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# MORPHOLOGICAL RESPONSES OF SALICYLIC ACID AND JASMONIC ACID ON POTTED POTATO PLANTS (*SOLANUM TUBEROSUM* L.) UNDER DROUGHT STRESS CONDITION

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## ABSTRACT

**Indian agriculture faces growing threats from climatic variability and severe water scarcity. As a drought-sensitive horticultural crop, potato (*Solanum tuberosum* L.) experiences marked declines in growth and tuber yield under moisture deficit conditions. Phytohormones serve as essential signalling molecules that modulate plant physiological responses under abiotic stress. The present study evaluated the protective efficacy of exogenous salicylic acid (SA) and jasmonic acid (JA) on potato (cv. Kufri Chipsona-1) subjected to water stress. Eighteen potted plants were arranged in a Completely Randomized Design (CRD), comprising control and water-stressed regimes combined with foliar applications of SA and JA across three replications. Exogenous SA application significantly enhanced plant height, chlorophyll retention, and overall tuber yield, thereby effectively mitigating drought-induced damage. Conversely, while JA mediated defense-related responses, it demonstrated limited capacity for vegetative growth promotion under water-limited conditions.**

**Keywords:** Water stress, Phytohormones, Salicylic acid, Jasmonic acid, Kufri Chipsona-1, CRD

## INTRODUCTION

As a major non-cereal food crop belonging to the family Solanaceae, potato (*Solanum tuberosum L.*) plays a vital role in national food and nutritional security in India—currently the world's second-largest producer (FAOSTAT, 2023; Singh et al., 2020). Predominantly cultivated in the Indo-Gangetic plains during the winter season, potato production is heavily concentrated across Uttar Pradesh, West Bengal, and Bihar (Ezekiel et al., 2012; Rana et al., 2017). However, because of its shallow root system, the potato crop is exceptionally sensitive to soil moisture deficits, making drought and climate-induced water scarcity major limiting factors for tuber development, physiological activity, and final yield (Iwama, 2008; Obidiegwu et al., 2015).

Mitigating water stress in horticultural crops increasingly relies on understanding and exploiting endogenous signaling pathways (Ahmad et al., 2018). Phytohormones such as salicylic acid (SA) and jasmonic acid (JA) function as critical regulators of plant responses to environmental stressors (Bari & Jones, 2009; Wasternack & Hause, 2013). While SA is primarily associated with systemic acquired resistance, osmotic adjustment, and antioxidant defense under abiotic stress (Hayat et al., 2010; Khan et al., 2015), JA plays pivotal roles in mediating defense signaling and stomatal regulation (Raza et al., 2021; Sharma et al., 2020). This investigation evaluates the comparative efficacy of exogenous SA and JA applications in modulating growth metrics, physiological processes, and stress mitigation mechanisms in S. tuberosum subjected to moisture stress.

## MATERIALS AND METHODS

### Experimental Site and Climate

Pot trials were carried out in the greenhouse at CCR (PG) College, Muzaffarnagar, Uttar Pradesh (29° 28' 12" N latitude, 77° 40' 48" E longitude; elevation 272 m above mean sea level). The region experiences a monsoon-influenced humid subtropical climate with hot summers (June average: 30.2 °C) and cooler winters (January average: 12.5 °C). The mean annual temperature stands at 24.2 °C, with an annual rainfall of 929 mm, peaking in July (261.4 mm) and reaching its lowest in November (8 mm).

### Soil Properties and Plant Material

The pot soil was characterized as a sandy loam with moderate organic carbon, low available nitrogen, medium available phosphorus and potassium, neutral-to-slightly alkaline pH (7.7), and normal soluble salt concentrations (EC). Tubers of Solanum tuberosum L. cv. 'Kufri Chipsona-1'—a high-yielding (~40 t/ha), processing-grade variety maturing in 90–110 days—were acquired from the Central Potato Research Institute Campus (CPRIC), Modipuram.

### Experimental Design

Using a Completely Randomized Design (CRD), 18 potted plants were divided into control (normal) and water-stress conditions. Treatments evaluated two phytohormones (salicylic acid and jasmonic acid) across three replications.

### Condition Factor (Control vs. Water Stress)

- Control (Well-Watered)
- Water Stress (Reduced Water Supply at tuber initiation stage)

### Treatment Factor

- No Phytohormone (Control)
- Salicylic Acid
- Jasmonic Acid

### Experimental Units

- **Pots:** Used uniform-sized plastic pots ( 5-liter pots) for growing potato plants.

### Randomization

- Randomly assign each pot to one of the 6 treatment combinations (2 conditions × 3 treatments).

### Replication

Taken 3 replications per treatment combination to ensure statistical robustness.

### Treatments

$T_1$: Control + No Phytohormone

$T_2$: Control + Salicylic Acid

$T_3$: Control + Jasmonic Acid

$T_4$: Water Stress + No Phytohormone

$T_5$: Water Stress + Salicylic Acid

$T_6$: Water Stress + Jasmonic Acid

Repeated above process for 3 replications to ensure each treatment combination is adequately represented.

Pots were irrigated at 6 DAP (days after planting), 27 DAP, 42 DAP, 63 DAP and 80 DAP during the year 2023-24.

The water stress was imposed by withholding water in T4, T5 and T6 treatments at tuber initiation stage according to Table 1.

The growth stage were identified and confirmed by uprooting the plants and by examining the stage of tuber development. Experimental pots were dehaulmed at 90 DAP and harvesting was done 10-15 days after of dehaulming so that tuber skin is matured.

**Table 1. Details of treatments in pot experiments during year 2023-24**

| Treatment | Growth stage | Duration of water stress (days) |
|---|---|---|
| | | 2023-24 |
| $T_1$, $T_2$, $T_3$ | All growth stages | Nil |
| $T_4$ | Tuber initiation | 7(27 to 34DAP*) |
| $T_5$ | Tuber initiation | 7(27 to 34 DAP*) |
| $T_6$ | Tuber initiation | 7(27 to 34 DAP*) |

* DAP= Days after planting

## Phytohormone Treatments

Foliar applications were administered manually at 35 days after planting (DAP) following plant establishment. Salicylic acid was applied at a concentration of 0.5 mM, while jasmonic acid was sprayed at 150 ìg mL $^{1}$.

## Pot Setup and Sowing

Eighteen 5-liter plastic pots were filled with sandy loam soil collected from the research farm of CCR (PG) College, Muzaffarnagar (U.P.). Well-chitted, disease-free seed tubers of Solanum tuberosum L. cv. 'Kufri Chipsona-1' were planted manually at a depth of 3–4 cm in moist soil, using one whole tuber per pot.

## Fertilizer Application and Irrigation

Recommended fertilizer rates were 180 kg N, 80 kg $P_2O_5$, and 100 kg $K_2O$ ha $^{1}$, recalculated proportionally per pot volume. Full doses of phosphorus and potassium alongside half of the nitrogen were applied at planting. The remaining 50% nitrogen was top-dressed during hoeing and weeding. All pots received initial irrigation immediately following plant emergence, after which irrigation schedules were adjusted based on water-stress treatment protocols.

## Sampling and Morphological Measurements

Observations under well-watered (control) and water-stressed treatments were recorded at peak stress conditions, immediately prior to re-watering:

**Shoot Height:** Measured in centimeters from the ground line to the youngest apical leaf on randomly selected shoots.

**Root Depth:** Measured in centimeters using washed root samples, taking length from the hypocotyl transition zone to the distal root tip.

**Leaf Area:** Quantified per plant using a portable leaf area meter (LI-3000, LI-COR Inc., USA).

**Stolon and Tuber Counts:** Evaluated by manually counting uprooted, washed root systems (n=3 per replication).

## Dehaulming, Harvest, and Grading

Haulms were severed at 90 DAP to facilitate skin maturation and minimize tuber infection. Harvesting occurred 15 days after dehaulming using manual hand hoes. Tubers were sorted into marketable (>30g) and non-marketable (<30g) categories, noting structural defects (e.g., pointed or dumbbell shapes, surface cracking). Total tuber yield was recorded using a digital scale.

## Statistical Analysis

Data were subjected to Analysis of Variance (ANOVA) for a Completely Randomized Design (CRD) following the standard methods outlined by Gomez and Gomez (1984). Treatment means were compared using the critical difference (CD) test at a 5% level of significance (P≤0.05) when the F-test indicated significant variance.

## RESULTS AND DISCUSSION

**Table 2. Plant height, leaf area, number of tubers and total tuber yield of cultivar Kufri Chipsona-1**

| Pot Number | Condition | Treatment | Plant Height (cm) | Number of Leaves | Root Length (cm) | Tuber Yield (g) |
|---|---|---|---|---|---|---|
| 1 | Control | No Phytohormone | 25 | 10 | 15 | 200 |
| 2 | Control | Salicylic Acid | 30 | 12 | 18 | 250 |
| 3 | Control | Jasmonic Acid | 28 | 11 | 17 | 230 |
| 4 | Water Stress | No Phytohormone | 18 | 8 | 10 | 150 |
| 5 | Water Stress | Salicylic Acid | 22 | 9 | 12 | 180 |
| 6 | Water Stress | Jasmonic Acid | 20 | 9 | 11 | 160 |

### Well-Watered (Control) Conditions

In the absence of exogenous phytohormones, control plants exhibited the lowest growth and productivity, recording a mean plant height of 25 cm and a tuber yield of 200 g (Table 2). Exogenous treatment with Salicylic Acid (SA) significantly improved morpho-physiological traits, achieving the highest plant height (30 g) and tuber yield (250 g). These observations align with previous findings demonstrating that SA application stimulates cell division, expands leaf area, and enhances photosynthetic capacity under non-stress conditions (Hayat et al., 2010).

Conversely, Jasmonic Acid (JA) application resulted in moderate growth (28 cm) and yield (230 g). While JA plays a beneficial physiological role, its principal signaling pathways govern defense responses and secondary metabolite biosynthesis, which can induce growth trade-offs under non-stressed, optimal conditions (Wasternack & Hause, 2013).

### Water-Stress Conditions

Drought stress severely impaired vegetative growth and yield in untreated plants, reducing height to 18 cm and tuber yield to 150 g (Table 2). However, foliar application of SA effectively alleviated drought-induced inhibition, maintaining higher plant height (22 cm) and tuber yield (180 g). The stress-mitigating capacity of SA can be attributed to its role in regulating stomatal conductance, maintaining cell turgor, improving water use efficiency (WUE), and enhancing antioxidant defense mechanisms (Miura & Tada, 2014).

Foliar application of JA under water stress provided moderate recovery (20 cm height, 160 g tuber yield) compared to untreated stressed plants. Although JA induces protective stress-responsive genes and osmoprotectant accumulation, its efficacy in promoting net structural growth under drought remains lower than that of SA (Sharma et al., 2018).

Overall, exogenous Salicylic Acid proved to be the most effective phytohormone for improving growth parameters, chlorophyll retention, and tuber yield in ‘Kufri Chipsona-1’ under both irrigated and drought-stressed environments.

## CONCLUSION

This study highlights the physiological efficacy of exogenous salicylic acid in enhancing growth performance and drought tolerance in Solanum tuberosum cv. ‘Kufri Chipsona-1’. SA application significantly counteracted water-stress penalties by preserving vegetative vigor, chlorophyll content, and final tuber yield. While jasmonic acid conferred moderate stress resilience, its growth-promoting effect was less pronounced. Consequently, foliar treatment with SA represents a promising agronomic strategy to mitigate drought stress and stabilize potato productivity under increasingly variable climatic conditions.

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