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FOLIAR SALICYLIC ACID APPLICATION MODULATES PHENOLOGY AND VEGETATIVE GROWTH OF SPRING MAIZE VARIETIES AT V8 AND VT STAGES UNDER PESHAWAR CONDITIONS

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Abstract
Salicylic acid (SA) is a plant growth regulator that has the ability to affect crop phenology, leaf growth and plant vegetative development. To observe the effect of foliar SA application on two maize varieties, CS-200 and Azam, at two crop growth stages (V8 and VT), a field experiment was carried out at the Agronomy Research Farm, The University of Agriculture, Peshawar in spring 2023. The treatments were four levels of SA (0, 100, 200 and 300 mg L^-1) and they were randomized complete block design with three replications. An analysis of variance was used for data analysis and the treatment means were compared with the LSD at P <= 0.05. The 300 mg L^-1 SA treatment resulted in a delay in tasseling (59.3 days), silking (65.6 days) and physiological maturity (101.8 days) and increases in number of leaves plant^-1 (13.6), leaf area plant^-1 (5494 cm2), leaf area index (3.0) and plant height (218.2 cm). CS-200 had superior vegetative growth compared to Azam in terms of plant height (218.4 cm), leaf area (5501 cm2) and leaf area index (3.0). Vegetative growth was generally better for application at V8 than VT. The findings indicate that application of SA 300 mg L^-1, especially at V8, can have a beneficial effect on vegetative growth of spring maize in Peshawar agro-ecology.

INTRODUCTION

In Pakistan, maize (Zea mays L.) is a significant cereal crop and plays an important role in rural livelihoods and food and feed security in KP. At farmers fields, however, the yield and growth performance is often affected by sub-optimal crop management, environmental stress and varietal differences. Therefore, the improvement in early vegetative growth is a working approach to enhance crop vigour and ultimate productivity.

Salicylic acid is a phenolic growth regulator that plays a role in plant defense, stomatal regulation, respiration, flowering, leaf development and abiotic stress tolerance (Raskin, 1992; Arfan et al., 2007; Ashraf et al., 2010). Previous studies on maize and other cereals showed that exogenous application of SA could enhance the status of chlorophyll, relative water content, seedling vigor and stress tolerance especially under drought, salinity or low temperature (Ahmad et al., 2014; Tufail et al., 2013; Yaghoubian et al., 2014).

In addition, the recent studies conducted in the region indicate that integrated nutrient management, biochar soil amendments, beneficial soil microorganisms and Zn management are potential strategies to boost the productivity of crops, whereas pest pressure and water quality is a critical environmental constraint for sustainable agriculture in Khyber Pakhtunkhwa (Farooq et al., 2026a; Farooq et al., 2026b; Jalal et al., 2026; Khan et al., 2026a; Khan et al., 2026b; Sherin et al., 2026; Anees et al., 2026; Rehman et al., 2026; Khan and Khan, 2026; Khan et al., 2025).

Even though SA has been tested under varying stress conditions, locally collected data on the timing of application, and response, of available maize varieties is found to be relevant for both farmers and researchers. The goal of this paper was to assess the impact of SA levels, maize varieties and application stages on phenological and vegetative characteristics of spring maize under agro-ecological conditions of Peshawar.

Materials and Methods

The experiment was carried out at Agronomy Research Farm, The University of Agriculture, Peshawar in Spring of 2023. Good agronomic practices were followed. All the nutrients (N, P and K) were applied as urea at 120 kg/ha, single super phosphate at 90 kg ha^-1 and sulphate of potash at 60 kg ha^-1. The plot size was 4 m x 3.5 m (14 m2) and it consisted of five rows, the row-to-row distance was 70 cm and plant-to-plant distance was 25 cm.

Table 1 Treatment structure and experimental design of the maize field experiment.

Factor	Treatments
Salicylic acid	0, 100, 200 and 300 mg L^-1
Maize varieties	Hybrid CS-200 and Azam
Application stages	V8 and VT
Design	Randomized complete block design with three replications
Statistical test	ANOVA and LSD at P <= 0.05

Days to tasseling, days to silking, days to physiological maturity, plant height, number of leaves plant-1, leaf area plant-1 and leaf area index were recorded. Statistix 8.1 was used for ANOVA in the original thesis. In this manuscript, Python was only used to rearrange the original mean values and to create graphical summaries; for this reason no original values were modified.

Results

The phenological and vegetative traits were strongly affected by salicylic acid. At 300 mg L^-1, the highest values of tasseling, silking and physiological maturity were obtained. In comparison with the control, 300 mg L^-1 increased plant height from 195.6 to 218.2 cm, number of leaves from 12.3 to 13.6 leaves plant^-1, leaf area from 4706 to 5494 cm2 and leaf area index from 2.5 to 3.0.

Table 2 Effect of different salicylic acid levels on phenological and growth traits of maize.

SA (mg L^-1)	Tasseling (days)	Silking (days)	Maturity (days)	Plant height (cm)	Leaves plant^-1	Leaf area (cm2)	LAI
0	56.8	62.3	98.7	195.6	12.3	4706	2.5
100	58.5	63.4	99.9	210.4	12.8	4925	2.6
200	59.0	64.4	100.3	215.8	13.3	5235	2.9
300	59.3	65.6	101.8	218.2	13.6	5494	3.0

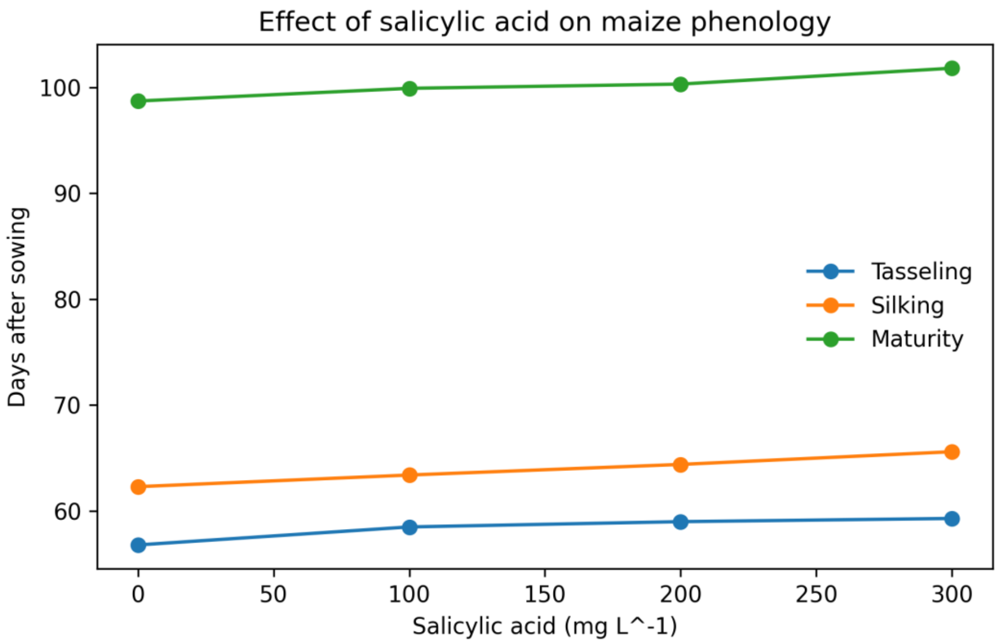

Figure 1 Effect of salicylic acid levels on days to tasseling, silking and physiological maturity of maize.

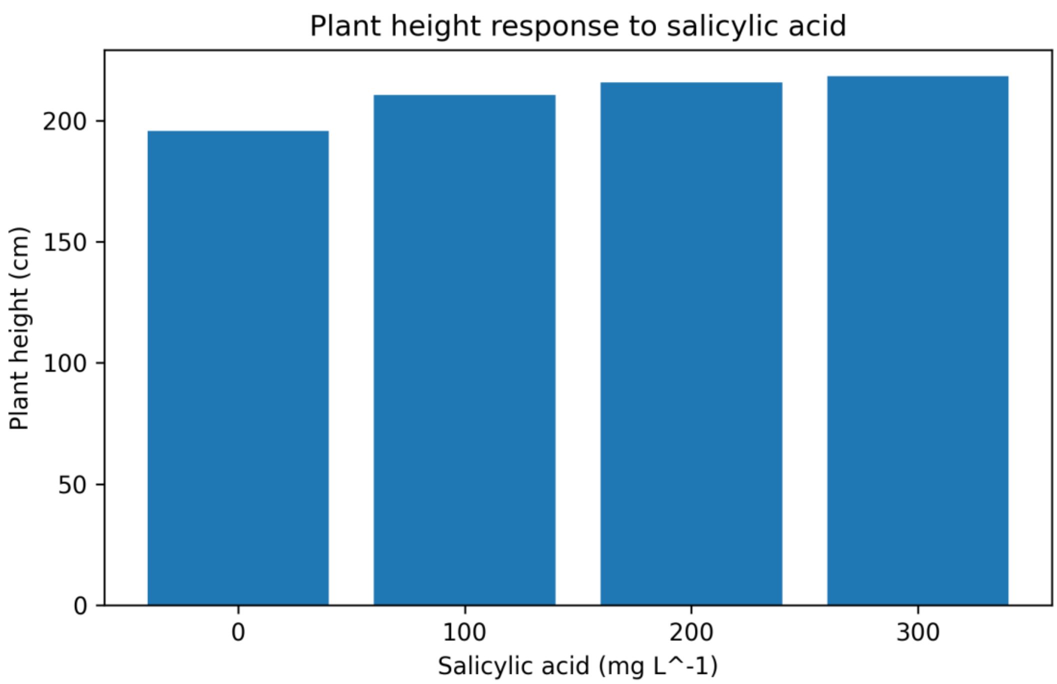

Figure 2 Effect of salicylic acid levels on plant height of maize.

In varietal comparison, it was observed that CS-200 did better than Azam for vegetative growth. CS-200 recorded 218.4 cm plant height, 13.4 leaves plant^-1, 5501 cm2 leaf area plant^-1 and 3.0 leaf area index. Application at V8 produced greater vegetative values than application at VT for plant height, leaves, leaf area and LAI.

Table 3 Performance of maize varieties and application stages for phenological and vegetative growth traits.

Trait	CS-200	Azam	V8	VT
Days to silking	64.1	63.8	64.0	63.9
Days to physiological maturity	98.6	101.7	99.1	101.2
Plant height (cm)	218.4	201.6	213.2	206.8
Number of leaves plant^-1	13.4	12.5	13.2	12.8
Leaf area plant^-1 (cm2)	5501.0	4679.0	5198.0	4982.0
Leaf area index	3.0	2.5	2.8	2.6

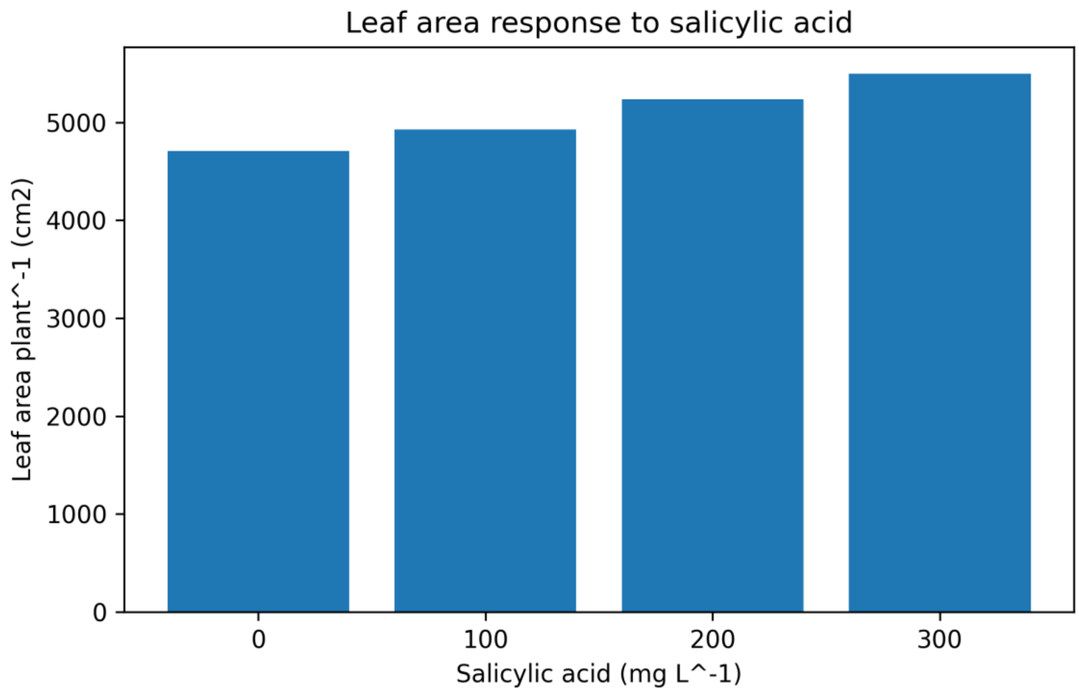

Figure 3 Effect of salicylic acid levels on leaf area plant^-1 of maize.

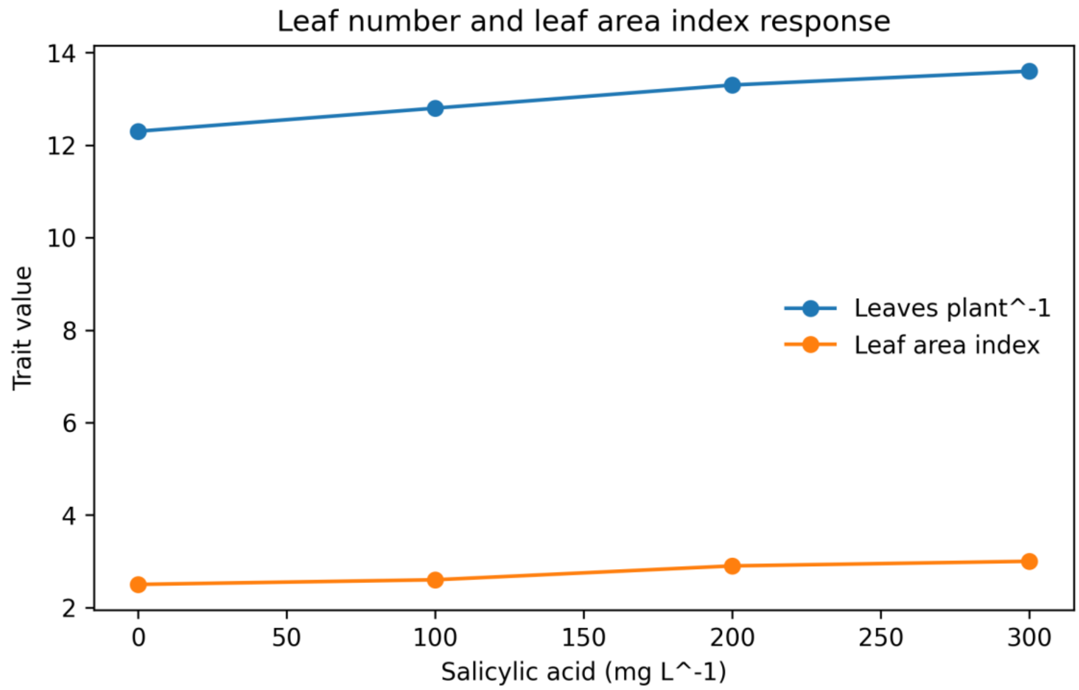

Figure 4 Effect of salicylic acid levels on leaf number and leaf area index of maize.

Discussion

Tasseling, silking and physiological maturity are delayed with increasing SA level, which might be related to increased vegetative activity and improved physiological regulation. SA has been reported to influence photosynthesis, enzyme activity and plant developmental responses (Khan et al., 2003; Raskin, 1992). The present experiment shows the higher LA and LAI at 200 and 300 mg L-1 suggest that SA induced canopy development prior to reproductive growth.

Varietal genetic potential had an important role in the utilization of foliar SA, as indicated by the stronger response of CS-200. Increased plant height, leaf area and LAI can increase light interception and dry matter production. Ahmad et al. (2018), Qasim et al. (2019), Tucuch-Haas et al. (2017) and Zamaninejad et al. (2013) found similar beneficial responses for maize when using foliar application of SA in stress and non-stress conditions.

The application stage was also a practical aspect. V8 application reduced vegetative growth when compared to VT application, likely as a result of the plant still having time to respond to improved physiology with leaf growth and canopy development. This reinforces the concept that besides dose and variety, consideration of the timing of SA is warranted when formulating maize management strategies.

Conclusion

Under the Peshawar environment, the application of foliar SA helped to enhance the phenology and vegetative growth of maize. The 300 mg L^-1 treatment resulted in the highest days to tasseling, days to silking, days to maturity, plant height, leaves plant^-1, leaf area plant-1 and LAI. For most vegetative traits, hybrid CS-200 did better than the cultivar Azam. V8 had a more positive effect on vegetative growth than VT. Hence, it is recommended that SA at 300 mg L-1 be applied at V8 stage for vegetative growth improvement of spring maize in similar agro-ecological zones.

Recommendations

Future experiments should validate the 300 mg L^-1 SA treatment across multiple seasons and locations. Additional physiological measurements such as chlorophyll content, photosynthetic rate, antioxidant activity and water-use efficiency should be included to better explain the mechanisms behind SA-mediated growth improvement.

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