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Influence of Salicylic Acid on The Vegetative and Reproductive Attributes of Sweet Pea

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Sweet pea is an important cut flower and a garden plant. Its growth needs to be optimized for quality flower production. In this regard, a study on the influence of salicylic acid on the vegetative and reproductive attributes of sweet peas was conducted at the ornamental nursery, Horticulture Department, University of Agriculture Peshawar, Pakistan. The experiment was conducted in RCBD arrangement with a single factor i.e. salicylic acid (SA) whose concentrations were 0, 60, 80, and 100mgL^{-1}. All the treatments were replicated three times. The results showed that SA at the rate of 100 mgL^{-1} resulted in maximum number of branches plant^{-1} (43.733), number of leaves plant^{-1} (71.667), chlorophyll content (65.84 SPAD), and number of flowers plant^{-1} (65.02) of sweet pea which were statistically similar to the results obtained when the SA at the rate of 80mgL^{-1} was applied to the plants. The maximum plant height (343.40cm) and minimum days to flowering (93.33 days) were noted when the plants were sprayed with 80 mgL^{-1} of SA. The minimum number of branches plant^{-1} (33.400), number of leaves plant^{-1} (63.167), Plant height (325.53 cm), chlorophyll content (47.42 SPAD), number of flowers plant^{-1} (44.45) and maximum days to flowering (108.67 days) were observed in control. Keeping in view the above results it was recommended that SA at the rate of 80 mg/L be used for enhanced vegetative and reproductive attributes of sweet pea.
Keywords: Sweet Pea, Salicylic Acid, Vegetative attributes, Reproductive Attributes, Early Flowering

Introduction:

Sweet pea (*Lathyrus odoratus* L.) is a member of the Fabaceae family [1]. It is an annual climbing plant that typically grows between 1 to 2 meters in height and requires support for upright growth. The leaves are pinnate with two leaflets and a terminal tendril which helps sweet peas to climb and support plant structure. Its vibrant colors make it a perfect garden flower [2]. Sweet pea is native to southern Italy and the Aegean Islands. It is cultivated as a cut flower and is grown in greenhouses from winter to spring. Summer flowering sweet peas are the wild types and have blooms with a longer shelf life. The cut flower industry prefers the day-neutral winter flowering varieties of sweet peas [3].

Sweet peas thrive in well-drained sandy loam soil. Adding compost enhances soil fertility and organic matter without causing any issues. Sweet peas are cool-season plants that require low temperatures for germination. To facilitate the germination of sweet pea seeds, the hard seed coat is broken by soaking the seeds in the water for 24 hours. This plant can be grown in summer in the garden and needs a continuous supply of water and adequate nutrients to keep its growth going for as long as possible [4]. Sweet peas are self-compatible and easy to raise with cultivars reflecting inbred lines. Their blooms are zygomorphic, featuring a corolla divided into a large dorsal petal (standard or banner), a pair of lateral petals (wings), and a fused pair of ventral petals, characteristic of legumes. Interestingly, in sweet peas, a purple flower color can emerge from a cross between two white-flowered plants, one with long pollen grains and the other with round pollen grains.

There is a remarkable variety of sweet pea types. Older varieties have smaller flowers but a stronger and more pleasant fragrance compared to newer cultivars like Grandiflora and Spencer. They come in a variety of sizes including dwarf, medium, and tall varieties. The dwarf cultivars are perfect for growing in pots or containers. Long-day sweet pea cultivars are wild-type plants while spring-flowering varieties are semi-long days [5]. They have a pleasant, flowery aroma that is sometimes compared to honeysuckle, lilac, and jasmine. The perfume is frequently characterized as light and delicate, although it can be highly overpowering. They are commonly used in perfumes and other scents [6].

Salicylic acid (SA) has important physiological roles in plant growth and development including increasing the plant's ability to cope with different stresses. SA is a signaling molecule that enhances the plant's stress tolerance. SA is an endogenous regulator of growth and signaling molecule responsible for inducing environmental stress tolerance of plants so the application of salicylic acid could enable the plants to tolerate stress conditions such as zinc toxicity because zinc stress decreases growth, chlorophyll content, and yield. SA also plays a role in flowering, nutrient uptake, controlling the movement of gaseous exchange, and regulation of stomata and protein synthesis [7]. SA positively enhances the amount of organic acids and dry matter increasing the chlorophyll content and carotenoid. It also reduces ethylene production and significantly increases metabolic rates [8].

Objectives:

- To evaluate the effect of salicylic acid on the vegetative growth of sweet peas (Lathyrus odoratus L.).
- To assess the impact of salicylic acid on the reproductive traits of sweet peas, including flowering and seed development.
- To determine the optimal concentration of salicylic acid for enhancing plant growth and yield.

Novely Statement:

This study explores the influence of salicylic acid on the vegetative and reproductive attributes of sweet peas, providing new insights into its capability as a growth regulator and stress mitigator, paving the way to optimize the yield of sweet peas.

Materials and Methods:

An experiment was performed at Horticulture Nursery, University of Agriculture, Peshawar, Pakistan in November 2021. Peshawar Valley has a subtropical climate with 4 seasons i.e., Summer, Spring, Winter, and Autumn. The annual rainfall in Peshawar is about 400mm. The latitude of the experimental plot is 34.02° and the longitude of the experimental plot is 71.48° while it is 360 meters above sea level [9].

The experiment was conducted using a Randomized Complete Block Design (RCBD) with a single factor, i.e. Salicylic acid Concentrations (0, 60, 80, 100 mg/L. It included four treatments and all treatments were replicated three times.

Field Management:

The field was prepared using a rotavator at the end of October, and a basal dose of NPK fertilizer was applied to the soil one month before sowing. Plant to plant distance was 20cm while row to row distance was kept at 30cm. There was a total of 10 plants per treatment and the plot size was $2.4m^2$. All the other cultural practices like weeding, hoeing, irrigation, fertilizer application, etc. were kept constant for all plots. Sowing was carried out on November 25, 2021. The first spray was applied 60 days after sowing, followed by the second foliar application one week later.

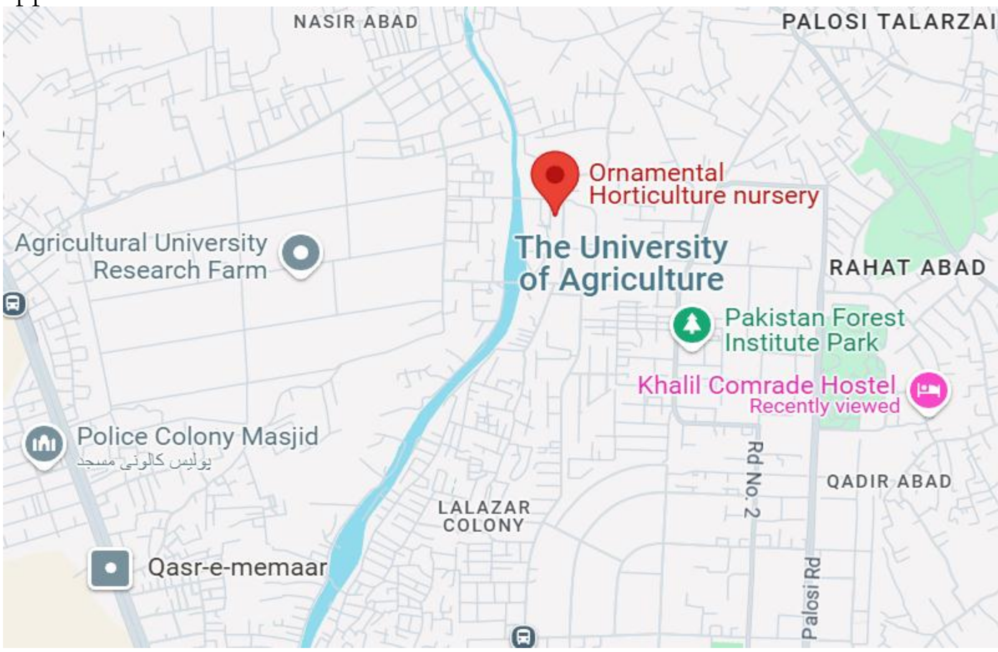

Figure 1. Map of the study cite

Parameters Studied:

Data was collected considering various growth attributes, including the number of branches per plant, number of leaves per plant, plant height (cm), chlorophyll content (SPAD), days to flowering, and number of flowers per plant. The number of branches and leaves was recorded from five randomly selected plants, and the average was calculated.

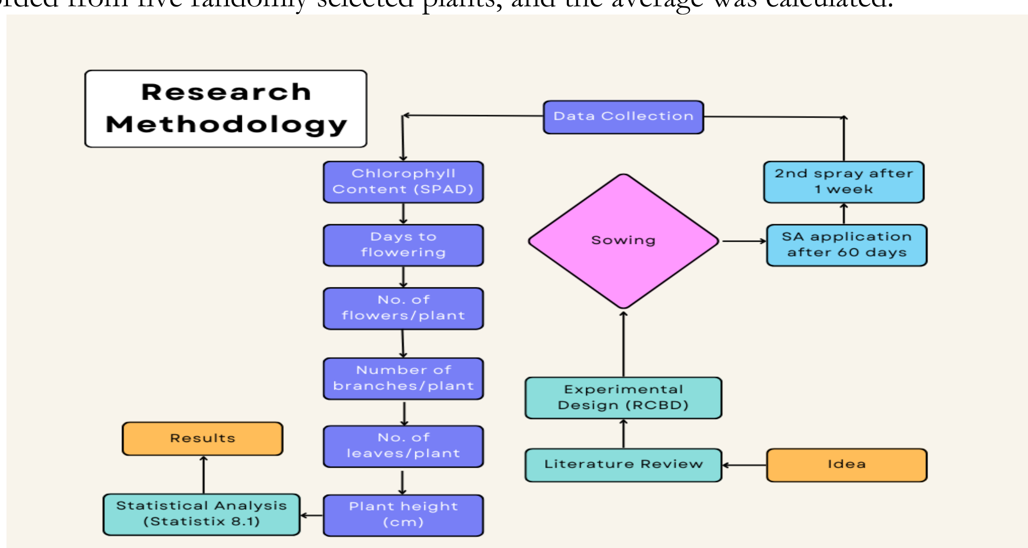

Figure 2. Flowchart of the research methodology

Plant height was measured with the help of a measuring tape from the base to the tip of the five randomly selected plants and their mean was taken. The measuring tape was calibrated by measuring a known distance of 1m and after ensuring the precise results, the plant height was recorded. Chlorophyll content was measured with the help of a SPAD meter in randomly selected five plants and their mean was taken. The SPAD meter was calibrated by comparing the results of the SPAD meter with those of chlorophyll content recorded by the spectrophotometer. Days to flowering were recorded from sowing to the first bloom in five randomly selected plants, and the average was calculated. Similarly, the number of flowers was recorded by counting flowers in five randomly selected plants and the average was taken.

Data Analysis:

Statistical analysis was carried out on STATISTIX 8.1 (statistical software). All the recorded data was subjected to Analysis of variance (ANOVA) following RCBD design. Means were separated using the LSD test at 1 and or 5 % level of significance where necessary [10].

Results:

The highest number of branches per plant (43.733) was observed with the application of 100 mg/L SA, which had a similar effect to 80 mg/L SA, resulting in 38.033 branches per plant. In contrast, the lowest number of branches (33.400) was recorded in the control treatment Figure 3.

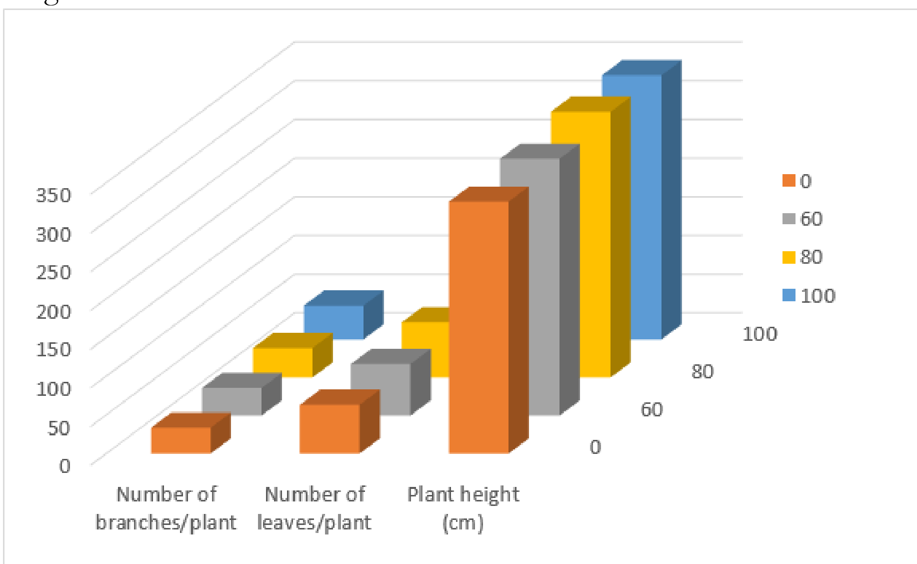

Figure 3. Number of branches/plants, number of leaves/plants, and plant height (cm) as influenced by Salicylic acid application

The number of leaves per plant was significantly affected by the application of salicylic acid (Table 1). The maximum number of leaves per plant (71.667) was recorded when 100 mgL^{-1} of SA was applied to sweet peas whose effect was statistically similar to the SA at the rate of 80 mgL^{-1} and the number of leaves $plant^{-1}$ (71.400) was noted. While the minimum number of leaves (63.167) was recorded in plants sprayed with distilled water (Figure 3).

Table 1: Number of branches per plant, Number of leaves per plant, Plant height (cm), Chlorophyll Content (SPAD), Days to flowering, and Number of flowers per plant as affected by different salicylic acid concentrations

Salicylic Acid Conc. (mg/L)	Number of branches per plant	Number of leaves per plant	Plant height (cm)
0	33.400B	63.167B	325.53B
60	35.600B	66.733AB	331.83B
80	38.033AB	71.400A	343.40A
100	43.733A	71.667A	341.43A
Salicylic Acid Conc. (mg/L)	**Chlorophyll Content (SPAD)**	**Days to flowering**	**Number of flowers per plant**
0	47.42B	108.67A	44.45C
60	56.38AB	95.67AB	51.14BC
80	61.48A	93.33B	57.66AB

100	65.84A	97.33AB	65.02A
LSD	13.274	13.204	10.459

The plant height of sweet pea plants was significantly affected by SA application (Table 1). The maximum plant height (343.40cm) was recorded when 80 mgL^{-1} of SA was applied to sweet peas which was statistically similar to the plant height recorded at 100 mgL^{-1}. While the minimum plant height (325.53cm) was recorded in plants sprayed with distilled water (Figure 3).SA significantly influenced the chlorophyll content of Sweet Pea (Table 1). The maximum chlorophyll content (65.84 SPAD) was recorded when 100 mgL^{-1} of SA was applied which was statistically similar to the effect of SA applied at the rate of 80 mgL^{-1} while the minimum chlorophyll content (47.42 SPAD) was recorded in the control treatment (Figure 4).

Days of flowering were significantly affected by the application of SA. The maximum days to flowering (108.67 days) were recorded at control while the minimum days to flowering (93.33 days) were recorded in plants sprayed with 80 mgL^{-1} of SA (Figure 4). The number of flowers in plant^{-1} was significantly affected by the application of salicylic acid (Table 1). The maximum number of flower plant^{-1} (65.02) was recorded when 100 mgL^{-1} of SA was applied to sweet peas. Mean data shows that SA at the rate of 80 mgL^{-1} has statistically similar effects as that of 100 mgL^{-1}. The minimum number of flowers plant^{-1} (44.45) was recorded in plants sprayed with distilled water (Figure 4).

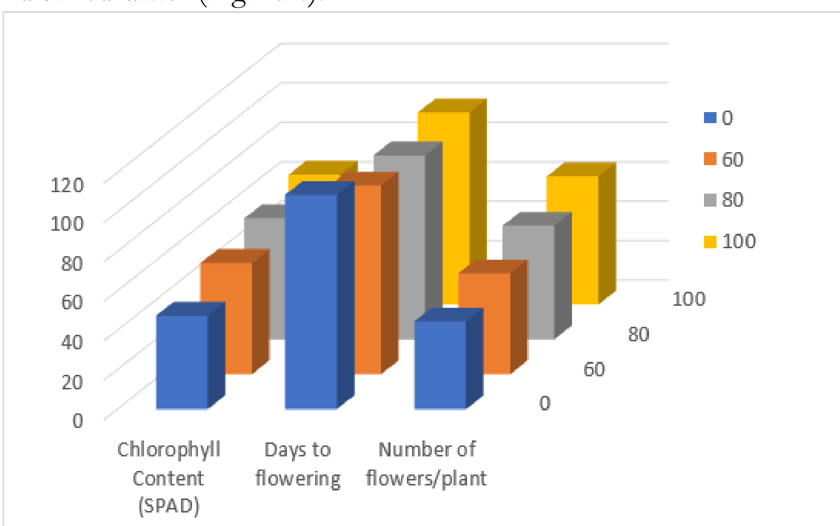

Figure 4. Chlorophyll content (SPAD), days to flowering, and number of flowers/plant as influenced by salicylic acid application

Discussions:

SA is a plant growth regulator responsible for enhancing plants' nutrient uptake. Optimum nutrient availability resulted in the maximum branching of the sweet pea. It also influences the plants' hormonal balance, contributing to the enhanced branching of the sweet pea. The results are in correlation with [11] who also observed that the number of branches increased with the application of salicylic acid. [12] also reported that SA enhances the nutrient uptake of plants and contributes to more branches per plant. SA is a plant growth promoter that enhances root activity and ensures the optimum uptake of plant nutrients. Optimum nutrient uptake results in vigorous vegetative growth and plants tend to have more leaves per plant. [13] also reported that the number of leaves increased in marigold plants when they were treated with SA. It is found to enhance the photosynthetic activity in plants due to which more carbohydrates are produced and more food is available for the optimum growth and nourishment of plants [14]. [15] also observed that the application of SA significantly enhanced the plant height of tomato plants.

SA is a biostimulant that enhances the plant's ability to absorb nutrients from the soil causing an increase in the chlorophyll content of the sweet pea plants. It is responsible for the increase in photosynthetic efficiency thus maximizing the plant's photosynthetic efficiency and ultimately leading to an increase in the food availability to enhance the overall growth and development of plants. [16] also observed that foliar application of SA enhanced the chlorophyll content in the cucumber plants.

SA is a signaling molecule that directly affects various hormonal pathways, including auxins, gibberellic acid, and cytokinins [17]. It promotes the activity of gibberellic acid which influences the hormonal balance of the plant making it shift to the reproductive phase. A healthy plant with a higher carbon-to-nitrogen ratio shifts to the reproductive stage and produces flowers early. By influencing the concentration of these plant growth regulators, it can enhance the number of flowers per plant. Moreover, optimum nutrient absorption and nourishment also lead to an increase in the number of flowers per plant. [13] also recorded that the SA enhances the number of flowers per plant.

It plays a vital role in regulating various growth and reproductive attributes of sweet peas, influencing parameters such as the number of branches/plant, number of leaves per plant, plant height, chlorophyll content (SPAD), days to flowering, and number of flowers per plant. Through its involvement in systemic acquired resistance (SAR), SA enhances the plant's defense mechanisms, improving overall plant health. This results in more robust vegetative growth, manifested in an increase in the number of branches and leaves per plant, as the plant can allocate more resources toward growth rather than stress responses. Additionally, SA's effect on chlorophyll content ensures better photosynthetic efficiency, leading to healthier foliage and more efficient energy production. This boost in photosynthetic capacity can directly impact plant height and overall growth, contributing to stronger plants that can withstand environmental challenges [18].

Moreover, SA's hormonal interactions with auxins, cytokinins, gibberellins, and abscisic acid (ABA) further regulate reproductive processes in sweet peas. SA influences days to flowering, potentially reducing the time required for plants to reach flowering stages, and can increase the number of flowers per plant by promoting better floral initiation and development. The precise timing of flowering and reproductive success is enhanced by SA's modulation of growth hormones, particularly in coordination with gibberellins, which regulate flowering time and fruit set [19]. In this way, SA not only improves the vegetative attributes like branching, leaf number, and plant height but also optimizes the reproductive potential of sweet peas by ensuring early and abundant flowering.

Conclusions:

Salicylic acid (SA) improves the vegetative as well as reproductive attributes of the sweet pea by enhancing the number of branches per plant, number of leaves per plant, chlorophyll content, and number of flowers per plant of sweet pea. It directly influences the hormonal and photosynthetic activity which improves nutrient uptake and maximizes the plant productivity to enhance the vegetative and reproductive growth. Among the studied treatments, SA at the rate of 80mg/l showed improved results and it should be applied for optimum growth of sweet pea plants.

Conflict of Interest:

All the authors declare no conflict of interest.

Authors Contributions:

M.A. conceived the idea, S.J. performed the experiment, K.A. and L.N. provided technical assistance during the experiment, A.M. and A.A. prepared the Initial draft of the manuscript, H.A. prepared the final draft, graphs, and figures for the manuscript, B.R. and I. proofread the paper.

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