IMPACT OF CULTIVATION SYSTEMS ON GROWTH AND YIELD OF STRAWBERRY *(FRAGARIA ANANASSA)* CV. "CHANDLER"

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ABSTRACT:-The proposed research study was conducted during 2010-11 at the Research Farm, Department of Horticulture, PMAS-Arid Agriculture University, Rawalpindi. The runner plants of the strawberry (*Fragaria ananassa*) cv. Chandler were collected from Swat (Mingora.) Different cultivation systems were adapted i.e., standard growing media in polyethylene bags (T_1), soil less media (T_2), high tunnel (T_3), green house (T_4), including open field condition on ridges (T_5) by keeping plant to plant distance of 30 cm and row to row distance of 60 cm. The study was conducted to evaluate the effects and suitability of different cultivation systems for better vegetative growth, production and fruit quality of strawberry. The results of cultivation systems on different vegetative traits i.e., plant height, number of leaves, leaf area, fresh and dry weights of leaves, crown size , root length and reproductive parameters i.e., number of trusses, number of flowers, number of fruits, fruit size, fruit weight and qualitative measures viz., total soluble solids, total sugars, ascorbic acid were found significantly higher under tunnel condition as compared to other cultivation systems. The experiment was arranged by employing the Randomized Complete Block Design (RCBD) by using five treatments, each comprising three replications with 20 plants per replicate.

Key Words: Fragaria ananassa; Cultivar; Cultivation; Growth; Yield; Yield Components; Pakistan.

INTRODUCTION

Strawberry *(Fragaria ananassa)* is an ancient crop. The strawberry is a small herbaceous perennial plant, which can be grown as an annual or perennial crop. Strawberry plants consist of a crown (shortened stem) from which all leaves, roots, flowers and runners grow (Maas, 1984; Bowling, 2000). Various strawberry species are grown all over the world, but the cultivated strawberry is hybrid between two species *Fragarin chiloensis* and *Fragarin verginiana*. These two species were the ancestor of all the modern strawberry cultivars. Strawberry has great dietetic value and is one of the potential sources of vitamin C. One hundred gram edible portion contain 89 g water, 0.07 g protein, 0.5 g fats, 8.4 g carbohydrates and 59mg ascorbic acid. Strawberries also contain the higher percentage of non nutrients e.g. phenolics and flavonoids as compared to other berry fruits (Hakkinen and Torronen, 2000). Pakistan having a variety of climates and topography, which provides appropriate conditions for cultivation of strawberry. It is being cultivated in specific areas of Punjab and Khyber Pakhtunkhwa during

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October April which are most suitable months for commercial production in open field. In Sindh strawberry is being produced by few growers in Khairpur district on small scale. At present Islamabad, Lahore, Charsada and Mardan are the major producing areas, which usually supply to different markets. For many years, strawberry is being grown commercially under open conditions which can cause poor fruit quality and production. Therefore, developing new methods to increase its yield and quality are important. Different methods are being used for cultivation of strawberry like open field, glasshouse or polyethylene tunnel all over the world. High tunnel may give good opportunity to produce early season strawberry. The high tunnel protects the growing crop from environmental extremes and results in earlier and higher marketable yield. Sandra et al. (2009) described the effect of two different growing systems (under a high plastic tunnel and in the open field) on the quality of strawberry fruits (cv. Clery and cv. Asia). Results demonstrated that the fruits of cv. Clery had more antioxidant compounds than the fruits of cv. Asia when grown in the open field. The fruits of both cultivars grown under a tunnel generally had good properties; however, total acids content, total soluble solids and total soluble solids / total acids ratio were slightly higher in fruits of plants grown under a high plastic tunnel. On the other hand, sugar content (reducing sugars and sucrose) was considerably higher in fruits cultivated under a high plastic tunnel. The highest content of phenolic compounds was found in cv. Clery from the open field production. Cultivation systems can have a big influence on chemical composition of strawberry fruits (Voca et al., 2006, Cantliffe et al., 2001). The present study is to investigate the influence of the different cultivation systems on the vegetative and reproductive growth, quality and yield of strawberry cv. Chandler.

MATERIALS AND METHOD

The proposed research study was conducted during 2010-11 in experimental field area of Department of Horticulture, PMAS-Arid Agriculture University, Rawalpindi. The runner plants of the strawberry *(Fragaria ananassa)* cv. Chandler were collected from Swat (Mingora), Khyber Pakhtunkhwa and grown under different cultivation systems i.e. polyethylene bags (T_1), soil less media (T_2), high tunnel (T_3), green house (T_4), including open field condition on ridges (T_5) by keeping plant to plant distance of 30 cm and row to row distance of 60 cm. The study was conducted to evaluate the effects and suitability of different cultivation systems for better growth and production of strawberry and to observe fruit quality under different cultivation systems. Data were taken weekly during study period. The vegetative growth characteristics: plant height, number of leaves, leaf area and crown size, reproductive traits: number of flowers, number of fruits, fruit weight, fruit size and quality parameters: total soluble solids, total sugars and ascorbic acid contents were observed. Randomized Complete Block Design

(RCBD) using five treatments, each comprising three replications with 20 plants per replicate was employed. Plants were sprayed uniformly with insecticides. Fertilizer and irrigation were also applied uniformly as required.

RESULTS AND DISCUSSION

Statistical analysis of data regarding plant height indicated significant ($P<0.05$) effect on cultivation systems (Table 1). Results revealed that maximum plant height was 26.2 cm produced in high tunnel (T_3) while minimum 16.9 cm observed in open field on ridges (T_5). The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$. Many researchers have also reported better growth of strawberry plants, when grown under plastic tunnels than other cultivation systems (Ram et al., 2005).

Maximum numbers of leaves were 22 produced in high tunnel (T_3) while minimum 5 observed in cultivation on ridges (T_5) and soil less culture (T_2) (Table 1). Furthermore, cultivation in green house (T_4) and bags cultivation (T_1) performed similar for leave production. The trend of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 \approx T_5$. More leaves production might be related to better exploration of nutrients and water in high tunnel cultivation (Sturm et al., 2003) .

Data demonstrated that maximum leaf area was 78.93 m^2 produced in high tunnel (T_3) while minimum 25.60 m^2 observed in cultivation on ridges (T_5) (Table 1). Furthermore, there is no significant difference between soil less media (T_2) and green house (T_4). Following trend have been observed among cultivation systems, T_3 followed by $T_1 > T_2 \approx T_4 > T_5$. More leaf area was observed in tunnel cultivation might be related to better utilization of water, light, and temperature (Sturm et al., 2003). The leaf area may be attributed to increase in soil temperature and moisture retention which changed plant microclimate as a result faster plant growth was observed. Furthermore, plants have better exploited the growing medium for nutrients acquisition which resulted in more leaf area production. As nitrogen has a tendency to increase leaf cell

Table 1. Vegetative growth characteristics as affected by cultivation systems

Treatment	Plant height (cm)	No. of leaves	Leaf area (m^{-2})	Fresh wt. of leaves (g)	Dry wt. of leaves (g)	Crown size(cm)
T_1	21.1 b	10 b	57.81b	10.13 b	1.82 b	7.79 b
T_2	17.5 cd	5 c	35.99 c	5.5 d	0.99 d	1.65 d
T_3	26.2 a	22a	78.93a	19.93 a	3.59 a	16.17 a
T_4	19.4 bc	9 b	40 c	8.2 c	1.48 c	4.8 c
T_5	16.9 d	5 c	25.6 d	5.37 d	0.96 d	1.9 d

Means followed by same letters do not differ significantly at 5% level

numbers and size with overall increase in leaf area thus resulted in better vegetative growth. The statistical data pertaining to the fresh weight of leaves (FWL) of strawberry plants represented that maximum fresh weight of strawberry leaves was found with high tunnel (T_3) that maximum FWL produced was 19.93 g, while minimum 5.37 g observed in open field on ridges (T_5) (Table 1). The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 \approx T_5$.

The recorded data for the dry weight of leaves (DWL) depicted significant ($P<0.05$) effect of cultivation systems on DWL of strawberry plants. Results demonstrated that maximum DWL was 3.59 g produced in high tunnel (T_3) while minimum 0.96 g observed in open field on ridges (T_5) (Table 1). Furthermore, cultivation in soil less media (T_2) and on ridges T_5 performed almost equally. The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 \approx T_5$. Minimum FWL in soil less culture might be due to poor utilization of nutrients to achieve the maximum weight. Maximum DWL in high tunnel cultivation might be due to high tunnel provide optimum climate and soil conditions for better growth to strawberries. Such a cultivation system also enables better water, light, and temperature control (Sturm et al., 2003). There were significant ($P<0.05$) effect of cultivation systems on crown size of strawberry plants. Results showed that maximum crown size was 16.17 cm produced in high tunnel(T_3) while minimum 1.65 cm observed in soil less media (T_2). The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_5 > T_2$. The results indicate that increase in crown size may be attributed to protected environment on creation of comparatively favorable environment and better moisture conservation, suppression in weed growth, which might have resulted in comparatively better growth of plants than other treatments.

Data related to number of trusses per plant showed a significant ($P<0.05$) effect of cultivation systems. Results described that maximum number of trusses per plant was 6 produced in high tunnel (T_3) while minimum 2

Table 2· Reproductive growth characteristics as affected by cultivation systems

Treatments	No. of trusses (o-bri2)	No. of flowers/ truss	Flower size (cm)	No. of fruits/ truss	Fruit size (cm)	Fruit weight (g)
T_1	3 bc	3 b	1.33 b	2 b	3.56 b	73.78 b
T_2	2 d	1 c	1.16 c	1 c	3.33 c	46.06 d
T_3	6 a	5 a	1.62 a	3 a	5.27 a	117.9 a
T_4	3 b	3 b	1.21 bc	2 b	3.33 c	60.76 c
T_5	2 cd	2 c	1.1 c	1 c	1.11 d	37.97 e

Means followed by same letters do not differ significantly at 5% level

Table 3. Qualitative characteristics as affected by different cultivation systems

Treatment	Total soluble solids	Total sugars (g)	Ascorbic acid (mg 100^{-1} ml)
T_1	7.08 b	77.44 b	61 b
T_2	4.97 d	63.13 cd	60 d
T_3	7.23 a	92.89 a	61.38 a
T_4	6.85 c	66.29 c	60.38 c
T_5	4.88 d	53.96 d	60.01 bc

Means followed by same letters do not differ significantly at 5% level

was observed in soil less media (T_2) and on ridges (T_5) (Table 2). Furthermore, there is no significant difference between cultivation polyethylene bags (T_1) and (T_4). Likewise, (T_2) and (T_5) performed similar for number of trusses per plant. Cultivation systems followed the following trend $T_3 > T_1 \approx T_4 > T_2 \approx T_5$. Significant effects of cultivation systems was observed on number of flowers per truss (Table 2). Maximum number of flowers per truss was 5 produced in T_3 while minimum was recorded in T_2. The order of cultivation systems was T_3 followed by $T_1 \approx T_4 > T_5 > T_2$.Pre requisites for successful strawberry growing are climate, cultivars and soil which was attain in high tunnel cultivation. Thus it resulted in more production of flowers per truss. Results demonstrated that maximum flower size was 1.62 cm produced in high tunnel (T_3) while minimum 1.10 cm found in open field on ridges (T_5). The trend of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$. There were significant ($P<0.05$) effect of cultivation systems on number of fruits per truss of strawberry (Table 2). Results demonstrated that maximum number of fruit was 3 produced in high tunnel (T_3) while minimum was 1 observed in cultivation in soil less culture (T_2) and on ridges (T_5). The order of cultivation systems was T_3 followed by $T_1 \approx T_4 > T_2 \approx T_5$. Fruit size is an important attribute that directly affect the production and yield of plants. It plays significant role for attraction of the consumers. Data revealed that there were significant ($P<0.05$) effect of cultivation systems on fruit size of strawberry (Table 2). Results demonstrated that maximum fruit size was 5.27 cm produced in high tunnel (T_3) while minimum 1.11 cm found in cultivation on ridges (T_5). The trend of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$.Results demonstrated that maximum fruit weight was 117.90 g produced in high tunnel (T_3) while minimum 37.97 g found on ridges (T_5) (Table 2). The trend of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$. These results were agreed with those results obtained by Olabode et al.

(2007). In high tunnel cultivation plants get benefit from all the control climatic and soil conditions. During the flowering, high amount of nutrients were transferred to regenerative organs which resulted in more fruit size and weight (Cantliffe et al., 2001). Results demonstrated that maximum TSS was (7.23 ºBrix) produced in high tunnel (T_3) while minimum (4.88 ºBrix) was observed in cultivation on ridges (T_5) (Table 3). The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$.

There were significant ($P<0.05$) effect of cultivation systems on total sugar percentage of strawberry. Data showed that maximum total sugar was 92.89 % produced in high tunnel (T_3) while minimum 53.96 % observed in open field on ridges (T_5). (Table 3). The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$. Results demonstrated that maximum ascorbic acid was 61.38 mg 100^{-1} ml juice produced in (T_3) high tunnel and while minimum 60 (mg 100^{-1} ml juice) observed in soil less culture (T_2) (Table 3). The order of cultivation systems was T_3 followed by $T_1 > T_4 > T_2 > T_5$. Hancock (1999) has mentioned that like all other fruit quality parameters, soluble solids are dependent on environmental conditions. Soluble solids content was more dependent on environmental conditions than genetic inheritance. The cause of increase in total sugars may be due to protected environment which increase the soil temperature and enable favorable conditions for nutrients, metabolite mobilization and energy. In many research studies it was concluded that organic cultivation showed better improvements in ascorbic acid contents of fruits. It is being affected by the environmental factors, time of harvesting, plant vigor and age of plant. As maximum ascorbic acid was observed in high tunnel which might be due to the fact that high tunnel production alters the micro-environment and better utilization of nutrients which causes favorable effect on plant growth and development (Reiss et al., 2004).

LITERATURE CITED

Bowling, B. L. 2000. The berry grower's companion. Timber Press Inc., Portland, Oregon, USA.

Cantliffe, D. Shaw, J. N. Jovicich, E. Rodriguez, J. C. Secker, I. and Karchi, Z. 2001. Passive ventilated high-roof greenhouse production of vegetables in a humid mild winter climate. Acta. Hort. 559: 515-520

Hakkinen, S. H. and Torronen, A. R. 2000. Content of flavonols and selected phenolic acids in strawberries and Vaccinium species : influence of cultivar, cultivation site and technique. Food Res. Int. 33(6): 517-524.

Hancock, J. F. 1999. Strawberries, CABI publishing, Wallingford, UK.

Kramer, P. J. 1969. Plant and soil water Relationships :A modern Synthesis. McGraw Hill New York.

Maas, J. L. 1984. Compendium of strawberry disease. American phytopathological Society, St Paul, Minnesota, USA.

Olabode, O. S. Ogunyemi, S. and Adesina, G.O. 2007. Response of okra *(Abelmoschus esculentus*

L.). Moench) to weed control by mulching. J. Food Agric. Environ. 5: 324-326.

Ram, R. B. Dwivedi, A. K. and Yadav, A. K. 2005. Effect of various mulches on growth, flowering, fruiting, yield and quality of strawberry *(Fragaria ananassa duch.)* cv. "Chandler". Bioved. 16(1/2): 61-64.

Reiss, E. Both, A. J. Garrison, S. Kline, W. and Sudal, J. 2004. Season extension for tomato production using high tunnels. Acta Hort. 659:153-160.

Sandra, V. Jakobek, L. Druzic, J. Sindrak, Z. Dobricevic, N. Seruga, M. and Kovaca, A. 2009. Quality of strawberries produced applying two different growing systems. CyTA. J. Food, 7 (3): 201–207.

Sturm, K. Koron, D. and Stampar ,F. 2003. The composition of fruit of different strawberry varieties depending on maturity stage. Food Chem. 83: 417–422.

Voca, S. Duralija, B. Druzicolric, J. Skendrovic, M. Cmelik, Z. and Dobricevic, N. 2006. Influence of cultivation systems on physical and chemical composition of strawberry fruits cv. Elsanta.