Research Article

EFFECT OF PINCHING AND SALICYLIC ACID APPLICATION ON FLOWER AND SEED PRODUCTION IN LARKSPUR (*Delphinium ajacis* L.)

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ABSTRACT

Delphinium ajacis L. (Larkspur) is a widely cultivated ornamental plant valued for its vibrant inflorescences and use in cut flower production. To enhance its growth, flowering, and seed yield, a study was conducted using a Randomized Complete Block Design (RCBD) with a factorial arrangement of two factors: salicylic acid (0, 100, 150, and 200 mg L^{-1}) and pinching treatments (no pinching, 1-inch, and 2-inch pinching). A total of 12 treatments were replicated three times. The analysis revealed that both salicylic acid and pinching had a significant influence on plant performance ($p < 0.01$). The highest concentration of salicylic acid (200 mg L^{-1}) resulted in the earliest flowering (112.2 days), tallest plants (104.3 cm), highest number of capsules per plant (51.5), branches (10.8), spike length (34.9 cm), and seed weight per plant (21.6 g). Among pinching treatments, 2-inch pinching produced the highest number of branches (11.7), capsules per plant (46.6), and seed weight (23.9 g), though with reduced plant height (77.6 cm). These results suggest that applying 200 mg L^{-1} salicylic acid combined with 2-inch pinching significantly enhances the vegetative and reproductive performance of *Delphinium ajacis* under the agro-climatic conditions of Peshawar.

Key Words: *Delphinium ajacis*, Pinching, Salicylic Acid, Flower, Seed Production.

INTRODUCTION

The genus *Delphinium*, derived from the Greek word *delphis*, meaning "dolphin," is so named due to the flower's resemblance to the shape of a dolphin. *Delphinium* belongs to the family Ranunculaceae (buttercup family) and comprises over 300 species, including annuals, biennials, and perennials (Simon et al., 2001). Commonly known as larkspur, this genus is predominantly distributed in the North Temperate and North Frigid Zones, where many wild species naturally occur (Honda et al., 2002).

Although more than 300 species exist, only a few are widely cultivated today, including *Delphinium elatum* L., *Delphinium nudicaule*, and *Delphinium ajacis*, which have been in cultivation for over three centuries (Legro, 1961).

Morphologically, *Delphinium* flowers are characterized by five united sepals, typically in shades of blue ranging from pale to deep hues. Within the sepals lie four small, inconspicuous petals, often matching the sepal color. The main flowering stem is typically erect, with height variations ranging from as short as 10 cm to as tall as two meters, depending on the species. The seeds are small, black, and lightweight (Singh, 2014). *Delphinium* species are highly valued as ornamental plants, particularly as cut flowers, both in fresh and dried forms. Their striking floral structure, wide range of vibrant colors, and aesthetically appealing foliage contribute to their

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popularity in commercial floriculture (Chakrabarty & Datta, 2022).

Salicylic acid (SA) is a plant hormone that plays a pivotal role in regulating plant defense mechanisms against both abiotic and biotic stresses through various physiological, morphological, and biochemical pathways (War et al., 2011). It significantly contributes to several key plant processes, including growth and development, transpiration, photosynthesis, iron uptake, and internal transport mechanisms (Vlot et al., 2009). Although present in very small quantities in plants, salicylic acid is crucial in activating disease resistance responses following pathogen attacks. It modulates stress responses by influencing biochemical signals, thereby enhancing traits such as plant height, number of branches, leaf count, fresh and dry biomass, and total carbohydrate content (Gharib, 2006).

However, excessive concentrations of salicylic acid can be detrimental, potentially causing physiological damage to plants (Sweify and Abdel-Wahid, 2008). Moreover, SA plays a key role in establishing systemic acquired resistance (SAR), where a bacterial infection in a mature leaf induces resistance in newly forming leaves. Pinching is a horticultural technique that involves removing the apical bud to promote lateral branching and encourage a bushier growth habit (Islam et al., 2010). Pinching results in optimum root growth and improves the branches of the plants (Antonio et al., 2000). It also regulates the flowering and pinched plants tends to form more flowering buds as compare to the unpinched plants thus significantly influencing the flower bud emergence in plants (Mutlu and Agan, 2015).

Keeping in view the importance of *Delphinium ajacis*, a study was conducted to evaluate various level of salicylic acid and pinching and their interactive effect on the growth and production of *Delphinium ajacis*.

MATERIALS AND METHODS

Experimental Conditions

A study on "Effect of Pinching and Salicylic Acid Application on Flower and Seed Production of Larkspur (*Delphinium ajacis* L.) was conducted at the Horticultural Nursery, The University of Agriculture, Peshawar, Pakistan. It's located at 34.02°N, 71.47°E. Maximum rainfall is recorded in the month of March i.e. 77 mm, while the least is recorded in June i.e. 7mm (Basit et al., 2022). The soil had 17.60% sand, 55.95% silt, 26.25% clay, 0.37 dSm^{-1} EC, 8.1 PH, 0.09% nitrogen, 4.30 $mg.kg^{-1}$ phosphorus, and 118 $mg.kg^{-1}$ potassium. The field was plowed, leveled and properly decomposed farm yard manure was applied to the field before transplantation. Seeds were sown in trays and were transplanted to the field on 9th Nov 2022. Germination was observed on 22nd November 2022, and vigorous seedlings were selected for field transplantation on 21st December 2022 once they reached a size of 10–12 cm. Standard agronomic practices, including irrigation and weeding, were followed throughout the experiment

Experimental Layout

Seedlings were transplanted into plots arranged in a Randomized Complete Block Design (RCBD) with a factorial arrangement, consisting of two factors: pinching and salicylic acid application. Each treatment was replicated three times, resulting in a total of 36 experimental units. Each plot measured 1.5 m × 1.5 m, accommodating 15 plants per plot at a spacing of 30 cm between plants and 30 cm between rows to ensure adequate growth and light exposure. Factor A (Pinching) comprised three levels i.e. No pinching, Pinching at 1 inch (2.5 cm) from the apex, Pinching at 2 inches (5.0 cm) from the apex while the Factor B (Salicylic Acid) included four concentrations i.e. 0, 100, 150, and 200 mg L^{-1}.

Pinching was performed manually using sterilized scissors to remove the apical bud at the designated heights. Salicylic acid solutions were prepared freshly and applied as a foliar spray 70 days after transplanting using a hand-held sprayer. Each plant received a uniform spray volume of approximately 100 mL of solution, applied early in the morning to minimize evaporation. The treatments were applied once at the designated time. Standard cultural practices such as weeding, irrigation, and pest management were uniformly applied across all plots throughout the experiment.

Studied Parameters

Data on various growth and reproductive parameters were collected from five randomly selected plants per treatment, and the mean values were calculated for analysis. The number of days to first flowering was recorded by counting the days from the date of transplantation until the appearance of the first flower on each selected plant. Plant height (cm) was measured using a measuring tape, from the base at soil level to the tip of the main stem. Similarly, the spike length (cm) was also measured using a measuring tape. Data regarding branches and capsules were recorded by counting the no. of branches and capsules from each treatment and replication and their average was then computed. Seed yield was determined by using a digital balance to weigh the collected seeds from each treatment and replication and after that its average was noted.

Statistical Analysis

The ANOVA was computed under a two-factor Randomized Complete Block Design (RCBD) having three replication using Statistix 8.1. Where significant differences were found ($p \leq 0.01$), the Least

Significant Difference (LSD) test at a 1% probability level was applied for mean separation (Ali et al., 2024).

RESULTS

Table 1 shows the data regarding days to flowering, plant height (cm), number of Capsules plant^{-1}, number of branches plant^{-1}, spike length (cm), Seed weight plant^{-1} (g) as affected by Salicylic acid concentration (mg L^{-1}) and Pinching.

The statistical analysis revealed that salicylic acid application had a significant effect on all observed parameters of larkspur (*Delphinium ajacis*), including days to flowering. The earliest flowering was recorded in plants treated with 200 mg L^{-1} salicylic acid (112 days), followed by treatments with 150 mg L^{-1} (114 days) and 100 mg L^{-1} (118 days) (Fig. 1). The maximum number of days to flowering was observed in the control treatment using distilled water (121 days). In contrast, pinching treatments had no statistically significant effect on days to flowering (Table 1).

The tallest plants were recorded in the treatment where salicylic acid was applied at 200 mg L^{-1} (104.3 cm), followed by treatments with 150 mg L^{-1} (95.6 cm) and 100 mg L^{-1} (89.2 cm), respectively. The shortest plants were observed in the control treatment with distilled water (80.2 cm). Similarly, the highest number of capsules per plant was recorded under the 200 mg L^{-1} salicylic acid treatment (51.5), while the lowest number was observed in the control group (27.9).

The highest number of branches per plant (10.8) was observed in plants treated with 200 mg L^{-1} salicylic acid. This was followed by treatments with 150 mg L^{-1} and 100 mg L^{-1}, which produced 9.0 and 7.4 branches per plant, respectively (Fig. 1). The lowest number of branches (6.6) was recorded in the untreated control plants (Table 1).

Table 1. Days to flowering (DF), Plant Height (PH), Number of Capsules plant^{-1} (NOC), Number of branches plant^{-1} (NOB), Spike length (SL), Seed weight plant^{-1} (SW) as affected by Salicylic acid concentration (mg L^{-1}) and Pinching.

Pinching stages	**DF**	**PH (cm)**	**NOC**	**NOB**	**SL (cm)**	**SW (g)**
Control	116.5	112.1 A	29.1 C	6.4 C	32.3	9.5 C
1" pinch	116	87.3 B	38.5 B	7.4 B	31.2	17.6 B
2" pinch	117.2	77.6 C	46.6 A	11.7 A	30.7	23.9 A
LSD P≤ 0.01	NS	6.7	6.78	0.62	NS	3.25
Salicylic acid conc. (mg L^{-1})						
0	121.4 A	80.2 C	27.9 C	6.6 D	26.5 C	13.1 C
100	118.2 B	89.2 B	32.6 BC	7.4 C	30.8 B	15.7 BC
150	114.6 C	95.6 B	40.4 B	9 B	33.4 AB	17.6 B
200	112.2 D	104.3 A	51.5 A	10.8 A	34.9 A	21.6 A
LSD P≤ 0.01	1.8	7.8	7.83	0.72	2.81	3.75
Interaction	NS	NS	NS	NS	NS	NS

NS: Non-significant; Significant at P≤ 0.01; The means that are shown by various letters differ significantly from one another at P ≤ 0.01.

Application of salicylic acid at a concentration of 200 mg L^{-1} resulted in the greatest spike length per plant (34.9 cm), followed closely by treatments with 100 mg L^{-1} (34.8 cm) and 150 mg L^{-1} (33.4 cm). The shortest spike length (26.5 cm) was recorded in the control plants (Table 1). Salicylic acid also positively influenced seed weight in larkspur. The highest seed weight per plant (26.1 g) was observed with 200 mg L^{-1} salicylic acid, followed by 150 mg L^{-1} (17.6 g) and

100 mg L^{-1} (15.7 g). The lowest seed weight (13.1 g) was found in untreated control plants (Fig. 1).

Pinching had a significant effect on plant height (cm), number of capsules per plant, number of branches per plant, and seed weight (g), as shown in Fig. 1. The tallest plants were observed in the unpinched treatment (112.1 cm), followed by plants pinched at 1 inch (87.3 cm), while the shortest plants were recorded when pinched at 2 inches (77.6 cm). Statistical analysis further revealed that pinching significantly influenced the number of capsules per plant. The highest number of capsules (46.6) was recorded in plants pinched at 2 inches, followed by the 1-inch pinching treatment (38.5), whereas the lowest number of capsules (29.1) was observed in unpinched control plants (Table 1).

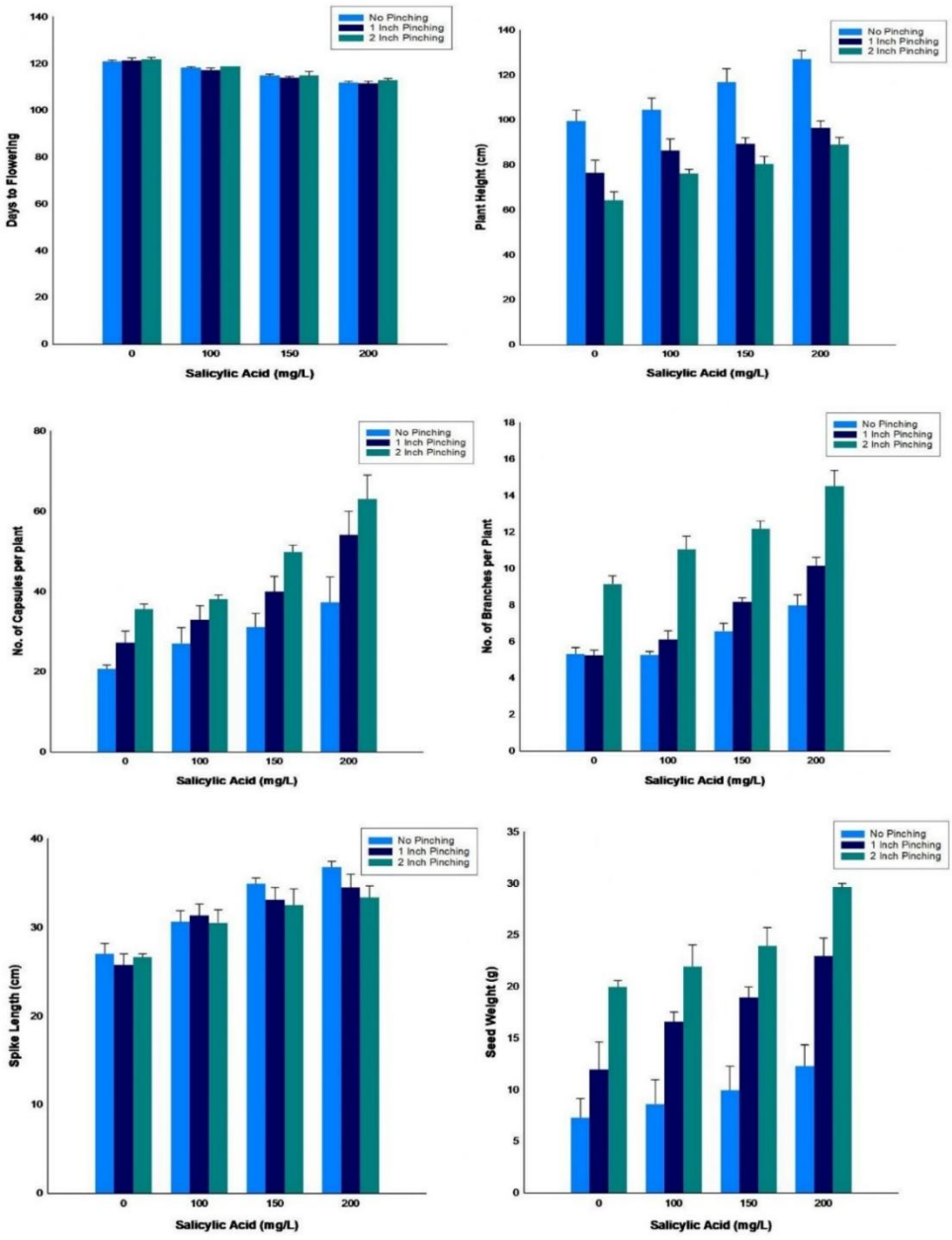

Fig 1. *Influence of Salicylic acid and Pinching on the studied attributes of Larkspur*

The highest number of branches per plant (11.7) was observed in plants pinched at 2 inches, followed by those pinched at 1 inch (7.4). The lowest number of branches (6.4) was recorded in the unpinched control plants. The maximum seed weight (23.9 g) was noted in plants pinched at 2 inches while the minimum weight of seeds (9.5 g) was recorded in unpinched plants (Fig. 1).

DISCUSSIONS

The current experiment showed that the use of salicylic acid (SA) and pinching played major roles in the growth, flowering and seed production of *Delphinium ajacis*. Such findings are in line with previously reported outcomes that show that pinching and SA are good sessions that improve vegetative and reproductive characters of almost all crops and ornamentals. Improved growth under salicylic acid is explained by a combination of factors due to the multifactorial role of salicylic acid as a signaling molecule that regulates the plant metabolism, growth and development (Jabin et al., 2025). SA triggers the production of secondary metabolites that speed up the initiation of floral buds and early flowering (Zong-You et al., 2021). It affects the regulation of flowering-related genes and alters hormone signaling, especially in using auxins, gibberellins and cytokinins, which are directly involved in floral transition and fruit development (Arif et al., 2020; Trejo et al., 2023). The use of 200 mg L -1 SA in the present study showed the minimal flowering time, highest plant height and longest spikes and this aligns with the report of Hayat et al. (2007) and Li et al. (2022), who reported that SA increases plant height and organ elongation by inducing cell division and extension and by modulating the levels of ethylene.

Moreover, SA greatly enhanced reproductive output which was indicated by capsules and seed weight per plant. This is ascribed to prior research exposing that SA can enhance the viability of pollen, minimize flower and pod loss, and improve seed filling (Seta-Koselska et al., 2015; Ahmad et al., 2023). Its binding with plant hormones leads to more branching and accumulation of biomass (Mohammed et al., 2020), which further results in more photosynthetic efficiency and resource allocation to reproductive organs. Consistent with these results, our experiment revealed that SA-treated plants had better performance with regard to all the significant yield measures, such as the number of branches, capsules and seeds per plant.

Pinching caused interference in plant architecture by deactivating apical dominance by the removal of the shoot apex, and lateral shoot growth was encouraged. This method shortened the height of the plant but multiplied the number of side branches, which helps to have more flowering places and a more extensive canopy. These observations are in agreement with one made by Rezazadeh and Harkess (2015) that pinching is a technique fantasized to modify plant morphology through manipulation of hormonal balances, particularly in auxin levels. The fact that pinching 2 inches produced more branches and more seed yield correlates with other studies not only with the tomato (Kattel et al., 2023), but also with other crops, including okra and fenugreek, in which pinching also resulted in increased overall productivity (Kattel et al., 2023; Ali et al., 2021). In addition, increased canopy development and branching enhanced light capture and photosynthesis as also indicated by Ona et al. (2015), which could be a possible reason behind the observed flower and seed yields.

Salicylic acid application and pinching had a synergistic effect, especially when 200 mg L^{-1} SA was used together with pinching through 2-inch pinching. The combination of this treatment yielded the highest figures in most of the characteristics such as plant height, spike length, number of branches and seed yield. The associated processes such as SA enhancement of inner hormonal balance and physiological action, and pinching benefiting the structural organization probably contributed to greater efficacy of the plant in making use of the resources available (Ali et al., 2024). This synergy is in concordance with the increased perspective of integrated plant management, wherein hormonal and mechanical interventions may additionally be employed synergistically to promote the highest degrees of reproductive accomplishment.

In terms of practical implications, the findings indicate that foliage application of salicylic acid at 200 mg L^{-1} and 2-inch pinching could be a recommended procedure to commercial larkspur producers as a means of enhancing general yield and quality. Salicylic acid is a very common input that is relatively cheap, particularly when it is bought in bulk, and therefore is affordable and effective to small and medium-sized growers. Pinching cannot be done easily without specialized equipment but it is a labor-intensive method that can be easily implemented and be included in general crop management schedules. In small-scale farmers and commercial floriculture, this dual strategy is a cost-effective way to increase ornamental traits and seed-producing traits with scalable volume. But when operations are of a large scale, pinch automation or more efficient planning of labor might also have to be resorted to in order to cut down costs. Moreover, the practicability of such a strategy can be different due to climatic factors, and it is advisable to conduct a regional test prior to it being used widely. Making these methods parts of regular production would help a great deal in increase of yield, quality of the floral spikes as well as uniformity of seed production and would thus help the ornamental and seed supply industry.

CONCLUSION

The application of Salicylic acid at the rate of 200 mgL^{-1} was found more effective and resulted in the least Days to flowering, maximum plant height (cm),

number of capsule plant^{-1}, number of branches plant^{-1}, spike length plant^{-1} (cm) and seed weight plant^{-1} (g) while the pinching at 2-inch was found more effective for plant height (cm), number of capsule plant^{-1}, number of branches plant^{-1} and seed weight plant^{-1} (g). Hence salicylic acid application at the rate of 200 mgL^{-1} along with pinching at 2-inch stage is recommended for enhanced growth and flower production of Larkspur.

Conflict of Interest

The authors declare no conflict of interest.

Authors Contributions

MA designed and supervised the experiment; MA performed the experiment, collected and analyzed the data; HA and SJ prepared the manuscript; ZK, BR and R provided guidance during the experiment; AI, and SMI reviewed the Manuscript; FA and AS helped in conducting the experiment**.**

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