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Effect of Salicylic Acid and Potassium Sulfate on Yield and Fruit Quality of Frigo Strawberry Plantations

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ABSTRACT

Two field experiments were conducted at a private farm in Shoney Village, Tanta, El-Gharbia Governorate, Egypt, during the two successive seasons of 2019/2020 and 2020/2021, to study the effect of spraying salicylic acid (SA) at four levels viz, 0, 5, 10 and 15 mM/L and potassium sulfate (K_2So_4) at two levels 0 and 5gm/L. The variety used was Monterey. The research aim was to study the effect of the above mentioned treatments on growth, flowering, yield and quality of strawberry fruits cultivated with cold stored transplants (Frigo). The obtained results recorded that spraying salicylic acid with 5mM/L or 5 gm/L potassium sulfate led to the highest significant increase in growth, yield, quality and chemical constituents in both seasons. Conclusively, spraying of SA at 5 mM/L, adding 5 gm/L (K_2So_4) had the best results in most of the studied traits.

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Keywords:
Frigo strawberry; SA; K_2So_4; Growth; Flowering; Yield; Fruit quality; Chemical composition.

1. INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) is one of the most popular fruits globally, for local consumption and export. The natural plant hormone Salicylic acid (SA) functions as an essential signaling molecule and enhances biotic stress tolerance in treated plants **(Khan *et al*., 2012)**. Salicylic acid is also a critical factor in plant development, ion absorption, and plant nutrient transfer. Salicylic acid, a phenolic molecule, is found in many plants and contributes to local or systemic fungal infection resistance **(Meena *et al*., 2001)**. In water interactions, photosynthesis, and plant development, an important function was proposed in salicylic acid **(Arfan *et al*., 2007)**.

Plants exposed to harmless amounts of salicylic acid may become more resistant to fungal diseases. Plant growth regulator and non-enzymatic antioxidant are other possible uses for it. Heat generation (thermo genesis), ion transport, disease resistance, seed germination, polarization of sexes, and crop yield are some of the physiological processes that it is engaged in **(Zhang *et al*., 2003)**. Salicylic acid greatly enhanced overall plant development in terms of shoot length, leaf area, and the fresh and dry weights of the plant, as well as flowering and fruit set **(Fariduddin *et al*., 2003)**.

Growing and developing strawberry require large amounts of potassium; plants absorb more K than many other plants **Treder *et al*. (2014)**. Adequate K also enhances the fruit's soluble sugar, acidity, and dry weight content. A large amount of potassium is transferred from leaves to the fruit during the ripening process when potassium absorption takes place. Strawberries treated with potassium exhibited substantial increases in vegetative growth, production, and fruit quality, according to **Shamaila *et al*. (2016)**. It is also essential for berry quality since it contributes to a high sugar and acid content and an outstanding flavor **(Afroz *et al*., 2016)**. As well as nitrate translocation and enzyme activation, potassium is involved in several transport and accumulation activities inside plants, when it comes to stress, such as frost, osmotic potential can reduce freezing point by raising cell solution osmolality as found by **Lisjak *et al*. (2009) and Schwarz *et al*. (2018)**.

Therefore, the aim of study was carried out to investigate the effect of salicylic acid and potassium sulfate on yield and fruit quality of frigo strawberry plantations.

2. MATERIALS AND METHODS

This study was conducted at a private farm in Shoney Village, Tanta, El-Gharbia Governorate, Egypt during the two successive seasons of 2019/2020 and 2020/2021to investigate the effect of spraying salicylic acid (SA) at 0, 5, 10 and 15mM/L. and the effect of spraying potassium sulfate (K_2So_4) at 0 and 5gm/L. Soil type was clay in texture, the physical and chemical properties of experimental soil are presented in Table 1. The soil analysis was at Ministry of Agriculture.

Frigo strawberry transplants were planted on September 20th and 21st in the first and second seasons, respectively. The study was conducted in two separate experiments.

Area of the plot was 10.5 m^2 each plot consists is of 5 rows with 3 m in length and 70 cm width. The total area of the first experiment was 168 m^2, while, it was 84 m^2 in the second one.

Table 1: Some physical and chemical properties of the experiment soil

Physical analysis

Depth (cm)	Particle size distribution			Soil texture
	Sand (%)	Silt (%)	Clay (%)	
0-30	26.2	37.5	36.3	Clay loam

Chemical analysis

Sample depth (cm)	pH	EC	Cations (meq/L)				Anions (meq/L)			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{-}	Hco_3^{-}	Cl^{-}	So_4^{-}
0-30	7.86	1.6	4	2.5	7.2	0.3	0	0.5	11	2.5

The first experiment: Effect of spraying salicylic acid (SA)

The plants were sprayed after 30, 60, 90 and 120 days from transplanting, and the treatments were spraying (SA) at 5, 10 and 15 mM/L in addition to control.

The second experiment: Effect of spraying potassium sulfate (K_2So_4)

The product name is SoluPotasse for company Tsndrlo, Belgium. The plants were sprayed after 30, 60, 90 and 120 days from transplanting, the two treatments were spraying (K_2So_4) at zero and 5gm/L.

Data recorded: the following data were recorded:

2.1. Vegetative growth:

After 75 days from transplanting.

Plant height was measured from the highest point of the plant up to the crown surface.

The number of leaves/plant were estimated.

Leaf area/plant: Leaf area was determined using the fresh weight method according to the following formula: Five leaf discs from the leaves, with 0.78 cm² for each disc, were used for this estimation.

Dry weight (%): Representative samples of 100 g leave for each unit were taken and dried at 70 ℃ till the weight becomes constant, then the percentage of fruit moisture and dry matter contents were calculated.

Number of roots was determined at the end of the season.

A- Flowering:

Number of days to first flowering

The number of early and total flowers/plant

B- Yield and its components:

Full color stage, 2-3 days intervals during the growing season.

Early yield, (t/fed): was determined for the seventh harvests (at 92 to 96 days from transplanting) each season.

Total yield, (t/fed): all harvested fruits each season.

A number of early fruits and number of total fruits /4000m^2.

Average fruit weight (g).

Average fruit volume (cm^3): according to **Gustafson, (1926)**.

Average shape index (L/d) (cm): Fully matured fruits having uniform color and size were selected from each treatment. The fruit length of five fruits from each treatment was taken with the digital slide calipers. The average length was calculated in millimeter. The fruit diameter was recorded on the same five fruits in which fruit length was recorded, with the slide calipers. The average diameter was calculated in millimeter.

Fruit firmness (g/cm): according to **Qurecky and Bourne (1968)**.

C- Chemical constituents:

Ten mature fruits were collected randomly from each treatment in the middle of the growing season after 130 days from transplanting to determine the chemical fruit quality as follows:

Chlorophyll a, b and total: according to the method which described by **Moran (1982)**.

Total titratable acidity (TAA) (%): as the method described in **A.O.A.C. (1990)**.

Total soluble solids (TSS) (%): the results were expressed as Brix.

Ascorbic acid content (mg/100 g FW): as the method mentioned in **A.O.A.C. (1990)**.

Anthocyanin (mg/100g): The content of fruit from Anthocyanin was determined spectrophotometrically as described by **A.O.A.C. (1990)**.

Sugar contents (%): method described by **Somogyi (1952) and Nelson (1974)**.

Total nitrogen%: it was determined in the digested dry weight of plant leaves using the micro Kjeldahl method, according to **Pregl (1945)**.

The Phosphorus content: It was determined using the spectrophotometer method as described by **John, (1970)**.

The Potassium content: It was determined using the flame photometer method described by **Brown and Lilleland (1946)**.

The Calcium content: It was determined according to the method described by **Rowell (1995)**.

All obtained data were subjected to an analysis of variance using the CoStat package program (Version 6.303, CoHort Software, USA). The differences among the means were compared using the least significant difference *(L.S.D.) at p ≤ 0.05*.

3. RESULTS AND DISCUSSION

3.1 Vegetative growth

It is evident from data tabulated in Table 3 that there was a significant effect with the highest value for leaf area and dry weight of leaves for plant obtained by using SA at 5mM/L similes to other concentrations in both seasons. The stimulatory effects of salicylic acid sprayings on vegetative growth parameters of strawberries were reported by **Mohamed *et al*. (2018)** and **Haghshenas *et al*. (2020)**. Sustained levels of salicylic acid may be a prerequisite for auxin and cytokinin synthesis **(Metwally *et al*., 2003)**. The beneficial effect of salicylic acid could be explained by the fact that SA plays an essential role in regulating vital processes and growth in plants **(Raskin, 1992** and **Horvath *et al*., 2007)** salicylic acid has been found to induce various metabolic and physiological responses in plants, affecting their growth and development. However, the effect of salicylic acid on growth depends on plant species, developmental stage, and salicylic acid concentrations. In addition, the superiority of salicylic acid may be due to the role of salicylic acid as the phenolic growth-promoting substance which affects plant cells division and elongation and, in

Statistical analysis:

The effect of spraying salicylic acid

Data presented in Table 2 clearly show a significant effect on plant height, the number of leaves, and number of roots for plant by applying SA at 5mM/L compared to other concentrations in both seasons. The obtained results agree with those reported by **Abo-Sedera *et al*. (2014) and Mohamed *et al*. (2018)** on strawberries.

turn, increased plant growth. The obtained results are similar to those reported by **Babalar *et al*. (2007) and Porras *et al*. (2007)** on strawberries.

The effect of spraying potassium:

The data recorded in Table 2 show that there was a significant effect on plant height, the number of leaves, and number of roots for plant by application of K_2So_4 5gm/L, compared to the control in both seasons. The obtained results are in agreement with **Bamouh *et al*. (2019) on strawberry.**

Data presented in Table 3 indicate that there was significant effect for K_2So_4 5gm/L with the highest value on leaf area and dry weight of strawberry leaves, compared to the control in both seasons (**Valentinuzzi *et al*., 2017 and Bamouh *et al*., 2019**).

In many plant species, the uptake of K occurs mainly during the vegetative stage, when photosynthesis is available for root growth. There is an intense competition between developing fruits and vegetative organs for this photo assimilates during the reproductive stage. This phenomenon may affect the K acquisition in the root and yield and quality **(Lester *et al*., 2005 and 2006)**.

Table 2: Effect of SA, and K_2So_4 on plant height, number of leaves, and number of roots of Strawberry during 2019/2020 and 2020/2021 seasons

Treatments	Plant height (cm)		Number of leaves		Number of roots	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	12.69	12.96	11.64	11.46	58.38	57.95
SA at 5mM/L	18.12	18.29	18.41	18.50	73.55	74.23
SA at 10mM/L	9.92	10.12	4.80	5.04	51.48	51.65
SA at 15mM/L	7.26	7.32	2.09	2.25	30.90	32.05
L.S.D at 0.05%	0.50	0.72	0.53	0.75	1.48	1.73

Control	12.88	12.90	11.90	11.82	58.27	57.55
K_2So_4 at 5gm/L	14.00	14.08	13.77	14.20	63.41	63.29
L.S.D at 0.05%	0.57	0.68	0.27	0.63	0.30	0.21

Table 3: Effect of SA, and K_2So_4 on leaf area, and dry weight of strawberry during 2019/2020 and 2020/2021 seasons

Treatments	Leaf area $(cm)^2$		Dry **weight** (%)	
	Season 2019	Season 2020	Season 2019	Season 2020
Control	1014.93	1023.08	11.91	11.65
SA at 5mM/L	1870.31	1903.65	16.02	15.58
SA at 10mM/L	186.55	185.09	5.33	4.43
SA at 15mM/L	45.92	49.53	2.47	2.47
LSD at 0.05%	106.34	188.61	0.75	0.92
Control	975.89	983.53	12.00	11.92
K_2So_4 at 5gm/L	1130.40	1217.35	12.43	12.34
LSD at 0.05%	26.65	21.56	0.23	0.37

A- Flowering: The effect of spraying salicylic acid

Spraying of salicylic acid gave significant effect on early flowers number and flowers number (Table 4). The highest values were found by application SA at 5mM/L compared to other used concentrations in both seasons. While number of days to first flowering gets the lowest value at 15mM/L. The results from **Qureshi *et al*. (2013) and Mohamed *et al*. (2018)** stated that salicylic acid stimulates flowering in a range of plants, increasing flower life and controlling ion uptake by roots stomatal conductivity. The mechanism of action for salicylic acid was reported by **Oata (1975) and Pieterse and Muller (1977)**, who concluded that salicylic acid-induced flowering by acting as a chelating agent. **Raskin *et al*. (1987)** supported this result, and confirmed that salicylic acid functioned as an endogenous growth regulator for flowering and florigenic effects.

The effect of spraying potassium:

Data presented in Table 4 show that the K_2So_4 treatment had a significant effect on flowers number, the highest values were obtained by applying K_2So_4 5gm/L., while the number of days to first flowering get the best result by applying K_2So_4 5gm/L., compared to the control in both seasons. The data obtained are in harmony with these of **Ahmad *et al*. (2014) and Bamouh *et al*. (2019)** on strawberries.

The K has critical regulatory roles inside and outside of plant cells, so we can expect that plant access to an available K source should optimize plant growth, and consequently, this enables plants to flower more frequently **(Rahemi and Asghari, 2004)**. **Ahmad *et al*. (2014)** mentioned that flowering play a vital role in plants for pollination processes, essential for fruit growth and development. Early flowering induced in strawberry plants might be because of the applied potassium because K induces early growth, activates enzymes, and the efficiency of other applied nutrients **(El-Nemr *et al*., 2012)**, our results are in line with previous pieces of evidence that potassium application significantly influenced days to flower.

Table 4: Effect of SA, and K_2So_4 on number of days to first flowering, early flowers, and total flowers number of strawberry during 2019/2020 and 2020/2021 seasons

Treatments	Number of days to first flowering		Early flowers number/plant		Total flowers number/plant	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	88.50	88.25	2.36	2.41	11.43	11.19
SA at 5mM/L	81.25	81.50	5.25	5.39	18.87	19.04
SA at 10mM/L	76.00	70.75	1.49	1.76	5.23	5.11
SA at 15mM/L	70.50	69.50	1.05	1.21	3.13	3.25
LSD at 0.05%	1.07	1.13	0.58	0.50	1.01	1.07
Control	88.50	88.75	2.34	2.41	11.35	11.39
K_2So_4 at 5gm/L	86.78	86.25	3.77	3.85	13.98	14.44
L.S.D at 0.05%	1.52	0.92	0.20	0.15	0.35	0.11

B- Yield and its components

The effect of spraying salicylic acid:

It is evident from data tabulated in Table 5 that spraying with salicylic acid rates had a significant effect on average fruit volume, average fruit weight, and fruit firmness per plant by application SA the highest values were at 5mM/L compared to other in both seasons. Also, the average fruit shape index were a significantly affected by SA at 15mM/L in both seasons. The data obtained are in harmony with these of **Lolaei *et al*. (2012), Kazemi (2013b) and Youssef *et al*. (2017)**.

Data in Table 6 indicate that the spraying with salicylic acid rates significantly affected the number of early and whole fruits especially with the highest value by SA at 5mM/L compared to other used concentrations. The current results indicate that the spraying with salicylic acid rates significantly affected early yield and total yield, with the highest value (SA at 5mM/L) compared to other used concentrations in both seasons. The result is in agreement with **Mohamed *et al*. (2018), Kumar *et al*. (2019) and Favaro *et al*. (2019)** on strawberry plant.

From the obtained data in Table 7 it could be noticed that salicylic acid rates had a significant effect on early and total distorted yield with the highest value with SA at (15mM/L) in both seasons. In this respect **Haghshenas *et al*. (2020)** stated that foliar application of SA ameliorates the harmful effects of salt stress on strawberry fruits' growth, yield, and quality. Obtained results may be attributed to the role of such natural anti diseases substances in decreasing the susceptibility for diseases infection, decreasing ethylene's respiration rate and its production **(El-Shafie, 2003) and (Babalar *et al*., 2007)** on strawberry. Also the revealed data showed that, salicylic acid rates had significant effect on early and total yield infected with mold. Where, the highest value was obtained by control compared with other treatments in both seasons.

The effect of spraying potassium:

It is evident from data tabulated in Table 5 that spraying K_2So_4 rates had significant effects on average fruit volume, average fruit weight, fruit shape index and fruit firmness for plant by application K_2So_4 at 5gm/L compared to the control in both seasons. Similar trend was also obtained by

Valentinuzzi *et al*. (2017) in strawberries. Despite not being involved in the formation of either organic molecules or cell structure, it is required for a plethora of biochemical and physiological processes that are fundamental for plant growth, resistance to stresses, yield, fruit quality, and its shelf life **(Lester *et al*., 2005, 2006 and Marschner, 2011)**.

The data in Table 6 reveal that spraying K_2So_4 rates significantly affected the number of early and whole fruits. The highest value was obtained by K_2So_4 at 5gm/L as compared to the control in both seasons. Our data revealed that spraying K_2So_4 rates significantly affected early and total yield. The highest values were obtained by 5gm/L in both seasons. Similar results were also obtained for strawberries **(Miri *et al*., 2017 and Bamouh *et al*., 2019)**.

In Table 7 data revealed that K_2So_4 rates significantly affected early and total distorted yield, compared to the control in both seasons. The obtained results from treated plants with K_2So_4 rates had a substantial impact on early and total yield infected with mold. The highest significant value was found by the control treatment compared to the other treatments throughout both seasons.

Table 5: Effect of SA, and K_2So_4 on some physical characters of strawberry fruits during 2019/2020 and 2020/2021 seasons

Treatments	Average fruit volume (cm^3)		Average fruit weight (g)		Average shape index (L/d)		Fruit firmness **(g/cm)**	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	142.49	142.84	31.71	32.92	1.24	1.27	64.94	67.24
SA at 5mM/L	149.64	149.49	35.34	35.24	1.17	1.15	74.01	73.40
SA at 10mM/L	129.75	128.67	30.77	30.17	1.20	1.15	43.21	48.70
SA at 15mM/L	119.34	119.93	24.78	24.80	1.39	1.34	36.93	38.40
L.S.D at 0.05%	0.99	1.036	0.74	0.94	0.01	0.02	3.26	2.69
Control	141.50	142.13	31.76	32.27	1.18	1.17	62.38	65.74
K_2So_4 at 5gm/L	144.78	145.56	33.74	33.75	1.26	1.23	66.77	69.35
L.S.D at 0.05%	0.15	0.28	0.22	0.53	0.06	0.05	2.83	2.97

Table 6: Effect of SA, and K_2So_4 on number of early fruits, number of total fruits, early, and the total yield of strawberry during the 2019/2020 and 2020/2021 seasons

Treatments	Number of early fruits (4000 m^2)		Number of total fruits (4000 m^2)		Early yield (t/fed)		Total yield (t/fed)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	58265.72	63797.14	516476.19	575523.81	1.92	2.01	16.72	17.89
SA at 5mM/L	73176.19	79045.72	607714.29	1063255.4	2.57	2.63	21.27	22.41
SA at 10mM/L	33084.76	33688.57	261322.86	223989.53	0.93	0.93	6.23	6.13
SA at 15mM/L	32607.62	38977.15	242461.91	242379.05	0.85	0.93	5.70	5.73

LSD at 0.05%	2541.57	4915.50	10341.39	26347.32	0.06	0.14	0.30	0.41
Control	50587.62	42696.19	573383.81	590855.24	1.55	1.24	17.47	19.01
K_2So_4 at 5gm/L	53406.67	50039.05	655639.05	692000.00	1.70	1.57	21.09	23.30
LSD at 0.05%	1128.26	1556.95	8168.45	31153.22	0.03	0.06	0.18	1.09

Table 7: Effect of SA, and K_2So_4 on early and total distorted yield, and yield infected with mold of strawberry during the 2019/2020 and 2020/2021 seasons

Treatments	Early distorted yield (t/fed)		Total distorted yield (t/fed)		Early yield infected with mold (t/fed)		Total yield infected with mold (t/fed)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	0.02	0.03	0.07	0.07	0.13	0.12	0.61	0.61
SA at 5mM/L	0.02	0.02	0.04	0.04	0.11	0.10	0.20	0.20
SA at 10mM/L	0.05	0.05	0.30	0.35	0.05	0.05	0.09	0.09
SA at 15mM/L	0.08	0.07	0.47	0.56	0.04	0.04	0.08	0.08
L.S.D at 0.05%	0.005	0.01	0.07	0.11	0.002	0.002	0.006	0.003
Control	0.06	0.08	0.64	0.46	0.13	0.13	0.65	0.62
K2So4 5gm/L	0.02	0.05	0.14	0.30	0.11	0.10	0.30	0.36
L.S.D at 0.05%	0.002	0.01	0.05	0.04	0.004	0.003	0.008	0.01

Chemical constituents of plants

The effect of spraying salicylic acid:

Data in Table 8 indicated that spraying salicylic acid rates had a significant effect on the chlorophyll content of leaves mainly with SA at 5mM/L compared to other concentrations in both seasons. Obtained results confirmed those reported by **Kalaki *et al*. (2014) and Youssef *et al*. (2017)** on the strawberry plant. **Babalar *et al*. (2007)** reported that salicylic acid at all concentrations effectively reduced fruit ethylene production and fungal decay and kept overall quality.

Data presented in Table 9 clearly show that spraying salicylic acid rates on had significant effects on vitamin-C and TSS content of fruits in both seasons; otherwise, acidity was significantly affected when using 15mM/L compared to other concentrations in both seasons. Similar observations were recorded by **Jing-Hua *et al*. (2008)** who reported that the application of SA could increase vitamin-C and then decrease antioxidants in fruit the increase resistance to chilling damage in strawberries, **(Kazemi *et al*., 2013a) and Mohamed *et al*. (2018)** on strawberry fruits found similar results.

Results in Table 10 illustrates that reducing, non-reducing, and total sugars content of fruits were significantly affected by SA at 5mM/L as compared to other concentrations in both seasons. Obtained results are in the same direction with those recorded by **Hayat *et al*. (2010)** who stated that exogenous application of lower concentrations of salicylic acid was beneficial in improving photosynthesis, growth, and various physiological and biochemical properties of plants.

The results in Table 11 indicated that, spraying salicylic acid rates significantly affected NPK of leaves mainly with 5mM/L in both seasons as reported by **Shafshak *et al*. (2010) and Jamali *et al*. (2013)** on strawberries. It is clear from data in Table 12 that, spraying salicylic acid rates had a significant effect on K, Ca, and anthocyanin of fruits at 5mM/L in both seasons. This result was in harmony with **Jamali and Eshghi (2015) and Youssef *et al*. (2017)** on strawberries. Salicylic acid could induce the alternative oxidase enzyme activity in mitochondria, which is involved in stress alleviation mechanism, and enhancing or reducing specific secondary metabolites of plants **(Prithiviraj *et al*., 2005 and D'onofrio *et al*., 2009)**.

The effect of spraying potassium:

Data in Table 8 indicated that the effects of spraying K_2So_4 had a significant effect on chlorophyll content of leaves control in both seasons. The obtained results are in agreement with **Bamouh *et al*., (2019)**.

The data presented in Table 9 clearly show that spraying K_2So_4 rates had a significant effect on vitamin-C and TSS content of fruits of strawberry fruits at 5gm/L in both seasons.

The data in Table 10 showed that K_2So_4 has non-significant effect on non-reducing From the data in Table 12, it is clear that spraying K_2So_4 rates gave significant effect on K, Ca, and anthocyanin of fruits mainly at 5gm/L, compared to control in both

sugars in the first season. On the other hand, significant effect was found for K_2So_4 at 5gm/L for non-reducing sugar in the second season. **Bamouh *et al*. (2019)** reported that potassium is considered a determining factor on fruit quality, such as sugar content, vitamin-C levels, and fruit acidity. These parameters increase with potassium fertilization.

In conclusion, the foliar application of based fertilizers during the development of strawberry fruits effectively enhances the quality parameters of strawberries in field conditions, yet without significantly affecting the yield. In addition, the treatments increased the TSS content of fruits and induced. Finally, the K concentration increased in both leaves and fruits, showing a significant macronutrient accumulation in strawberries because of the foliar application **(Valentinuzzi *et al*., 2017)**.

The data tabulated in Table 11 showed that, K_2So_4 significantly affect the strawberry plant NPK content in the leaves particularly at 5gm/L compared to the control in both seasons. These results are in accordance with **Valentinuzzi *et al*. (2017) and Bamouh *et al*. (2019)**.

seasons. Similar trend was also obtained by **(Miri *et al*., 2017)** on strawberries.

Table 8: Effect of SA, and K_2So_4 on chlorophyll a, chlorophyll b, and total chlorophyll of strawberry leaves during the 2019/2020 and 2020/2021 seasons

Treatments	Chlorophyll a (mg/100g FW)		Chlorophyll b (mg/100g FW)		Total Chlorophyll (mg/100g FW)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	3.97	4.03	1.42	1.34	5.39	5.37
SA at 5mM/L	4.44	4.47	2.81	2.57	7.24	7.04
SA at 10mM/L	2.73	3.03	1.04	1.24	3.77	4.26
SA at 15mM/L	1.85	2.34	1.16	0.83	3.00	3.17
L.S.D at 0.05%	0.17	0.20	0.32	0.23	0.41	0.34
Control	3.65	3.73	1.32	1.26	4.96	4.98
K_2So_4 at 5gm/L	3.95	3.93	1.49	1.44	5.44	5.37
L.S.D at 0.05%	0.24	0.17	0.14	0.06	0.278	0.13

Table 9: Effect of SA, and K_2So_4 on vitamin-C, total acidity and TSS of strawberry fruits during the 2019/2020 and 2020/2021 seasons

Treatments	Vitamin-C (mg/100g)		Acidity (%)		TSS (%)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	61.57	63.33	1.49	1.49	10.64	10.79
SA at 5mM/L	82.86	85.76	1.15	1.11	12.99	13.49
SA at 10mM/L	39.76	40.30	1.83	2.03	7.54	6.33
SA at 15mM/L	36.72	37.54	2.34	2.32	5.34	6.06
LSD at 0.05%	3.19	3.12	0.12	0.12	1.03	1.39
Control	60.14	60.27	1.41	1.45	10.23	10.57
K_2So_4 at 5gm/L	68.08	66.34	1.19	1.19	11.59	11.57
L.S.D at 0.05%	1.48	1.57	0.06	0.05	0.26	0.22

Table 10: Effect of SA, and K_2So_4 on reducing, non-reducing, and total sugars of strawberry fruits during 2019/2020 and 2020/2021 seasons

Treatments	Reducing sugars (%)		Non-reducing sugars (%)		Total sugars (%)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	4.20	4.40	2.30	2.28	6.50	6.70
SA at 5mM/L	4.55	4.75	3.08	3.15	7.63	7.85
SA at 10mM/L	1.50	1.75	1.30	1.20	2.80	2.95
SA at 15mM/L	1.15	1.40	1.13	1.10	2.23	2.50
L.S.D at 0.05%	0.05	0.05	0.05	0.06	0.05	0.05
Control	4.53	4.66	1.89	1.87	6.41	6.53
K_2So_4 at 5gm/L	4.64	4.71	1.90	1.94	6.54	6.64
L.S.D at 0.05%	0.02	0.04	NS	0.05	0.01	0.01

Table 11: Effect of SA, and K_2So_4 on N, P, and K of strawberry fruits during 2019/2020 and 2020/2021 seasons

Treatments	N (%)		P (%)		K (%)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	2.49	2.34	0.31	0.31	1.48	1.54
SA at 5mM/L	2.55	2.48	0.34	0.35	1.77	1.70
SA at 10mM/L	2.06	1.97	0.26	0.27	1.43	1.45
SA at 15mM/L	1.86	1.82	0.23	0.23	1.30	1.24
L.S.D at 0.05%	0.09	0.15	0.02	0.02	0.07	0.09
Control	2.50	2.48	0.31	0.31	0.92	0.94
K_2So_4 at 5gm/L	2.64	2.57	0.38	0.38	1.22	1.31
L.S.D at 0.05%	0.05	0.03	0.02	0.01	0.04	0.04

Table 12: Effect of SA, and K_2So_4 on K, Ca, and anthocyanin of strawberry fruits during 2019/2020 and 2020/2021 seasons

Treatments	K (%)		Ca (%)		Anthocyanin (mg/100g)	
	Season 2019	Season 2020	Season 2019	Season 2020	Season 2019	Season 2020
Control	2.49	2.34	0.31	0.31	73.15	79.26
SA at 5mM/L	2.55	2.48	0.34	0.35	130.01	117.19
SA at 10mM/L	2.06	1.97	0.26	0.27	56.43	51.85
SA at 15mM/L	1.86	1.82	0.23	0.23	45.49	46.50
L.S.D at 0.05%	0.09	0.15	0.02	0.02	6.45	5.17
Control	2.50	2.48	0.31	0.31	68.48	70.18
K_2So_4 at 5gm/L	2.64	2.57	0.38	0.38	81.38	86.30
L.S.D at 0.05%	0.05	0.03	0.02	0.01	5.01	4.44

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