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EFFECT OF SALICYLIC ACID AND POTASSIUM SULPHATE ON GROWTH AND YIELD GRAPES CV. 2A CLONE

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ABSTRACT

A field experiment was conducted during the year of 2023-2024 at Main Horticulture Research and Extension Centre (MHREC) under the University of Horticultural Sciences, Bagalkot in order to evaluate the effect of salicylic acid and potassium sulphate on growth, yield and quality of grapes cv. 2A clone. The experiment was laid out in randomized block design with three replication and nine treatments. The results revealed that, T_8 treatment (salicylic acid 4mM + potassium sulphate 0.75 %) recorded the highest internodal length and girth of fruiting shoots (4.44 and 5.28 cm and 5.52 and 7.80 mm respectively), Leaf chlorophyll (26.77 and 36.41SPAD value), leaf area(73.53 and 103.10 cm^2), number of bunches per vine (45.41), number of berries per bunch (204.50), bunch length (20.17cm), bunch width (17.55 cm), bunch weight (620.30 g), yield (21.60 kg/vine) and yield (39.61 t/ha).

***Keywords* :** Grapes (*Vitis vinifera* L.), salicylic acid, potassium sulphate, growth and yield

Introduction

Grapes (*Vitis vinifera* L.) are not only prized for their deliciousness but also stand as one of the foremost and widely cultivated fruit crops globally. Classified botanically as berries, grapes are non-climacteric fruits that grow on both deciduous and perennial woody vines of the genus *Vitis,* believed to have originated around the Black Caspian Sea region. They are celebrated for their distinctive flavour nutritional richness and low-calorie profile being particularly high in easily digestible sugars notably hexose. Grapes are cultivated across 162 thousand hectares in India, yielding a total production of 3445 thousand metric tons with a productivity rate of 21.27 tons per hectare (Anon., 2021). Approximately, 90 per cent of India's grape production originates from the tropical regions of Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. Recently grape cultivation has gained popularity in northern states such as Uttar Pradesh, Punjab, Haryana and West Bengal due to its adaptability and potential for profitable returns. In Karnataka, the primary grape growing regions are situated in the Northern dry zone encompassing districts like Vijayapura, Bagalkot, Belagavi, Gadag, Koppal and Raichur. Grapes are categorized into five distinct groups based on fruit quality to cater to various processing needs such as canning, juicing, raisins, dessert and wine varieties, ensuring suitability for different commercial purposes. In India, the majority of grapes are cultivated for direct consumption. Approximately, 72 to 76 per cent of the grape production is used for table consumption, followed by 22 to 24 per cent for making raisins, 3.50 per cent for wine production and 0.50 per cent for juice. Grapes are grown in both seeded and seedless varieties for fresh consumption and seeded varieties such as Anab-e-Shahi, Dilkush, Bangalore Blue and Muscut Hamburg

(Gulabi or Paneer) along with seedless varieties like Thompson Seedless and its clonal variants (Tas-E-Ganesh, 2A Clone, Sonaka), Sharad Seedless, Beauty Seedless and Perlette are cultivated extensively to meet the demand for fresh grapes. Thompson Seedless stands out as the predominant grape variety cultivated in India. Recently the 2A Clone has been gaining attraction in Karnataka and other regions of India due to its excellent quality for both fresh consumption and raisin production. The 2A Clone is a late maturing white seedless grape variety that excels in both fresh consumption and raisin production. It responds exceptionally well to hormonal treatments which can enhance berry size and produce larger clusters. The introduction and promotion of new table grape varieties like 2A Clone, KR White, Flame Seedless, Crimson Seedless and Fantasy Seedless have piqued the interest of Indian farmers. These varieties are being considered as replacements for older ones due to their high fruit quality and suitability for table use. However, there has been limited research on how to standardize growth regulator use for these varieties, particularly in the context of Indian agricultural conditions.

Potassium plays a crucial role as an activator for various enzymes essential for photosynthesis and respiration, as well as for the production of starch and proteins. It also contributes to the osmotic potential of cells and helps regulate the turgor pressure in guard cells, which control the opening and closing of stomata. However, studies indicate that 50-90% of the potassium in applied fertilizers is often lost to the environment, resulting in significant economic losses (Shalan, 2020). Furthermore, the low efficiency of chemical fertilizers leads to higher production costs and environmental pollution. This highlights the potential benefits of exploring alternative methods.

Maintaining quality standards in grape cultivation hinges on precise practices such as balanced nutrition efficient water management and use of salicylic acid. Use of salicylic acid plays a role in plant growth, stress responses, disease resistance, enhancement of nutrient uptake biotic and abiotic stress response which are vital for the growth and development of grapes. The effective utilization of these metabolites is closely tied to the hormonal balance within the plants.

Recent research highlights the significant benefits of salicylic acid in grapevine cultivation particularly in growth, yield, fruit quality and management. This compound enhances key attributes such as cluster uniformity, berry size and color consistency which are crucial for consumer appeal. Salicylic acid effectively supports seedless varieties which often produce smaller berries by stimulating growth and size increase. Additionally, it is associated with better resistance to transportation and extended post-harvest life due to its role in ethylene suppression. The compound also maintains fruit firmness and delays ripening, thus preserving grape quality from harvest through to market. Beyond these benefits, salicylic acid significantly boosts disease resistance through systemic acquired resistance (SAR). By triggering this defense mechanism in response to biotic and abiotic stressors, salicylic acid promotes the production of pathogenesis-related proteins, strengthens cell walls and enhances the plants ability to combat various pathogens including bacteria, fungi, and viruses. This makes salicylic acid a valuable asset for managing plant health and improving disease resistance (Koche *et al.,* 2021).

Material and Methods

The present experiment was conducted during 2023-2024 at Main Horticultural Research and Extension Centre (MHREC), Sector 70, Division of fruit science, University of Horticultural Sciences, Bagalkot. The site was geographically situated at 16° 10' North latitude, 75° 42' East longitude and an altitude of 542 m above mean sea level. The experiment site soil texture is red sandy loam soil with good physical qualities and drainage with a pH of 8.05 and an EC of 0.15 dS/m. The study location experienced a minimum and maximum temperatures were 17.07 °C and 38.33 °C respectively with an average annual rainfall of 255.6 mm.

To conduct the field experiment, 12-year-old grapevines of cv. 2A clone planted at a spacing of 3 m x 1.5 m and trained on a Y trellis system were selected. A total of 108 plants were chosen using a randomized block design. The selected plants for the experiment were pruned uniformly during the third week of October 2023, as part of the October pruning.

Treatment Details

T_1- Salicylic acid 2 mM
T_2- Salicylic acid 4 mM
T_3- Potassium sulphate 0.5 %
T_4- Potassium sulphate 0.75 %
T_5- Salicylic acid 2 mM + potassium sulphate 0.5 %
T_6- Salicylic acid 2 mM + potassium sulphate 0.75 %
T_7- Salicylic acid 4 mM + potassium sulphate 0.5 %
T_8- Salicylic acid 4 mM + potassium sulphate 0.75 %
T_9- Control

The treatments were imposed at different stages 20 days after forward pruning, 45 days after forward pruning, 55-60 days after forward pruning, 75-80 (veraison stage) days after forward pruning and 15 days before harvesting by foliar application method.

Procedure for preparation of salicylic acid

Determine the desired concentration of salicylic acid based on your specific application requirements. Foliar application of specific concentrations as required. Weigh the required amount of salicylic acid powder accurately and add it to a container with dissolved water. Stir until fully dissolved, then transfer the solution to a clean, residue-free spray tank. Mix thoroughly before use.

Apply the solution for foliar spraying according to the recommended rates and timing for your crop. In this experiment, 2 mM and 4 mM of salicylic acid was used.

So that, 1 M salicylic acid = 138 g in 1lit of water solution.

Then, 1 mM SA= 0.138 g in 1lit of water solution.

2 mM SA= 0.276 g in 1lit of water solution.

4 mM SA= 0.552 g in 1lit of water solution

Growth parameters (At 45 and 90 days after forward pruning)

Internodal length of fruiting shoot (cm)

Measuring scale of 30 cm length is used to take the readings holding between fourth and fifth node from the base end of the fruiting shoot.

Internodal girth of fruiting shoot (mm)

Five each fruiting shoot chosen for internodal length are used to measure the girth of fruiting shoot using vernier caliper between the fourth and fifth nodes from base of selected shoot.

Leaf chlorophyll (SPAD value)

A SPAD-502 meter is used to record the chlorophyll content of physiologically matured leaves. Three readings average were taken from each vine of each replication from all the treatments at 45 and 90 days after forward pruning.

Leaf area (cm^2)

Leaf area was calculated by using the linear method (LBK method) by selectingen leaves per vine and the mean was worked out and expressed in square centimeters.

The mathematical equation to calculate is as follows;

$$\text{Leaf area (LA)} = L \times B \times K\ (0.81)$$

Where, L = Maximum length, B = Maximum breadth and K = Correction factor

Yield parameters (At the time of fruit harvest)

Number of bunches per vine

The total number of bunches were counted and readings were recorded in all treatments considering the replications.

Bunch length (cm)

The bunch length measurements were observed and recorded using the scale of 30cm. Three bunches were measured at harvest to calculate average bunch length.

Bunch width (cm)

The bunch width readings were recorded from left to right-side ends of the bunch. Two bunches readings were taken from each replication in order to obtain the mean value. The results were represented in centimeters.

Bunch weight (g)

During the harvest period three grape bunches were collected from each replication to weigh and get average mean value using the electronic weighing machine, which was expressed in grams (g).

Yield (kg/vine)

The yield per vine, expressed in kilograms (kg) was determined by multiplying the average bunch weight by the average number of bunches per vine.

Yield (t/ha)

The yield per hectare expressed in tons (t), was calculated by multiplying the yield per vine by the total number of vines per hectare.

Results and Discussion

Among the different treatments there was a significant variation observed in the vine growth parameters like internodal length and girth of fruiting shoots. Treatment T_8 showed the maximum internodal length (4.44 cm at 45 days and 5.28 cm at 90 days after forward pruning) and intermodal girth (5.52 mm at 45 days and 7.80 mm at 90 days after forward pruning). The treatment T_8 which is a combination of application of salicylic acid 4 mM and potassium sulphate 0.75 per cent concentrations favored greatly on the internodal length and internodal girth of fruiting shoot.

This result is because of the role of salicylic acid which enhances internodal length and girth of fruiting shoots by influencing cell elongation, expansion and stress response. Thereby increasing internodal length and helps mitigate stress which supports overall growth and development. As reported by Khan *et al.* (2003). This result can be attributed to the vital roles that potassium sulphate on the other hand provides essential nutrients that support cell turgor wall synthesis and overall plant health.

It maintains cell turgor pressure and facilitates the synthesis of structural components in cell walls thereby enhancing the robustness and growth of fruiting shoots. Together these substances contribute to better development and increased structural dimensions of fruiting shoots. Bassiony and Mahmoud (2019) and Eisa *et al.* (2023) in grape cv. Thompson Seedless.

The highest total chlorophyll content 45 and 90 days after forward pruning was observed in T_8 (26.77 and 36.41 SPAD value) which, involved the foliar application of salicylic acid 4 mM and potassium sulphate 0.75 per cent (Table 1). This treatment significantly influenced the total chlorophyll content of the plant. This outcome is largely attributed to the role of salicylic acid which through its various functions contributes to enhanced chlorophyll production and maintenance. It is also due to the role of salicylic acid enhances chlorophyll synthesis in maize under salt stress by boosting chlorophyll a level improving nutrient uptake and acting as an antioxidant. It stabilizes thylakoid membranes increases total chlorophyll and helps plants manage stress, though it lowers the chlorophyll a/b ratio have also been reported in several crops, such as in onion by Amin *et al.* (2007), Lian *et al.* (2000) in soybean, Al-Atrushy (2021) in grape. Chlorophyll content was determined using a SPAD-502-meter (Minolta Camera Co., Osaka, Japan) then it was converted to µg./m^2 according to. Noori *et al.* (2023) in strawberry.

The data on leaf area (cm^2) were displayed in Table 3. Significant variations were identified with regard to leaf area. T_8 exhibited the highest leaf area (73.53 cm^2 and 103.10 cm^2) at 45 and 90^{th} day after fore pruning respectively. This outcome is largely attributed to the role of salicylic acid which through its various functions, contributes to enhanced leaf area, plant growth and development. It is also due to the role of salicylic acid increases leaf area by promoting cell expansion and division enhancing nutrient uptake, mitigating oxidative stress and improving photosynthetic efficiency leading to larger and healthier leaves as reported by Abbaspour and Babaee, (2017) in grape. This positive effect of SA could be related to increasing of CO_2 assimilation and photosynthetic functionality and increasing of mineral uptake in plant under SA application Szepesi *et al.* (2005). It has been reported that application of SA and other relative analogues to the leaves, increase leaf area in corn and soybean plants Khan *et al.* (2003). It has been reported that application of SA and other relative analogues to the leaves, increase leaf area in corn and soybean plants Khan *et al.* (2003). Similar effect was obtained by Cornelia *et al.* (2010) under stress conditions. Gharib (2010) and Khan *et al.* (2003) reported that application of SA enhanced photosynthesis rate and increased the leaf area. It is role of potassium sulphate to increases leaf area by enhancing cell expansion, improving photosynthesis and boosting stress tolerance, leading to larger, healthier leaves as reported by Kumar and Kaur (2019) in strawberry.

The significant effect on number of bunches per vine was observed among different treatments. The highest number of bunches per vine was noticed in T_8 (45.41) and the lowest number of bunches per vine was noticed in T_9. The foliar application salicylic acid 4 mM and potassium sulphate 0.75 per cent. Might be influenced directly on increase in number of bunches per vine. Salicylic acid likely played a role in stimulating growth and strengthening plant tissues, while potassium sulphate improved nutrient uptake and overall plant health. Together, these factors enhance cell development and structural integrity in the bunches leading to increased bunches per vine. This increase in the number of bunches per vine can be attributed to these combined effects (Tasgin *et al.*, 2003).

Among the treatments, significant differences were observed in bunch length, bunch width, and bunch weight with the best results achieved using salicylic acid and potassium sulphate 0.75 per cent (T_8). This positive effect can be attributed to increased activities of key enzymes involved in nitrogen metabolism, such as nitrate reductase, glutamine synthetase and protease, as well as enhanced photosynthesis which together promote plant growth. Bunch length were significantly influenced by different treatments as compared to control. It was recorded that the highest bunch length (21.62 cm) was recorded with 4 mM salicylic acid (T_8) and potassium sulphate 0.75 per cent. This increase in bunch length and bunch volume is due to the fact that salicylic acid has been found to induce cell elongation and expansion. Similar results for the positive effects of salicylic acid on cluster and berry characteristics have been reported by Marzouk and Kassem (2011) in Thompson Seedless grapes, Champa *et al.* (2015) in Flame Seedless grapes and Alrashdia *et al.* (2017) in El-Bayadi Table grapes.

Bunch width was increased significantly by different treatments with the highest bunch width recorded in T_8 (4 Mm salicylic acid and potassium sulphate0.75 %) with (17.55cm) and the lowest was recorded in T_9 (control). Positive effects of salicylic acid on parameters like increase in cell elongation, increasing leaf area, photosynthetic pigments and subsequently rate of photosynthesis might account for improved bunch width (Hayat *et al*., 2010).

The data on bunch weight (g) were displayed in Table 6. Bunch weight was significantly influenced by different treatments compared to control. The highest bunch weight (620.30 g) was recorded in T_8 (4 mM salicylic acid and potassium sulphate 0.75 %) and lowest bunch weight (456.50 g) was recorded in control. This increase in bunch weight might be due to enhance in bio productivity of salicylic acid treated crops by increasing leaf area, photosynthetic pigments and subsequently rate of photosynthesis (Hayat *et al*., 2010). Our results coincide with the findings of Srivastava and Dwivedi (2000), Zhang *et al*. (2003), Shafiee *et al*. (2010), Marzouk and Kassem (2011) who observed positive effects of salicylic on berry weight and size, Champa *et al*. (2015) and Abdel-Salam (2016) in Bez El Naka grape cultivar. The data on fruit yield (kg/vine and t/ha) were displayed in Table 9. And Fig.7 Production parameters like number of fruits per panicle number of fruits per tree total yield per tree and average weight of fruits were significantly affected by different salicylic acid treatments. Among them, salicylic acid 4 mM and potassium sulphate 0.75 per cent was found to be most effective and resulted in maximum number of fruit yield (24.23 kg/vine and 52.17 t/ha) which directly contributed to increased number of fruits per panicle and number of fruits per tree and ultimately resulted in higher yield. The increase in yield parameters due to salicylic acid observed in the present investigation can be attributed to increased photosynthesis activity in leaves and translocation of more photo assimilates to fruits. Salicylic acid is responsible for increasing yield by increasing fruit set percentage increase in fruit weight and number of fruits per tree.

These findings are in agreement with the findings of Singh *et al.* (2001), Ngullie *et al.* (2015) and Ahmed *et al.* (2022) in strawberry, Ashraf *et al*. (2012) in Kinnow and El-EI-Razek *et al*. (2013) in olive.

Role of potassium sulphate (K_2SO_4) enhances fruit yield by promoting better plant health and nutrient uptake. It increases fruit yield per vine (kg/vine) and overall yield per hectare (t/ha) by supporting cell development, improving water regulation, and boosting photosynthesis. These effects lead to more vigorous growth, higher fruit set and larger, more productive vines.

Conclusion

Based on the study results, it can be concluded that the combination of foliar applications of salicylic acid and potassium sulphate significantly affects plant growth, yield and quality in grapevines of cv. 2A Clone. Specifically, the combination of salicylic acid and potassium sulphate enhances berry growth, development and quality. Vines treated with 4 mM salicylic acid and 0.75 per cent potassium sulfate showed significantly improved growth, bunch and berry parameters, yield and overall grape quality.

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Table 1 : Internodal length and girth of fruiting shoot, leaf chlorophyll and leaf area after forward pruning of grapes cv. 2A Clone as influenced by foliar application of salicylic acid and potassium sulphate

Treatment	Internodal length of fruiting shoot (cm)		Internodal girth of fruiting shoot (mm)		Leaf chlorophyll (SPAD value)		Leaf area (cm^2)	
	45 DAFP	90 DAFP	45 DAFP	90 DAFP	45 DAFP	90 DAFP	45 DAFP	90 DAFP
T_1	3.07	4.03	4.21	6.80	23.44	34.74	60.72	94.02
T_2	3.11	4.95	4.96	6.37	24.51	35.15	63.48	94.91
T_3	2.61	3.19	3.51	5.51	23.28	32.43	62.40	88.98
T_4	3.20	4.57	4.91	6.71	24.16	33.77	64.51	90.69
T_5	3.07	4.65	4.66	6.71	23.35	35.79	69.53	97.24
T_6	3.20	4.78	5.28	6.38	24.83	35.83	70.12	99.75
T_7	4.36	5.21	5.44	7.08	26.67	36.18	71.11	102.90
T_8	4.44	5.28	5.52	7.80	26.77	36.41	73.53	10.3.10
T_9	2.35	3.11	3.47	5.59	22.20	32.12	51.86	86.22
S.Em ±	**0.04**	**0.05**	**0.07**	**0.30**	**0.36**	**0.55**	**1.01**	**1.01**
CD at 5 %	**0.13**	**0.16**	**0.21**	**0.91**	**1.08**	**1.65**	**3.04**	**3.04**

Note: DAFP- Days after forward pruning

T_1 – Salicylic acid 2 mM
T_2 – Salicylic acid 4 mM
T_3 - Potassium sulphate 0.5 %
T_4 - Potassium sulphate 0.75 %
T_5 – Salicylic acid 2mM + potassium sulphate 0.5 %
T_6 – Salicylic acid 2mM + potassium sulphate 0.75 %
T_7 – Salicylic acid 4mM + potassium sulphate 0.5 %
T_8 – Salicylic acid 4mM+ potassium sulphate 0.75 %
T_9 - Control

Table 2 : Number of bunches, bunch length, bunch width, bunch weight and yield of grapes cv. 2 A Clone as influenced by foliar application of salicylic acid and potassium sulphate

Treatment	Number of bunches per vine	Bunch length (cm)	Bunch width (cm)	Bunch weight (g)	Yield (kg/vine)	Yield (t/ha)
T_1	38.85	17.92	16.30	510.11	23.34	48.65
T_2	40.83	17.08	16.03	520.33	22.46	45.13
T_3	33.92	16.92	15.40	470.30	22.12	42.44
T_4	36.67	17.00	16.29	550.20	22.42	43.06
T_5	42.50	18.50	16.50	573.13	23.50	48.65
T_6	43.09	18.92	16.59	585.26	23.79	49.98
T_7	44.45	19.50	16.92	608.23	23.89	51.25
T_8	45.41	20.17	17.55	620.30	24.23	52.17
T_9	29.63	15.50	15.29	456.50	21.60	39.61
S.Em ±	**0.64**	**0.48**	**0.25**	**8.49**	**0.43**	**1.43**
CD at 5 %	**1.93**	**1.42**	**0.75**	**25.45**	**1.28**	**4.29**

T_1 – Salicylic acid 2 mM
T_2 - Salicylic acid 4 mM
T_3 - Potassium sulphate 0.5 %
T_4 - Potassium sulphate 0.75 %
T_5 - Salicylic acid 2 mM + potassium sulphate 0.5 %
T_6 - Salicylic acid 2 mM + potassium sulphate 0.75 %
T_7 – Salicylic acid 4 mM + potassium sulphate 0.5 %
T_8 – Salicylic acid 4 mM+ potassium sulphate 0.75 %
T_9 - Control

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