Influence of date of planting on Total sugars and Titratable acidity of Strawberry varieties in vertical Farming

Abstract:

The research on "Influence of date of planting on total sugars and titratable acidity of strawberry varieties in vertical farming" using vertical towers was carried out at Centre of Excellence (COE) for vegetables and flowers, Jeedimetla, Medchal Malkajgiri district of Telangana during Rabi 2022-23 and 2023-24 in Factorial Completely Randomized Design (FCRD) evaluating four varieties V1- Nabila (Short day), V2- Flaminia (Short day), V3- Murano (Everbearing), V4-Vivara (Everbearing) and four planting dates D1- planting on October 15th D2-Planting on October 30th, D3- planting on November 15th, D4- planting on November 30th. The vertical tower was divided into three tiers, namely the top tier, middle tier and lower tier and the observations were taken accordingly. The results revealed that, the top tier of the vertical tower has exhibited higher percentage of total sugars and lower percentage of titratable acidity than subsequent tiers of the vertical tower among all the varieties, dates of planting and interactions. Among varieties, Shortday varieties V1 (Nabila) and V2 (Flaminia) has revealed highest percentage of total sugars and lowest percentage of titratable acidity than everbearing varieties V3 (Murano) and V4 (Vivara) in all the tiers of the vertical tower. Among planting dates, D2 (Planting on October 30th) has registered with highest percentage of Total sugars and lowest percentage of titratable acidity in all the tiers of the vertical tower. The interaction of V1 (Nabila) and V2 (Flaminia) with D2 (planting on October 30th) indicated highest percentage of total sugars and the lowest percentage of titratable acidity in all the tiers of the vertical tower.

Key words: Vertical farming, Strawberry, Dates of planting, Tier

Introduction:

The Strawberry (*Fragaria x ananassa* Duch.) is a member of the Rosaceae family. The edible portion of strawberry fruit is 90% and is a rich source of minerals like calcium, phosphorus, potassium, iron, sodium and vitamins A, B, C, E and antioxidants. In the world, strawberry crop has extended to all arable regions of the globe from the Arctic to the tropics with the USA (34.0%) as the leading producer followed by Turkey (8.20%), Spain (5.60%), Egypt (5.40%) and Mexico (5.30%) (FAOSTAT, 2020).

Strawberry is mainly a crop of temperate climate, however the introduction of suitable varieties lead to the cultivation of strawberry in various geographical areas. Strawberry behaves as perennial in temperate climate and as an annual in subtropical and tropical climate. Planting time within the season also influences the growth, floral production, fruit size, quality, and yield of strawberry. The qualitative evaluation of strawberry is as important as quantitative analysis as Strawberry has become an important table fruit throughout the world. It is not only consumed as fresh fruit but also has great demand in fruit processing. The quality parameters of the strawberry are significantly affected by the choice of season and date of planting which varies across different locations.

In view of the above, an experiment was done to evaluate the date of planting on total sugars and titratable acidity on strawberry.

Materials and Methods:

The present study was carried out at Centre of Excellence (COE) for vegetables and flowers, Jeedimetla, Medchal Malkajgiri district of Telangana during Rabi 2022-23 and 2023-24 in Factorial Completely Randomized Design (FCRD) evaluating four varieties V1- Nabila (Short day), V2- Flaminia (Short day), V3- Murano (Everbearing), V4-Vivara (Everbearing) under naturally ventilated polyhouse at four planting dates *viz*. D1- planting on October 15th D2-Planting on October 30th, D3- planting on November 15th, D4- planting on November 30th in the vertical towers. Each strawberry seedling was transplanted into individual pouches of the vertical tower. The vertical tower was divided into three tiers, namely the top tier, middle tier and lower tier in which each tier had eight pouches accommodating one plant in each pouch such that each tier has a total of eight plants and each vertical tower has twenty four plants.

Procedure for evaluation of total sugars (%):

Total sugars were determined by Lane and Eynon's (AOAC, 1965) method. The clarified lead free solution (50 ml) was taken into a 250 ml volumetric flask and to it 10 ml of HCl was added, mixed well and allowed to stand at room temperature for 24 hours. The solution after 24 hours was neutralized with NaOH using a drop of phenolphthalein as an indicator and volume was made up. The solution was taken into a burette and titration was carried out against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator and taking brick red colour as an endpoint. The titer value is noted, and total sugars were calculated by following the formula.

$$\text{Total sugars (\%)} = \frac{\text{Factor} \times \text{Volume made up}}{\text{Titer value} \times \text{Weight of sample}} \times 100$$

Procedure for evaluation of titratable acidity (%):

Ten grams of fruit pulp was taken and ground well and then transferred to a volumetric flask. The volume was made up to 100 ml in a volumetric flask. The contents were filtered through Whatman No.1 filter paper and an aliquot of 10 ml was taken into the conical flask to which 2-3 drops of phenolphthalein indicator was added and titrated against 10 N NaOH till a pink colour, as endpoint and titer value is noted. The titratable acidity was estimated in terms of per cent citric acid (Ranganna, 1986) and calculated by using the following formula.

$$\text{Titratable acidity (\%)} = \frac{\text{Titer value} \times \text{Normality of NaOH} \times 0.0064}{\text{The volume of aliquot taken}} \times 100$$

Statistical analysis:

The experimental data was arranged (Two factor completely randomized design) and analyzed by using analysis of variance (ANOVA). The overall significance difference (α- 0.05) among treatments was tested using critical difference (C.D. at 5%).

Results and discussion:

Total sugars (%):

The pooled data regarding total sugars of strawberry varieties at planted at various dates in top, middle and lower tier of the vertical tower was presented in Table 1. All three tiers of the vertical tower have exhibited a significant difference among varieties, planting dates, and interactions between varieties and dates of planting in total sugars.

In the top tier, the variety V2 (Flaminia) has revealed the highest percentage of total sugars (5.51) followed by V1 (Nabila) (5.41), while, the variety V4 (Vivara) revealed the lowest percentage of total sugars (4.79). Among various dates of planting, D2 (Planting on October 30th)

have recorded the highest percentage of total sugars (5.54) followed by D3 (Planting on November 15th) (5.30) and the lowest percentage of total sugars (4.87) was observed in D4 (Planting on November 30th) on par with D1 (Planting on October 15th) (4.95). In the interaction between varieties and dates of planting, the combination of V2D2 recorded the highest percentage of total sugars (6.02) and the combination of V3D1 resulted in the lowest percentage of total sugars (4.54) which was on par with V4D1 (4.69), V3D4 (4.58) and V4D4 (4.57).

In the middle tier, the variety V2 (Flaminia) has recorded the highest percentage of total sugars (5.35) followed by V1 (Nabila) (5.16), while the variety V4 (Vivara) revealed the lowest percentage of total sugars (4.61). Among various dates of planting, D2 (Planting on October 30th) have resulted in the highest percentage of total sugars (5.49) followed by D3 (Planting on November 15th) (5.14), while the lowest percentage of total sugars (4.53) was noticed in D4 (Planting on November 30th). In the interaction between varieties and dates of planting, the combination of V1D2 revealed the highest percentage of total sugars (5.77) which was on par with V2D2 (5.73) and the combination of V3D4 resulted in the lowest percentage of total sugars (4.24) which was on par with V4D4 (4.31), V1D4 (4.43), V3D1 (4.35) and V4D1 (4.28).

In the lower tier, the variety V2 (Flaminia) has exhibited the highest percentage of total sugars (5.10) followed by V1 (Nabila) (4.90), while, the variety V4 (Vivara) revealed the lowest percentage of total sugars (4.29). Among various dates of planting, D2 (Planting on October 30th) have recorded the highest percentage of total sugars (5.29) followed by D3 (Planting on November 15th) (4.94) and while, the lowest percentage of total sugars (4.40) was observed in D1 (Planting on October 15th) which was on par with D4 (Planting on November 30th) (4.41). In the interaction between varieties and dates of planting, the combination of V2D2 recorded the highest percentage of total sugars (5.62) and the combination of V4D1 resulted in the lowest percentage of total sugars (3.82).

In this experiment, it was observed that short day varieties V1 (Nabila) and V2 (Flaminia) registered with a higher percentage of sugars in all the tiers of the vertical tower than everbearing varieties V3 (Murano) and V4 (Vivara). Everbearing strawberry cultivars often show lower sugar content compared to short-day cultivars due to the differences in their physiological responses to environmental factors such as photoperiod and temperature. Everbearing strawberries have a facultative long-day flowering response, which means they accelerate flowering and fruiting under longer photoperiods and high temperatures which lead to higher respiration and lowers the allocation of food material, whereas short day cultivars require shorter photoperiods and lower temperatures to initiate flowering, this difference in flowering response affects the plant's carbohydrate metabolism and allocation (Rivero *et al.*, 2022).

It was noted that climatic conditions, especially warmer climate and longer day length impacts negatively on sugar metabolism within fruit tissues (Chandler *et al.*, 2003). In this

experiment as mentioned above, among planting dates D2 (Planting on October 30th) and D3 (Planting on November 15th) revealed higher percentage of total sugars than other planting dates. This might be attributed to the better accumulation of sugars in berries due to the favorable climatic conditions preferably lower temperatures prevailing at that time of fruit development. Rahman (2014), Jahangeera *et al.* (2010) Sadiq and Kaur (2017), Anwar *et al*. (2016) also reported the same in strawberry fruits planted at different times.

Titratable Acidity (%):

The pooled data regarding titratable acidity of strawberry varieties planted at various dates in top, middle and lower tier of the vertical tower was presented in Table 2.

The top tier of the vertical tower exhibited a significant difference among varieties and various dates of planting. Among varieties lowest titratable acidity (0.37) was revealed by V2 (Flaminia) followed by V1 (Nabila) (0.42). While variety V4 (Vivara) has recorded the highest percentage of titratable acidity (0.57). Among, dates of planting, D2 (Planting on October 30th) has revealed the lowest percentage of titratable acidity (0.31) followed by D3 (Planting on November 15th) (0.45), while D4 (Planting on November 30th) recorded the highest percentage of titratable acidity (0.56). There was no significant difference observed among the interactions between varieties and dates of planting in the percentage of titratable acidity in the top tier of the vertical tower.

In the middle tier, there was a significant difference observed among varieties and various dates of planting. The lowest titratable acidity (0.47) was revealed in V2 (Flaminia) followed by V1 (Nabila) (0.50), while the variety V3 (Murano) has shown the highest percentage of titratable acidity (0.62). Among various dates of planting, D2 (Planting on October 30th) has recorded the lowest percentage of titratable acidity (0.48) followed by D3 (Planting on November 15th) (0.52), while D4 (Planting on November 30th) revealed the highest percentage of titratable acidity (0.61). There was also a significant difference observed among the interactions between varieties and dates of planting in titratable acidity in the middle tier of the vertical tower, the combination of V2D2 has revealed lowest percentage of titratable acidity (0.40) which was on par with V1D2 (0.44). The interaction of V4D4 recorded a highest percentage of titratable acidity (0.67) which was on par with V3D3 (0.63).

In the lowest tier, there was a significant difference among varieties and various dates of planting. The lowest titratable acidity (0.49) was recorded by V2 (Flaminia) followed by V1 (Nabila) (0.53), while the variety V3 (Murano) has resulted with the highest percentage of titratable acidity (0.62). Among various dates of planting, D2 (Planting on October 30th) has revealed the lowest percentage of titratable acidity (0.52) which was on par with D3 (Planting on November 15th) (0.54), while, highest percentage of titratable acidity (0.61) was noticed in D4 (Planting on November 30th) which was on par with D1 (Planting on October 15th) (0.59). There was also a significant difference observed among the interactions between varieties and

dates of planting in titratable acidity in the lower tier of the vertical tower, the combination of V2D2 has revealed the lowest percentage of titratable acidity (0.45) which was on par with V1D2 (0.50), V1D3 (0.49), V2D3 (0.48) and V2D4 (0.51). The interaction of V4D4 recorded the highest percentage of titratable acidity (0.72) which was on par with V3D4 (0.66).

The differences in titratable acidity among varieties may be due to variations in adaptability to changing environments. In this experiment, short day varieties V1 (Nabila) and V2 (Vivara) have recorded with the lowest titratable acidity than everbearing varieties V3 (Murano) and V4 (Vivara). The continuous production cycle of everbearing strawberries may contribute to more consistent accumulation of organic acids throughout the growing season (Miri *et al.,* 2020). The variations in titratable acidity among varieties were also noticed in the experiments conducted by Jami *et al.* (2015) and Kumar *et al.* (2022).

In this experiment, among planting dates, planting in the late October and early November revealed the lowest titratable acidity in strawberry fruits than early October and late November planting which was similar to findings of Gogoi *et al*. (2022), Kaur (2010), Mawkhiew and Pereira (2015), Singh *et al*. (2006) and Sadiq and Kaur (2017) in strawberry. This was likely due to the differences in the environmental conditions such as temperature and the sunlight during plant growth and fruit development period which can alter the metabolic processes involved in the acid accumulation. In fruits, cooler nights and warmer days generally synthesize more acidity (Wani *et al.,* 2017) which was supported by the findings of Bhamini *et al*. (2017) who noticed that fruit acidity is increased with higher temperatures in strawberry.

Conclusion:

- The top tier of the vertical tower has exhibited higher percentage of Total sugars and lower percentage of titratable acidity than subsequent tiers of the vertical tower among all the varieties, potting media and interactions.
- Among varieties, Shortday varieties V1 (Nabila) and V2 (Flaminia) has revealed highest percentage of total sugars and lowest percentage of titratable acidity than everbearing varieties V3 (Murano) and V4 (Vivara) in all the tiers of the vertical tower.
- Among planting dates, D2 (Planting on October 30th) has registered with highest percentage of Total sugars and lowest percentage of titratable acidity in all the tiers of the vertical tower.
- The interaction of V1 (Nabila) and V2 (Flaminia) with D2 (planting on October 30th) indicated highest percentage of total sugars and lowest percentage of titratable acidity. in all the tiers of the vertical tower.

Table1: Effect of different dates of planting on total sugars of strawberry varieties in different tiers (Pooled)

Total sugars (%)															
Treatment	**Top tier**					**Middle tier**					**Lower tier**				
	D1	**D2**	**D3**	**D4**	**Mean**	**D1**	**D2**	**D3**	**D4**	**Mean**	**D1**	**D2**	**D3**	**D4**	**Mean**
V1	5.11	5.65	5.72	5.17	**5.41**	5.15	5.77	5.30	4.43	**5.16**	4.67	5.45	5.13	4.36	**4.90**
V2	5.47	6.02	5.40	5.16	**5.51**	5.20	5.73	5.33	5.15	**5.35**	4.83	5.62	5.25	4.70	**5.10**
V3	4.54	5.39	5.28	4.58	**4.95**	4.35	5.27	5.25	4.24	**4.78**	4.30	5.27	5.02	4.46	**4.76**
V4	4.69	5.11	4.79	4.57	**4.79**	4.28	5.22	4.65	4.31	**4.61**	3.82	4.82	4.37	4.14	**4.29**
Mean	**4.95**	**5.54**	**5.30**	**4.87**		**4.74**	**5.49**	**5.14**	**4.53**		**4.40**	**5.29**	**4.94**	**4.41**	
	SEm±			CD (5%)		SEm±			CD (5%)		SEm±			CD (5%)	
Varieties (V)	**0.03**			**0.09**		**0.04**			**0.11**		**0.02**			**0.06**	
Dates of planting (D)	**0.03**			**0.09**		**0.04**			**0.11**		**0.02**			**0.06**	
VxD	**0.06**			**0.18**		**0.08**			**0.23**		**0.04**			**0.12**	

Table 2: Effect of different dates of planting on titratable acidity of strawberry varieties in different tiers (Pooled)

Titratable acidity (%)															
Treatment	**Top tier**					**Middle tier**					**Lower tier**				
	D1	**D2**	**D3**	**D4**	**Mean**	**D1**	**D2**	**D3**	**D4**	**Mean**	**D1**	**D2**	**D3**	**D4**	**Mean**
V1	0.43	0.35	0.37	0.52	**0.42**	0.53	0.44	0.47	0.55	**0.50**	0.58	0.50	0.49	0.57	**0.53**
V2	0.36	0.27	0.38	0.47	**0.37**	0.50	0.40	0.44	0.55	**0.47**	0.54	0.45	0.48	0.51	**0.49**
V3	0.54	0.41	0.46	0.59	**0.50**	0.64	0.54	0.63	0.66	**0.62**	0.64	0.56	0.64	0.66	**0.62**
V4	0.56	0.50	0.58	0.65	**0.57**	0.53	0.54	0.54	0.67	**0.57**	0.60	0.56	0.56	0.72	**0.61**
Mean	**0.47**	**0.38**	**0.45**	**0.56**		**0.55**	**0.48**	**0.52**	**0.61**		**0.59**	**0.52**	**0.54**	**0.61**	
	SEm±			CD (5%)		SEm±			CD (5%)		SEm±			CD (5%)	
Varieties (V)	**0.01**			**0.03**		**0.01**			**0.02**		**0.01**			**0.03**	
Dates of planting (D)	**0.01**			**0.03**		**0.01**			**0.02**		**0.01**			**0.03**	
VxD	**0.02**			**NS**		**0.01**			**0.04**		**0.02**			**0.06**	

V1: Nabila, V2: Flaminia, V3: Murano, V4: Vivara

D1: Planting on October 15th, D2: Planting on October 30th, D3: Planting on November 15th, D4: Planting on November 30th

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