reached 4.72 tons/ feddan and 2.3 tons/ feddan in the open

field, while the total yield per feddan for navel orange in screen net reached 18,9 tons/ feddan and 12,35 tons/ feddan in the open field. Table 10 also shows that the net income is higher for cultivation under screen net than in open field, in both Keitt mango and navel orange despite, the total production costs of screen net is higher than in open field for both fruit crops[12].

In navel oranges

The constructing cost of the greenhouse on an area of one feddan (4200 m2) by local materials in the domestic market, with a total cost reached L.E 26000. Likewise, the reveals that the total costs of the cultivation for feddans of navel oranges under screen net during the first seven years of agriculture is about L.E 62731. Agricultural operations e.g. "irrigation, fertilization and hoeing, etc.", came in the first place with L.E 30000, which representing about 47.8% of the total production costs, while the value of screen net came in the second place being on average 24.55% of the total costs. Concerning open field, the costs of the cultivation of one feddan of navel orange in open field during the seven years considered was estimated by L.E 41300. The production practices e.g. "fertilization and hoeing, etc.", value ranked first in terms of costs with L.E 31500, representing about 76.27% of the total costs. The value of drip irrigation system depreciation ranked second representing 13.56% of the total costs. And the value of maintenance followed in the third rank representing 4.84% of the total costs. The comparison between navel orange total production, cost, total revenue and net return per feddan under the open field and under screen net during the first seven years of agriculture. The total production of screen net reached 132 tons/ feddan, compared to 86 tons/ feddan in the open field, during the years 2007- 2013. Result also showed that the total cost reached L.E 41300 in open field compared to L.E 62731 under the screen net. Moreover, total revenue reached L.E 86460 for the open field and L.E 132310 for the cultivation under screen net during the years 2007- 2013. Accordingly, the net return per feddan for the first seven years in screen net cultivation reached L.E 69579, while the net return per feddan in the open field reached L.E 45160[12].

Effect of Protected Cultivation On Bio-Chemical and Bio-Physical Parameters

In Custard apple

Leaf chlorophyll content was increased by low light intensity for pre-shade leaves. However, for post-shade leaves, the highest value was observed at middle shading condition (24% sunlight)[7].

In grape

Anthocyanins, rain-shelter cultivation reduced their content in the grape skins as a whole. Accordingly, the total anthocyanin content in the grape under rain-shelter cultivation were also lower compared to open-field, which was consistent with previous studies due to the sunlight and temperature could promote the accumulation of anthocyanins in the grape berry. Meanwhile high air humidity is detrimental to the anthocyanin accumulation. Although increasing diurnal air temperatures, the plastic covering can reduce solar radiation and the wind velocity, and increase the air humidity around the grape berry by reducing the evaporative demand on vineyards. It suggested that solar radiation and air humidity had higher influence on the anthocyanin accumulation than air temperatures during grape berries maturation. They are found in the solid parts of the berry (seed, skin, and stem) in the form of monomers, oligomers, or polymers and move to musts and wines during winemaking. In all of the grape samples both under rain-shelter cultivation and open-field cultivation, flavan-3-ols oligomer (procyanidin dimer and trimer) content was higher than monomer. Compared to grape berries under open-field cultivation, these grape berries under rain-shelter cultivation had low concentrations of proanthocyanidins[9].

In Custard apple.

Higuchi *et al*[7]., reported that, leaves at light and middle shading performed higher CO2 assimilation rate (Ac) with higher stomatal conductance. Under high light, high leaf temperature caused high leaf vapor pressure deficit, resulting in a reduction of gas

exchange rate. Throughout the daytime, Ac at light shading was maintained at a higher level than the other conditions except during midday, when stomatal conductance and leaf water potential were lowered. Under deeper shading conditions, fruit weight and quality were decreased and the harvest was delayed. Heavy shade using shade cloth under plastic house conditions appeared to detrimental to cherimoya production. A shading of 50-70% sunlight was thought to be adequate to obtain optimal light environment for cherimoya cultivation.

Effect of Protected Cultivation Pest and Diseases

In grape

Jaing *et al*[9]., the grapevines cultured on the open field presented serious diseases and the severity increased to the fourth grade (infected area of leaves is above 75%). The diseases of infected plants were found mainly to involve downy mildew on grape leaves, anthracnose and white rot in grape berries. These diseases could proliferate and spread during the hot and rainy season. In the two vintages, leaf disease (disease incidence of leaf, defoliation rates, and diseases index) and fruit disease (diseases incidence of cluster, diseases incidence of berry, and diseases index) in these grapevines cultured using rain-shelter technology were far lower than those cultured on the open field during the fruit ripening process.

CONCLUSION

Finally, it was concluded that, greenhouse/protected cultivation one new technology to protect crop from natural calamities, biotic and a biotic stress. It also promises the yield and quality improvement with good benefit cost ratio.

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