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Yield Performance of Strawberry (*fragaria x ananassa*) Plug Plants in Eastern Mediterranean Climatic Conditions*

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Abstract: This research were carried out in the years 2002 and 2003 in Aydın province located in western part of Turkey. The local climate in this region is of the mediterranean type. Strawberry plants which were rooted in plugs in mist propagation unit and grown as annual in black mulched raised beds under high tunnels were investigated and compared with frigo plants for total yield. Chandler and Camarosa are current primary cultivars which have vigor, high productivity, extended harvest as well as good color and shelf life. Hence, all experiments were done with this varieties. Commercially produced, cold stored and bare root (frigo) Chandler and Camarosa plants were used for control. Plug plants rooted and grown more vigoriously in plugs in rooting unit. Plug plants showed high field performance. Yield and quality were equal to bare root cold stored plants. Results showed that plug plants can be used sucessively for strawbery production in eastern Mediterranean climatic conditions.

Key words: Strawberry, propagation, plug plants, production

Introduction

Strawberry (*fragaria x ananassa*) has been grown in many countries for a long time due to adaptation ability of varieties to different ecological conditions (Gregoriou *et al*., 1992; Himelrick *et al*., 1996). Production has increased dramatically during the past decade; much of this increase resulted from recent research work. Hence, strawberry production has been a significant part of the diverse agriculture (Poling, 1990; Gregoriou *et al*., 1992; Rosati, 1993).

In many countries strawberry plants are generally planted in summer and frigo plants (bare root, dormant, cold stored) are used on a big scala. Initially cold stored plants were used for early spring cropping. Meanwhile this technique has become a normal commercial practise (Lieten, 2002).

On the other hand, strawberry growers have had some problems with frigo plants such as plant disase, slowly and weak growing and death in short time after planting because of the damaged roots.

Frigo plants which are pathogen free and well developed are required by commercial growers. But, propagation of frigo plants need a long time, great areas and well known technological and practical managements. Traditional frigo plant production practices include using of highest pests, fertilizers and irrigation for greatest and quality production. Also, the extension of the storage period increases the risk of the storage problems and of poor establishment at planting (Hennion *et al*., 1997; Pritts, 2001).

Frigo plants are less expensive than plugs, offer a larger number of variety choices and allow for earlier planting but requires more hand labor. Also there can be a decrease in plants viability with prolonged storage of plants at the nursery that ultimately reduces plant stands and necessitates costly planting (Fiola, 2005).

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Recently, Strawberry plug plants have been started to use as an alternative to frigo plants for strawberry production. The production of plug plants from unrooted runner cuttings was developed in order to overcome the problems of fresh and cold stored bare roort plants (Himelrick *et al*., 1996; Hennion *et al*., 1997).

Plug plants are propagated from actively growing terminal runner tips of stolons containing variable number of tips (Fiola, 2005). Plug plants require considerably less irrigation during the initial planting and establishment phase since their root systems are minimally disrupted upon transplanting. Plants size, fruit quality and yield are generally higher. Plug plants can also reduced risk of soil originated disase. Hence, some growers were start to prefer plug plants compared to bare root plants due to these benefits (Lareau and Lamame, 1993; O'Dell, 2000; Pritts, 2000).

But there are some information about plug plants and growers' experiences with plug plants are highly variable and little information is available for field performance of plug plants especially for meditarrenean climatic conditions. Also, a little information is avaible for plug plant propogation. Hence, our research has focused on propagation of plug plants and strawberry production by using plug plants that reported have performance characteristics similiar to, or better than conventional production by using frigo plants

In this research, strawberry plants which were rooted in plugs in mist propagation unit and grown as annual in black mulched raised beds under high tunnels were investigated and compared with frigo plants for total yield per plant.

Materials and Methods

This research were carried out in the years 2002 and 2003 in Aydın province located in western part of Turkey. The local climate in this region is of the mediterranean type Strawberry is one of the most important crops in Aydin. Chandler and Camarosa varieties are mostly used in production. Chandler and Camarosa are current primary cultivars which have vigor, high productivity, extended harvest as well as good color and shelf life. Hence, all experiments were done with varieties Chandler and Camarosa. Runner plants (plantlets) were taken from non-rooted daughter plants with 2 to 4 compound leaves. Then they were randomly planted (stuck) in plug tray containing 50 round-conic cells, with individiual cells measuring 5 cm wide × 6 cm deep which was full of peat. Commercially produced frigo plants were used for control.

Plugs were misted periodically 10 sec for each half hour for two weeks (15 days) in mist propagation unit. Hundered unrooted runner plants were used for each application. Applications formed a randomized split plots design with four replicate. Twentyfive runner plants were used each replicate. Plug plants were allowed for rooting in peat based media for 15 days until the rooting medium is held together by the newly formed roots. Rooted plug plants were transferred to adaptation tunnel and they were waited 3 days at lower humidity (60%) for adaptation to natural environmental conditions having higher temperature and lower humidity. The later, Plug and control plants planted in the raised and mulched beds in end of the August. Plants were set at 30 cm spacing in rows and 30 cm between rows with two rows per bed by using cross planting. Production beds were designed randomized split plots with four replicates and used 25 plants for each replicates.

Weeds were controlled by labor. Planting site was plowed and actual 36 kg ha^{-1} N, P_2O_5 and K_2O was disked into soil. Beds were fertilized supplementally with actual 3 kg ha^{-1} N and 3 kg ha^{-1} K_2O per week through the irrigation system. Production beds were prepared in 15 cm depth, 60 cm length

and 1 m^3 manure per 1 m^2 were mixed into the beds before planting. Most commonly used plastic mulch color is black to cover production beds therefore black poliethylene mulch covers were used for mulching.

Beds were mulched before a week planting. Plants were irrigated by drip irrigation systems, having time clock, with emmiters 30 cm spacing placed under the mulch over the center of each bed. Plants were irrigated frequently 5 days after planting. The later watering time clock were adjusted according temperature and plant need. Tensiometers were used to monitor soil moisture levels. High tunnels were established on beds and covered with transparent polyethylene plastic cover in January. Plants were harvested twice per weekly beginning March and ending June. Total yield per each plants were calculated and all data were analysed by analysis of variance using SAS (1990).

Results and Discussion

Propagation

Plants which were planted in plugs for rooting 100% rooted in every plug and produced more number and thicker roots and grew vigoriously. All plugs had well-developed root systems within two weeks after runner tip planting. It is monitored that newly formed roots of plants were spread like a net into plug cell and plug plants completely rooted down bottom of cells in 15 days. Plugs were produce more leaves and had a crown. Leaves were dark green, bright and large. Visual observation indicated that plug initial vegetative growth was greater than frigo plants and that plugs wintered well. These results correlate with previous studies suggesting that plants grow in peat vigoriously and produces more root (Jansen *et al*., 1996; Jiang *et al*., 1997; Lieten, 2002).

Field Performance

During two years of research, compared to conventional frigo plants, plug plants grew vigouriously and faster than control plants in production beds. Frigo control plants showed weak and slowly growth at the begining of production but later they also grew vigouriously and produced more leaves. These results are in agreement with previous studies conducted for different aims. It is noted that plug plants has larger crown size and yield equal to frigo plants (Bish *et al*., 1997; Hamann *et al*., 1997; Hennion *et al*., 1997; Durner, 1999).

Yield performance comparisons of plug and frigo plants were made in in each the two years of investigations. In the first year of research, plants of two varieties were give slightly higher yield than second year. It can be result of ecelogical conditions. It is inferred that seasonal differences in temperature between two years may be a little affect on plants growth thus yield can be resulted lower. No differences in total yield per plant were observed for either cultivar and plant types in two years of research. Plug plants of two varieties usually were produce numerically lower yield than frigo plants. There was a little differences in total yield per plant between first and second years. But there wasn't statistical differences between them (Table 1). Also, similiar results were taken from both varieties. No differences were found statistically in average yield per plant for two varieties. Chandler and Camarosa plants were yielded equal. For plant types, data showed that control (frigo) plants were yielded numerically great than plugs. But no statistiscal differences were found among the plant types for yield. Results indicated that there wasn't statistical differences for total yield per plants between years, varieties and plant types. Harvesting periods are significant at $p>0.05$ on yield while year, variety and plant type are non significant.

Table 1: Yield comparisons for years, varieties and plant types

Yield (g)					
Year[ns]		Variety[ns]		Plant[ns]	
1	903.24	Chandler	896.78	Plug	882.51
2	893.16	Camarosa	899.92	Control	914.55

[ns]: Non significant at p>0.05

Table 2: Average total yield per plant for harvesting periods

Yield (g) Harvesting period[xx]			
March	April	May	June
102.33d	1630.68a	1458.68b	401.66c

[xx]: Significant at p:0.05, a, b, c, d: means in the line followed by different letters differ significantly at p<0.05

Analysed yield performance comparisons of plug and frigo plants for harvesting periods were showed in Table 2. In March that environmental conditions not yet good for growing, plants gave a few fruit in each harvesting time and the ripening of these fruits took a long time. Yields for both cultivar were the significantly lowest in this harvesting period compared others. Fruits were relatively smaller and a few. On the other hand, through mid to end of the march, plants increased their branch and crown number. Flower increasing were also monitored in this period. It is observed that raising the temperature forced plants to vegetative growth and flowering.

Highest average total yield were taken in April harvesting period. Plants, plugs and controls, of two varieties greater yielded more in April than those of other harvesting periods. Fruits were high quality and marketable. Plants were also produce more yield in May. But yield were numerically lower than April. Therfore, April and May are in the different statistical group. Greater yield per plant were obtained from April and May harvest periods in two years compared other periods. These results suggest that raising the temperature to optimal in April and optimal temperature stability in May increase flowering and fruting. Hence yields were highest in this two periods. It is inferred that April and May have the optimal environmental conditions for flowering and fruiting. There are statistically differences between harvesting periods and all of them are in the different statistical groups. Plants yielded lowest and gave a few fruits which were small size in June but it is greater than March. We cocluded that plants flowered and yielded low in March because of the lowest air temperature while in June highest air and soil temperature. Effects of harvesting periods were most appearent on yield.

Other studies comparing strawberry yield have reported similiar results. Plants flowered and yielded low in March because of the lowest air temperature while in June highest air and soil temperature.

Conclusions

In this research, runner plants were easily rooted in plugs in a short time without rooting chemicals. Rooting of the runner plants in peat filled plugs can be a alternative for classical production of cold stored and bare root plants that need a long time for propagation. Plug plants were propagted easily and successfully in a short time. Plug plants were established easily after field setting, Plug plants, tested and compared with other plants especially bare root cold stored plants for field performance, were showed high yield performance. Plug plants which have well developed rooting system gave highest yield together with cold stored plants

Strawberry plug plants can be used for pruduction due to multiple benefits. Plug trays are most avaible for propagation of runner plants without soil pathogens. Plug plants can be produced succesfully with lower managements and risk of disease can be reduced by using pathogen free or non-contamined plants. Yield and quality of plugs is higher equal to bare root cold stored (frigo) plants. The production by using plug plants should answer the objectives disase free plants, easier establishment, higher yield and quality fruits.

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