Response of Spacing and Plant Growth Regulators on Organoleptic Evaluation of Strawberry (*Fragaria x ananassa* Duch) cv. Winter Dawn Under Polyhouse Condition

Abstract

Sensory quality encompasses the various characteristics of a product that add value for both buyers and consumers. Consumers tend to prefer fruits that are visually appealing, firm, and have good flavor and nutritional value. On the other hand, producers and handlers prioritize the appearance and texture of the fruit, as well as its ability to maintain quality over a long post-harvest period. The study was conducted in the polyhouse of the College of Agriculture, Ummedganj Kota, Rajasthan over two growing seasons (2021-22 and 2022-23) to assess the effects of plant spacing and growth regulators on the organoleptic quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn under polyhouse condition. The experiment followed a factorial randomized block design with eighteen treatment combinations that included two plant spacings (15 cm × 30 cm and 30 cm × 30 cm) and three plant growth regulators: salicylic acid (at 50 ppm, 100 ppm, and 150 ppm), Triacontanol (at 5 ppm, 10 ppm, and 15 ppm), and NAA (at 25 ppm, 50 ppm, and 75 ppm). The hedonic sensory evaluation rating for organoleptic tests indicated that highest score for colour (7.41), flavor (7.58), taste (7.77) and general appearance (7.84) was observed under S_2 (30 cm ×30 cm). The most significant plant growth regulator (PGR) effect on orgenoleptic score for colour (8.85), flavor (8.72), taste (8.65) and general appearance (8.49) was observed under treatment treated with SA at 100 ppm Moreover, in interaction effect S_2+SA100 ppm (30 cm ×30 cm + Salicylic acid at 100 ppm) received a higher and more favorable score of colour (8.87), flavor (8.74), taste (8.86), general appearance (8.65) respectively.

1. Introduction

Strawberry (*Fragaria x ananassa* Duch.) is a natural hybrid species which belongs to the Rosaceae family that is cultivated all over the world for its aggregate accessory fruits. The modern cultivated variety is a hybrid of *Fragaria virginiana* and *Fragaria chiloensis* (Hancock *et al.*,2000). In India, strawberry is generally cultivated in the hills and the climatic variability that exists in these areas and the broad adaptability of the plant allow its harvesting for more than

half part of the year. Strawberry, a non-climacteric, delicious fruit known for it's flavour, taste, fresh use and a rich source of vitamin C.

The most abundant bioactive phyto-chemicals reported to be ellagic acid and certain flavonoids: anthocyanin, catechin, quercetin and kaempferol (Hannum 2004). Strawberry fruits contain phenolic compounds that have antioxidant, anticancer, anti-atherosclerotic and anti-neurodegenerative properties. Specific antioxidants present in strawberries include quercetin, kaempferol, chlorogenic acid, p-coumaric acid and ellagic acid (Olsson *et al*., 2004).

The most important components of strawberry quality are appearance, firmness, flavor, maturity and absence of damage to the fruit. As the strawberry flavor and fragrance are among the most popular hedonic characteristics for consumers, strawberry fruits are widely used in a variety of manufacturing, including foods, beverages, confectionaries, perfumes and cosmetics.

2. Material and Methods

The study was conducted in the polyhouse of the College of Agriculture, Ummedganj Kota, Rajasthan over two growing seasons (2021-22 and 2022-23) to assess the influence of plant spacing and growth regulators on the organoleptic quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn. For this purpose strawberry fruits were harvested done when the fruits attained more than 75% color. At harvest, the fresh strawberry fruits were assessed by a panel of judges for quality characteristics, including color, taste, aroma, texture, and overall acceptability. An organoleptic scoring system ranging from 1 to 9 point Hedonic scale using was used. Where a score of 9 indicated "like extremely," 8 indicated "like very much," 7 indicated "like moderately," 6 indicated "like slightly," 5 indicated "neither like nor dislike," 4 indicated "dislike slightly," 3 indicated "dislike moderately," 2 indicated "dislike very much," and 1 indicated "dislike extremely as mentioned in Table 1. The mean of scores given by the judges were used for statistical analysis.

Table-1. Hedonic scale rating for various organoleptic attributes described by Ranganna, 2009

Hedonic scale	Colour	Flavor	Taste	General appearance
Like extremely	9	9	9	9
Like very much	8	8	8	8
Like moderately	7	7	7	7
Like slightly	6	6	6	6
Neither like or dislike	5	5	5	5
Dislike slightly	4	4	4	4
Dislike moderately	3	3	3	3

Dislike very much	2	2	2	2
Dislike extremely	1	1	1	1

2.1 Statistical Analysis

The data recorded during field experimentation and data obtained from laboratory determination were subjected to the statistical analysis of variance using factorial randomized block design and completely randomized design respectively as described by Panse and Sukhatme (1985). The overall significance of difference among the treatments was tested, using critical differences (C.D.) at 5% level of significance. The results were statistically analyzed with the help of a windows-based computer package OPSTAT which calculated the standard error of the difference in mean (SEd) and Critical difference (CD) between the treatments at 5% level of significance. Graphs were prepared by using Microsoft Excel (MS office ver. 2007).

3. Results and Discussion

3.1 Organoleptic score

3.1.1 Colour and Flavour

3.1.2 Effect of Spacing

The maximum color and flavour mean score measuring (7.21), (7.60) (7.41) and (7.17), (7.99) and (7.58) were observed in S_2 (30 cm ×30 cm) during the years 2021-22, 2022-23and in the overall combined data, indicating notable superiority over other spacing levels. In contrast, the minimum colour and flavor mean score, (7.02), (7.26), (7.14) and (6.92), (7.81) and (7.37) were recorded at the minimum spacing level, S_1 (15 cm ×30 cm), during the years 2021-22, 2022-23 and in the overall combined data, respectively. The findings indicate that selecting a 30 cm×30 centimeter spacing is a preferable option compared to choosing a 15×30 centimeter spacing. The results suggest that opting for a 30×30 cm spacing is a better choice than selecting a 15 cm × 30 cm spacing. The results are in accordance with Shiranal *et al.* (2019).

3.1.3 Effect of plant growth regulators (PGRs)

When evaluating the various levels of plant growth regulators, the colour and flavour mean score, measuring (8.73), (8.92), (8.85) and (8.65), (8.87) and (8.72) was observed to be the highest in treatments treated with SA @ 100ppm. Following closely, NAA @ 75 ppm demonstrated colour and flavor mean score of (8.36), (8.63), (8.50) and (8.23), (8.54) and (8.39) for both individual years and in the overall combined data. Conversely, the minimum color and flavor mean score, (6.24), (6.40), (6.32) and (6.05), (7.14) and (6.60) were recorded in plants

treated with TA@5ppm for both individual years and in the overall combined data, respectively.The findings indicated that using salicylic acid (SA) at a concentration of 100 ppm showed greater effectiveness compared to other plant growth regulators. This led to the most favorable results in terms of plant growth and development. These findings closely align with previous studies by Akhtar *et al.* (2015)

3.1.4 Interaction effect of spacing and plant growth regulators (S × PGRs)

The interplay between different spacing levels and plant growth regulators significantly affected the colour and flavour of the strawberry. The maximum colour and flavormean score, measuring (8.81), (8.93), (8.87) and (8.69), (8.80), (8.74) were observed in treatment combination of S_2+SA100 ppm (30 cm ×30 cm + SA@100 ppm). Similarly, S_2+NAA75 ppm (30 cm ×30 cm+ NAA@75 ppm) demonstrated color and flavour mean score of (8.49), (8.66), (8.58) and (8.35), (8.67) and (8.51) for both individual years and in the combined data. Conversely, the minimum colour and flavor mean score (6.22), (6.31), (6.26) and (6.03), (6.95) and (6.49) were noted in S_2+TA75 ppm (15 cm×30 cm spacing + TA@5 ppm) for the years 2021-22, 2022-23 and in the combined data, respectively. In this instance, the findings were deemed significant for both the individual years and in pooled. The present study is also in consonance with the reports of Kazemi *et al.* (2013)

3.2 Taste and General Appearance

3.2.1 Effect of spacing

Regarding analyzing the data, the highest mean scores for taste and general appearance, measuring (7.74), (7.81), (7.77) and (7.55), (8.13), (7.84) were observed in S_2 (30 cm ×30 cm) during the years 2021-22, 2022-23 and in the overall combined data, indicating notable superiority over other spacing levels. In contrast, the minimum mean scores for taste and general appearance, (7.32), (7.45), (7.39) and (6.87), (7.64), (7.26), were noted at the minimum spacing level, S1 (15 cm ×30 cm) during the years 2021-22, 2022-23 and in the overall combined data, respectively. These findings are consistent with the results reported by Datta *et al.* (2023) and Bhatia *et al.* (2017).

3.2.2 Effect of plant growth regulators (PGRs)

In the assessment of various levels of plant growth regulators, the mean score for taste and general appearance, measuring (8.47), (8.84), (8.65) and (8.24), (8.75) and (8.49) was

observed to be the highest in treatments treated with SA @ 100 ppm. Close behind, NAA @ 75 ppm demonstrated mean scores for taste and general appearance of (8.08), (8.16), (8.12) and (7.75), (8.48) and (8.12) for both individual year and in the overall combined data. Conversely, the minimum mean scores for taste and general appearance (6.33), (6.42), (6.38) and (6.36), (6.72) and (6.54) were noted in TA@5ppm for both individual years and in the overall combined data, respectively. The results showed that applying salicylic acid (SA) at a concentration of 100 ppm was more successful than using other plant growth regulators. This resulted in the best outcomes for the growth and development of the plants. These findings closely align with previous studies by El-sayed *et al*. (2015) and Sandhyarani *et al.* (2024)

3.2.3 Interaction effect of spacing and plant growth regulators (S × PGRs)

The interaction between different spacing levels and plant growth regulators significantly influenced the taste and general appearance of strawberries. The highest mean scores for taste and general appearance, measuring (8.83), (8.89), (8.86) and (8.51), (8.78), (8.65) were observed in treatment combination of S_2+SA100 ppm (30 cm ×30 cm spacing + SA at 100 ppm). Similarly, S_2+NAA75 ppm (30 cm ×30 cm spacing + NAA at 75 ppm) demonstrated taste and general appearance mean scores of (8.35), (8.43), (8.39) and (8.05), (8.76) and (8.40) for both individual years and in the combined data. On the other hand, the minimum mean scores for taste and general appearance (6.30), (6.36), (6.33) and (6.12), (6.30) and (6.21) were noted in treatment combination of S_1+TAppm (15 cm ×30 cm spacing + TA at 5 ppm) for the years 2021-22, 2022-23 and in the combined data, respectively. In this instance, the findings were deemed significant for both the individual years and when the data was combined. The results showed that applying salicylic acid (SA) at a concentration of 100 ppm was more successful than using other plant growth regulators. This resulted in the best outcomes for the growth and development of the plants. The current study aligns with Meena *et al.* (2023) and kumar *et al.* (2019)

Table 2- Effect of Spacing and PGRs on Color and Flavor of Strawberry cv. Winter Dawn

Treatments	Color (Out of 9 Point)			Flavor (Out of 9 Point)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
	Spacing(S)					
S_1 15 × 30cm	7.02	7.26	7.14	6.92	7.81	7.37
S2 30 × 30 cm	7.21	7.60	7.41	7.17	7.99	7.58
SE(m)±	0.02	0.06	0.03	0.06	0.01	0.03
CD(P=0.05)	0.06	0.17	0.09	0.17	0.03	0.09
	Plant Growth Regulators (PGRs)					
SA 50 ppm	7.45	7.58	7.52	7.30	8.12	7.71
SA 100 ppm	8.73	8.92	8.85	8.65	8.87	8.72
SA 150 ppm	7.66	8.20	7.93	7.93	8.37	8.15
NAA 25 ppm	6.44	6.76	6.60	6.23	7.75	6.99
NAA 50 ppm	6.51	7.11	6.81	6.81	7.94	7.38
NAA 75 ppm	8.36	8.63	8.50	8.23	8.54	8.39
TA 5 ppm	6.24	6.40	6.32	6.05	7.14	6.60
TA 10 ppm	6.27	6.60	6.43	6.10	7.20	6.65
TA 15 ppm	6.39	6.69	6.54	6.12	7.28	6.70
SE(m)±	0.01	0.03	0.02	0.02	0.01	0.02
CD(p=0.05)	0.03	0.08	0.04	0.08	0.01	0.04
Treatment Combinations	Interaction effect of Spacing and PGRs					
S_1+SA 50 ppm	7.18	7.41	7.29	7.13	8.05	7.59
S_2+SA 50 ppm	7.72	7.75	7.74	7.46	8.18	7.82
S_1+ SA 100 ppm	8.65	8.91	8.78	8.62	8.77	8.69
S_2+SA 100 ppm	8.81	8.93	8.87	8.69	8.80	8.74
S_1+SA 150 ppm	7.56	7.98	7.77	7.52	8.30	7.91
S_2+SA 150 ppm	7.75	8.41	8.08	8.34	8.43	8.38
S_1+NAA 25 ppm	6.39	6.46	6.42	6.21	7.72	6.97
S_2+NAA 25 ppm	6.49	7.06	6.78	6.24	7.78	7.01
S_1+ NAA 50 ppm	6.42	6.93	6.67	6.50	7.93	7.22
S_2+NAA 50 ppm	6.61	7.28	6.95	7.13	7.95	7.54
S1+NAA 75 ppm	8.22	8.60	8.41	8.10	8.41	8.26
S2+ NAA 75 ppm	8.49	8.66	8.58	8.35	8.67	8.51
S1+TA 5 ppm	6.22	6.31	6.26	6.03	6.95	6.49
S2+TA 5 ppm	6.25	6.49	6.37	6.08	7.33	6.71
S1+TA 10 ppm	6.24	6.35	6.30	6.08	7.05	6.57
S2+TA 10 ppm	6.29	6.85	6.57	6.11	7.36	6.73
S1+TA 15 ppm	6.35	6.41	6.38	6.10	7.15	6.63
S2+TA 15 ppm	6.44	6.96	6.69	6.14	7.41	6.78
SE(m)±	0.03	0.08	0.04	0.08	0.01	0.04
CD(p=0.05)	0.08	0.24	0.12	0.25	0.04	0.13

Table 3- Effect of Spacing and PGRs on Taste and General appearance of Strawberry cv. Winter Dawn

Treatments	Taste (Out of 9 Point)			General appearance (Out of 9 Point)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
	Spacing(S)					
S_1 15 × 30cm	7.32	7.45	7.39	6.87	7.64	7.26
S2 30 × 30 cm	7.74	7.81	7.77	7.55	8.13	7.84
SE(m)±	0.07	0.07	0.06	0.06	0.01	0.03
CD(P=0.05)	0.21	0.21	0.18	0.19	0.03	0.09
	Plant Growth Regulators (PGRs)					
SA 50 ppm	7.91	7.96	7.93	7.59	8.37	7.98
SA 100 ppm	8.47	8.84	8.65	8.24	8.75	8.49
SA 150 ppm	7.99	8.04	8.02	7.65	8.43	8.04
NAA 25 ppm	7.50	7.57	7.54	6.82	7.88	7.35
NAA 50 ppm	7.74	7.81	7.78	7.24	8.11	7.68
NAA 75 ppm	8.08	8.16	8.12	7.75	8.48	8.12
TA 5 ppm	6.33	6.42	6.38	6.36	6.72	6.54
TA 10 ppm	6.68	6.72	6.70	6.47	7.00	6.74
TA 15 ppm	7.06	7.12	7.09	6.77	7.22	6.99
SE(m)±	0.04	0.03	0.03	0.03	0.01	0.02
CD(p=0.05)	0.10	0.11	0.08	0.08	0.02	0.04
Treatment Combinations	Interaction effect of Spacing and PGRs					
S_1+SA 50 ppm	7.68	7.75	7.71	7.26	8.07	7.67
S_2+SA 50 ppm	8.13	8.18	8.15	7.92	8.67	8.30
S_1+ SA 100 ppm	8.11	8.78	8.44	7.96	8.72	8.34
S_2+SA 100 ppm	8.83	8.89	8.86	8.51	8.78	8.65
S_1+SA 150 ppm	7.81	7.87	7.84	7.31	8.13	7.72
S_2+SA 150 ppm	8.18	8.20	8.19	7.98	8.73	8.36
S_1+NAA 25 ppm	7.07	7.15	7.11	6.38	7.78	7.08
S_2+NAA 25 ppm	7.93	8.00	7.96	7.25	7.98	7.61
S_1+ NAA 50 ppm	7.48	7.55	7.52	7.03	8.03	7.53
S_2+NAA 50 ppm	8.00	8.07	8.04	7.46	8.19	7.82
S1+NAA 75 ppm	7.82	7.89	7.85	7.45	8.20	7.83
S2+ NAA 75 ppm	8.35	8.43	8.39	8.05	8.76	8.40
S1+TA 5 ppm	6.30	6.36	6.33	6.12	6.30	6.21
S2+TA 5 ppm	6.35	6.48	6.42	6.59	7.13	6.86
S1+TA 10 ppm	6.59	6.61	6.60	6.14	6.65	6.39
S2+TA 10 ppm	6.77	6.83	6.80	6.80	7.36	7.08
S1+TA 15 ppm	7.04	7.07	7.06	6.17	6.88	6.52
S2+TA 15 ppm	7.08	7.16	7.12	7.37	7.56	7.46
SE(m)±	0.11	0.10	0.09	0.09	0.02	0.05
CD(p=0.05)	0.30	0.31	0.25	0.27	0.05	0.13

Conclusion

The study concluded that a plant spacing of 30 cm × 30 cm, combined with the application of salicylic acid at a concentration of 100 ppm, produced the best results for organoleptic qualities such as color, flavor, taste, and overall appearance. These findings present a promising approach for strawberry cultivation, as the improved fruit characteristics are likely to enhance marketability.

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