Determination of strawberry Plug Transplants Planting date in Relation to Yield and Fruit Quality

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ABSTRACT

This study was carried out during 2018/2019 and 2019/2020 seasons in a private farm at Wardan, El-Giza Governorate, Egypt in pure sandy soil with pH of 6.77 and EC 0.3 mM, to investigate the suitable planting date for plug transplants and their effects on growth, yield and fruit quality especially with the reviling climate change in Egypt. Strawberry cultivar Festival was transplanted at three planting dates i.e., 15th September,30th September and 15th October. A randomized complete block design with three replicates was used. Plug transplants were produced from runner tips rooted in cups with sizes of 150 cm^3 filled with substrate. The results indicated that, planting on September 15th gave the highest plant height, leaf number, crown diameter, root length and number, fresh and dry weight as well as, early and total yield. In addition,the heaviest fruit weight was found with planting plug transplants on 30th September without significant differences and those of September 15th in the second season. Firmness and total sugars of fruit increased by late planting to October 15th. On the other side, the total soluble solids were not affected by planting date. In conclusion, plantingon September 15th was the best planting date for plug strawberry transplants due to its suitable growth, high early and total yield. However, for high sugars in fruits and high fruit firmness, the second date (October15th) was the best date.

Key words: Strawberry, Plug transplants, Planting date, Early yield, Fruit quality.

INTRODUCTION

Strawberry is one of the most important vegetable crops for local consumption and export. Strawberry is a vegetative propagated crop through runners. Environmental conditions and runner quality play a vital role in determining earliness, fruit quality and total yield of strawberry. Planting date of strawberry plays a critical role in successful strawberry production (Anna et al., 2003). In this regard, temperature, daylight and photoperiod have direct effect on transplanting time, which ultimately affect flowering, fruits size and yield (Zheng et al., 2009).The highest value of growth parameters noticed in plants from early planting may be due to high temperature that prevails during growth period speeding up vegetative growth of plants. Moreover, fruits of early planted dates (1st September and 1stOctober) contained more TSS than late planted plants (1st November and 1st December) (Rahman et al. 2014).Adak and Gubbuk (2015) stated that, the effect of planting dates on TSS was not determined to be statistically significant. On the other hand, Chaitanya et al. (2017) reported that an increase in plant height was recorded with early planting. Kanchan et al.(2017) mentioned that the predominant climatic conditions at the time of planting and next period of plant growth might affect the vegetative growth of strawberry plants. Also, Abd El-Rahman, (2021) stated that, Strawberry cultivation begins in Egypt late

August, September, and October according to temperature where high levels of heat raise the temperature of the air or soil. Usually, in bare root planting system with fresh transplants, intensive irrigations required for 1-3 weeks after transplanting to increase plant survival percent. The second planting date (15th of October) gave the highest values of total soluble solids comparing to the first planting date (15th of September).In addition, during transplants production, the Super Elite plants should be planted in the nursery to produce bare root fresh transplants, which have low quality due to infection by pathogens like Colletotrichum, Phytophthora, Verticillium and Rizoctonia. High quality bare root transplants production need soil disinfection with methyl bromide or its alternatives. To confirm the production of pathogen and nematode free transplants, the soil of the nurseries should be fumigated prior to planting with methyl bromide (MB). An alternative method for the production of clean strawberry transplants is that known as plug plant utilization (Fumiomi et al., 2004). Daniel et al. (2010) and Ahmed (2015) concluded that strawberry plug planting system is an excellent method for establishing plants and provide appropriate levels of vegetative vigor for a good yield. Plug transplants have a survival rate of almost 100%, reduced risks of soil borne diseases, and reduced pesticide cost. The information on plug propagation system under Egyptian condition are limited and its effect on earliness, productivity and fruit quality are lacking. Moreover, the use of containerized transplants ("tray plants", "plug plants", or "plugs") produced in disease-free; soilless media has been suggested as an alternative to methyl bromide nursery soil fumigation (Kirk et al., 2002).

Because of the high temperature around mid September when caused by climatic changes in the last few years using bare root transplants resulted in delaying planting which resulted in decreased earliness. Some growers started to use plug transplants instead of bare root ones, which enable them to establish their fields early and increase early yield with high prices for export. However, the ideal planting date with plug transplants is still not recognized.

Therefore, this study was conducted to determine the suitable planting date for Festival strawberry plug transplants (tray transplants) and determining their effects on growth earliness, yield and fruits quality.

MATERIALS AND METHODS

This study was carried out during the two successive seasons of 2018/2019 and 2019/2020 in a sandy soil a private farm at Wardan, El-Giza Governorate, Egypt, in pure sandy soil with pH of 6.77 and Ec 0.3 mM. The purpose of this work was to study the suitable planting date for plug transplants and its effect on growth, yield and fruit quality of Festival strawberry cultivar. The study included three planting dates (15th September as a control, 30th September and 15th October) using containerized transplants ("tray plants", "plug plants", or "plugs") produced in soilless technique. The soil physical and chemical properties of the experimental site are shown in Table (A), the maximum and minimum temperature and day length during cultivation period were shown in Table (B). Strawberry transplants were produced from runner tips rooted in cups with sizes of 150 ml filled with substrate as recommended by, Ahmed, (2015).The medium containing peat moss were enriched with vermiculite, perlite (1:1:1 v: v: v), compounds fertilizer (19-19-19) and adjust pH by calcium carbonate, as well as fungicides (Rhizolex 2g/l). Pots were placed in ascreen-house with a double door. Three weeks after culturing on rooting media, thetrays were transferred to the

experimental field to examine the effects of plant date on growth, yield and quality. A randomized complete block design with three replicates was used, each replicate contained two beds with 6 m in length, 120 cm width at plant distances of 25 cm between plants and 30 cm between rows. Four rows bed system was used. The plot area was 14.4 m^2. The drip irrigation system was used. Beds were mulched with 40 micron of double face black &silver mulch. The agricultural practices concerning cultivation, fertilization, irrigation and pest- and disease control were carried out commonly as the recommendation of ministry of agriculture for the commercial production of strawberry.

Table (A): The soil physical and chemical properties of the experimental site.

Physical properties				**Type of soil**
Sand	Silt	Clay		
86-100 %	0-14 %	0-10 %		
Chemical properties				Sandy soil
Organic matter (%)	Ca Co_3	pH	EC (Ds/m)	
0.12	3.69	6.77	0.3	

Table (B): Maximum and Minimum Temperature as well as day length data of Egypt-Giza-Wardan-Monthly Means of2018, 2019 and 2020 seasons.

Seasons	**First Season**			**Second Season**		
	2018-2019			**2019-2020**		
Months	**Minimum Temperature (°C)**	**Maximum Temperature (°C)**	**Day Length (Hours)**	**Minimum Temperature (°C)**	**Maximum Temperature (°C)**	**Day Length (Hours)**
September	21.44	36.41	12.31	20.84	35.89	12.32
October	18.64	31.96	11.40	19.12	32.68	11.41
November	14.60	26.41	10.62	15.27	28.60	10.62
December	10.53	20.54	10.22	10.53	21.51	10.22
January	6.27	18.62	10.44	8.15	18.30	10.43
February	7.35	20.78	11.12	8.44	20.66	11.11
March	9.33	23.64	12.01	9.79	24.39	12.00
April	12.27	28.09	12.94	12.46	27.11	12.93
May	17.36	36.57	13.70	15.54	32.71	13.69
Average	13.09	27.00	11.64	13.35	26.87	11.64

The following data were recorded:

1. Vegetative growth characteristics:

Representative samples of plug transplants were taken to record the vegetative growth characteristics were determined after 45 days from planting and the following data were recorded:

1.1. Number of leaves/plant.

1.2. Plant height (cm): It was measured from the base of the plant crown to the top of the longest leaf.

1.3. Crown diameter: It was measured by using the vernier caliper.

1.4. Number of roots.

1.5. Root length.

1.6. Fresh and dry weight/plant:

Five plants were weighed and fresh weight per plant was calculated then, the plants was dried in an oven at 70°C for 72 hrs. until constant weight. The dried plants were weighed and dry weight per plant was calculated.

2. Yield and its Components:

2.1. Total yield per feddan:

It was determined as the weight of all harvested fruits all over the season for each plot, and then total yield per feddan was calculated.

2.2. Average fruit weight:

All harvested fruits from each replicate were weighed and average fruit weight was then calculated.

3. Physical characteristics of fruits:

Samples of twenty fruits from each experimental plot were randomly chosen at mid-March to record fruit weight and fruit firmness.

3.1. Fruit firmness (g/cm^2):

It was determined by using a Shatillon Penetrometer **(Qurecky and Bourne, 1968).**

4. Chemical characteristics of fruits:

They were measured at mid-March as follows:

4.1. Total soluble solids (TSS):

Random samples of ten ripe fruits from each experimental plot at full ripe stage were randomly chosen to measure the percentage of total soluble solids using a hand refractometer.

4.2. Determination of juice pH:

Fruit juice of ten ripe fruits from each experimental plot was used to determine the pH of juice using an Orian pH meter, model 420A.

4.3. Totaltitratable acidity (TTA):

Samples of 100g fruits from each experimental plot at full ripe stage were randomly chosen to determine the total titratable acidity of juice by titration with 0.1N of NaOH solution, using phenolphthalein indicator, according to the method described in **A.O.A.C. (1990).**

4.4. Total soluble solids to total titratable acidity ratio:

Calculation based on the values of TSS and total titratable acidity percent.

4.5. Ascorbic acid content:

It was determined in mg/100 g fresh weight using two, 6 dichloro-phenol indophenol for titration as the method mentioned in **A.O.A.C. (1990).**

4.6. Total sugars (%):

It was determined in samples of ripe fruits from each experimental plot colormetrically as the method reported in **A.O.A.C. (1990)**.

Statistical analysis

The obtained data were subjected to statistical analysis by the method of Duncan's multiple range test as reported by **Gomez and Gomez (1984).**All statistical analysis was performed with SAS computer software.

RESULTS AND DISCUSSION

1. Vegetative growth characters:

1.1. Plant height:

Data presented in Table (1) revealed that planting plug transplant on 15th September significantly increased plant height in the two tested years. However, no significant differences were detected between other planting dates (30th September and 15th October). Similar results were found by Chaitanya et al. (2017) who reported that an increase in plant height was recorded with early planting, the plant height increased for both studied cultivars compared to the other dates. The highest values of growth parameters observed in plants from early planting may be due to high temperature that prevails during growth period speeding up vegetative growth of plants (Rahman et al., 2014).The results may be to the high temperature, long day and intensity of photosynthesis, which showed in Table (B) that enabled the plants to increase the vegetative growth in all its characters.

1.2. Number of leaves per plant:

Planting on September 15th gave the highest leaf number in the both seasons (Table 1). On the other hand, no significant differences were found among the planting

dates in the second season. Rahman (2014) stated that high numbers of leaves were produced by early planting for all tested strawberry cultivars (Festival, Camarosa, Sweet Charlie, FA008, BARI cvs.). The plant growth parameters i.e., plant height, and numbers of leaves per plant were affected by different dates of planting and varieties of strawberry (Kanchan et al., 2017). Weather parameters such as temperature and day length predominant at the time of planting and early growth stage might have played significant role in plant growth as the average maximum (36.41°C) and minimum (21.44°C) temperature (Table B).

1.3. Crown diameter:

Data presented in Table (1) indicated that generally crown diameter was affected with time of planting in the two tested seasons. Results show also that planting on September15th or September 30th gave the highest crown diameter in the two tested seasons. The lowest crown diameter was shown when planting on October 15th. The results may be attributed to higher temperature at September15th or September 30th which showed in Table (B). Our results confirm those of Fumiomi et al., (2004). Daniel et al. (2010), Rahman, (2014), Adak and Gubbuk (2015) and Abd El-Rahman, (2021).Temperature plays an major role in both variety and planting time. It affects both time and varietal responses. The faster pace of plant growth was noted at a higher temperature. In addition, the prevalent climatic conditions at the time of planting and next period of plant growth might affect the vegetative growth of strawberry plants (Kanchan et al., 2017).

Table (1). Influence of planting date on plant height (cm), number of leaves/plant and crown diameter (cm) of the strawberry plug plants during the two tested seasons.

Treatments	Plant height (cm)		No. of leaves/plant		Crown diameter (cm)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
15th September	18.30 a	17.37 a	10.36 a	10.30 a	1.30 a	1.32 a
30th September	15.40 b	14.52 b	9.86 c	10.33 a	1.28 a	1.29 a
15th October	15.30 b	14.73 b	10.13 b	10.13 a	1.22 b	1.24 b

Values in the same column followed by the same letter(s) do not significantly differ from each other according to Duncan's multiple range test at 5% level.

1.4. Number of roots per plant:

Number of roots per plants was differed among of the studied time of planting as presented in Table (2). Planting on September 15th and 30th recorded significantly the highest values. Otherwise, the lowest values were detected to the plants which planted on October 15th.This may be due to the high temperature during September which enabled the plants to grow and the roots to elongate more (Table B). This results are in harmony with found by Caracciolo et al. (2009), who mentioned that plug plants established in late September as plants were able to achieve adequate growth before the cold winter season.

1.5. Root length:

Data on root length presented in Table (2) showed that planting on September 15th showed significantly higher values than September 30th and October 15th.On the other hand, significant decrement in root length recorded for October 15th in the two studied seasons. These results are in harmony with those reported by Kanchan et al. (2017), who detected that the predominant climatic conditions at the time of planting and next period of plant growth might affect the growth of strawberry plants**.**

Table (2). Influence of planting date on number of roots/plant and root length (cm) of the strawberry plug plants during the two tested seasons.

Treatments	Number of rootsper plant		Root length (cm)	
	2018/2019	2019/2020	2018/2019	2019/2020
15th September	34.33 a	34.71 a	19.86 a	20.07 a
30th September	36.00 a	36.47 a	18.07 b	18.63 b
15th October	32.47 b	32.67 b	15.33 c	15.30 c

Values in the same column followed by the same letter(s) do not significantly differ from each other according to Duncan's multiple range test at 5% level

1.6. Plant fresh and dry weight:

Data in Table (3) showed that planting on September 15th recorded significantly the highest fresh and dry weight, while in October 15th plants showed the lowest values among all tested planting date. However, insignificant differences were detected between September 30th and October 15th planting dates in fresh and dry weights in the second season. These results are in agreement with those obtained by Kanchan et al. (2017) and Emmanu el et al.(2018) who stated that September plantings had a greater shoot dry biomass than early October in strawberry. This may be due to the suitable weather condition enhanced growth and improved all character of vegetative growth character thus increasing in plant fresh and dry weights (Table B).

Table (3). Influence of planting date on fresh weight (g) and dry weight (g) of the strawberry plug plants during the two tested seasons.

Treatments	Fresh weight/plant (g)		Dry weight/plant (g)	
	2018/2019	2019/2020	2018/2019	2019/2020
15th September	116.43 a	116.67 a	12.11 a	13.06 a
30th September	110.40 b	111.24 b	10.69 b	11.88 b
15th October	100.74 c	98.73c	10.60 b	10.75 b

Values in the same column followed by the same letter(s) do not significantly differ from each other according to Duncan's multiple range test at 5% level

2. Yield and its components:

2.1. Early yield per fedaan:

Data in Table (4), clearly, indicated that early yield of September 15th was significantly the highest than the other tested planting dates in the first season. While, no significant differences were detected between September 15th and September 30th in the second season. Moreover, planting on October 15th produced significantly lower early yield. The fruit yield was positively correlated with the vegetative growth characters such as number of leaves, plant height, crown diameter and plant fresh and dry weight that showed in Tables (1 and 2). Our results are in a general agreement with those of Adak and Gubbuk (2015) and Abd El-Rahman, (2021).

2.2. Total yield per feddan:

Planting on September 15th and September 30th produced significantly the highest total yield than October 15th , as presented in Table (4). Differences in yield plants due to planting time maybe due the differences in growing environment and during vegetative growing phase, as stated by Rahman, (2014). The obtained results agree also with those of Emmanuel et al. (2018) who suggested the earliest planting date tested increased early strawberry production in west-central Florida. Early planting (mid-September) increased the total yield of

'Florida127'by 25%, compared with early October traditional planting, with no difference in total yield.

2.3. Average fruit weight:

Planting on September 30th produced significantly the highest average fruit weight in the first season. In addition, September 30th and September15th had a greater fruit weight without significant differences between them in the second season as presented in Table (4). The results, also, showed that planting on October 15th had significantly the lowest values as compared with the other two tested dates. These results are in agreement with those obtained by Kirk et al. (2002), who mentioned that rooting date affected fruit size, with plugs rooted on August 2nd having larger fruits than plugs rooted on August 16th. However, plants planted on mid-October have sufficient time for proper growth up to mid-December, which might also have advanced the flowering and fruiting (Kanchan et al. 2017).

Table (4). Influence of planting date on average fruit weight (g), early yield (g), and total yield (g) of the strawberry plug plants during the two tested seasons.

Treatments	Early yield/fed.(ton)		Total yield/fed.(ton)		Average fruit weight(g)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
15thSeptember	7.381a	7.424a	22.482a	22.943a	25.21 b	26.79 a
30th September	7.223b	7.398a	22.248a	22.889 a	28.49 a	29.27 a
15th October	6.315b	6.133b	20.063b	19.913b	20.48 c	23.15 b

Values in the same column followed by the same letter(s) do not significantly differ from each other according to Duncan's multiple range test at 5% level

3. Fruit physical characteristics:

3.1. Fruit firmness:-

The data presented in Table (5), clearly, showed that planting on October 15th had significantly the highest values of fruit firmness as compared with the other tested planting dates in the two seasons. On the other hand, no significant differences between planting on September 15th and September 30th in fruit firmness. These differential responses of strawberry to fruit firmness maybe attributed to variable growth attained by the plant and differences in plant vigour, number and size of fruits due to different climatic condition under different planting dates. Temperature plays a vital role in both variety and planting time. It affects both time and varietal responses (Kanchan et al. 2017). These results are in harmony with those obtained by Adak and Gubbuk (2015) and Abd El-Rahman, (2021).

4. Chemical characteristics:

4.1. Total soluble solids (TSS):

Results in Table (5) showed that planting on September 30th and October15th gave the highest values of total soluble solids comparing to the first planting date 15th of September in the two tested seasons. These results, generally, coincide with those of Adak and Gubbuk (2015) who stated that the effect of planting dates on TSS was not determined to be statistically significant. On the other hand, the results are agree with Rahman, (2014) who indicated that, fruits of early planted dates (1st September and 1st October) contained more TSS than the late planted plants (1st November and 1st December). Also, Abd El-Rahman, (2021)found that the second planting date (15th of October) gave the highest values of total soluble solids comparing to the first planting date (15th of September).

4.2. Total sugars:

The influences of planting dates of cultivar strawberry Festival on total sugars were appeared in Table (5). The late planting date (15th October) gave the highest values of total sugars followed by planting plants on 15th September. However, the lowest data was recorded by the earliest planting date 15th September. This result may be attributed to the rapid growth, large size, excessive activity in absorbing water of the fruit, and its slow coloration. High temperature has negative effect on fruits quality in strawberry (Rahman, 2014).

Table (5). Influence of planting date on firmness, total soluble solids, and total sugars of the strawberry plug plants during the two tested seasons.

Treatments	Firmness (g/cm^2)		TSS (%)		Total sugars (%)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
15th September	408.33 b	450.00 ab	9.22 a	9.50 b	6.82 c	6.80 c
30th September	397.67 b	420.83 b	9.11 a	9.77 ab	6.87 b	6.86 b
15th October	466.67 a	491.67 a	9.66 a	10.00 a	6.90 a	6.91 a

Values in the same column followed by the same letter(s) do not significantly differ from each other according to Duncan's multiple range test at 5% level

4.3. pHvalue:

Data in Table (6) showed that planting on 15th September had the highest significant values of fruit pH as compared with the other tested planting time. Whereas, no significant difference in pH values were obtained between September 30th and October 15th in the two tested seasons.

4.4. Totaltitratable acidity and Ascorbic acid contents:

Regarding total titratable acidity and ascorbic acid content, it is evident from Table (6) that there were no significant differences among all tested planting dates. These results are in a general agreement with those obtained by Adak and Gubbuk (2015) and Abd El-Rahman, (2021) The previous results may be attributed to the genetic constituents for the cultivar (Ahmed, 2015) and Abd El-Rahman, (2021) who registered that, there were no significant differences between the 15th of September and the 15th of October in fruit acidity.

Table (6). Influence of planting date on pH, titratable acidity, and ascorbic acid (mg/100 g f. w.) of the strawberry plug plants during the two tested seasons.

Treatments	pH		Titratableacidity (%)		Ascorbic acid (mg/100 g f. w.)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
15th September	3.90 a	3.88 a	0.017 a	0.025a	55.27 a	54.27 a
30th September	3.48 b	3.54 b	0.118 a	0.027 a	57.54 a	56.54 a
15th October	3.45 b	3.46 b	0.061 a	0.026a	59.35 a	58.02 a

Values in the same column followed by the same letter(s) do not significantly differ from each other according to Duncan's multiple range test at 5% level

CONCLUSION

This study concludes that, 15th September is the ideal date for planting strawberry cultivar Festival with plug transplants in Giza governorate to which enhanced growth, high early and total yield. However, for high sugars content in fruits and high fruit firmness, the second date (October15th) was the best date.

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تحديد ميعاد الزراعة المناسب لشتلات الفراولة المجذرة وعلاقتها بالمحصول وجودة الثمار

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**** قسم بحوث البطاطس والخضر خضرية التكاثر– معهد بحوث البساتين – مركز البحوث الزراعية– مصر**

أجريت هذه الدراسة خلال موسمي 2019/2018 و2020/2019 في مزرعة خاصة فى قرية وردان – محافظة الجيزة لتحديد موعد الزراعة الأنسب لشتلات الفراولة المجذرة ومعرفة تأثيرها على النمو والإنتاجية والجودة خاصة مع التغيرات المناخية السائدة. تم زراعة شتلات الفراولة صنف فستفال في ثلاث مواعيد هي (15 سبتمبر و30 سبتمبر و15 أكتوبر) خلال موسمين زراعيين. تم استخدام تصميم القطاعات كاملة العشوائية في ثلاث مكررات. تم تجذير الشتلات الناتجة في أكواب بلاستيك حجم 150 ملى في بيئة من البيت موس و الفرميوكليت و البرليت 1:1:1 ثم نقلها إلى الحقل بعد شهر وزراعتها في المواعيد الثلاثة.

أشارت النتائج إلى أن زراعة شتلات الفراولة المجذرة في 15 سبتمبر أعطت أعلى عدد للأوراق، قطر التاج، طول وعدد الجذور وأعلى كمية من المحصول المبكر والكلى. وأعطى الميعاد المتأخر للزراعة زيادة معنويه في صفات السكريات ، الصلابة للثمار والمواد الصلبة الذائبة.

وتوصى الدراسة بناء على النتائج السابقة بزراعة الفراولة بالشتلات المجذرة (بصلايا) في منتصف سبتمبر لتحسين النمو والمحصول المبكر والكلى وبعض مواصفات الثمار حتى مع أرتفاع درجات الحرارة،يمكن اختيار ميعاد الزراعة المتأخر (منتصف اكتوبر) عند الرغبة فى ثمار عالية الصلابة وذات محتوى سكريات عالي تصلح للتجميد والتصنيع للمربات والعصائر. كما يمكن الزراعة بالشتلات المجهزة بصلايا في اول أكتوبر لزيادة صلابة وحلاوة الثمار

الكلمات الدالة: الفراولة – الشتلات المجذرة –مواعيد الزراعة – المحصول المبكر والكلى– جودة الثمار.