Bangladesh J. Bot. **53**(2): 273-278, 2024 (June) DOI: https://doi.org/10.3329/bjb.v53i2.74046

EFFECTS OF FOLIAR APPLICATION OF SALICYLIC ACID ON MORPHOLOGICAL, BIOCHEMICAL AND YIELD ATTRIBUTES OF MAIZE (*ZEA MAYS* L.) UNDER RAINFED CONDITION

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Keywords: Foliar application, Yield attributes, Salicylic acid, Protein content, *Zea mays*

Abstract

An experiment was performed in the kharif- 2022 focusing on the impact of foliar applications of Salicylic acid on morphological, biochemical, and yield attributes in maize, using the CP-858 variety. The study involved four concentrations of salicylic acid: T1-50ppm, T2-100ppm, T3-150ppm, and T4-175ppm. Notable differences emerged in morphological and yield attributes such as sink size, test weight and yield per plot, revealing a marked increase in plant physiological efficiency treated with salicylic acid when compared to control. This trend was also evident in key biochemical parameters like chlorophyll 'a', 'b', and total chlorophyll content, and protein content in leaves, showing a positive response to exogenously applied salicylic acid. Similar outcomes were recorded in terms of yield and yield-related indicators. These outcomes underscore the significance of salicylic acid as a potent growth regulator for crop plants, particularly those cultivated under dryland conditions.

Introduction

One of the many phenolic compounds that includes an aromatic ring bearing a hydroxyl group or its functional derivative and is naturally produced by plants is salicylic acid. Salicylic acid acts as a potential, non-enzymatic antioxidant as well as a plant growth regulator and plays an important role in regulating some plant physiological processes (Arif Y *et al.* 2020) such as stimulating adventitious organ development, herbicidal effect and providing resistance to biotic and abiotic stress (Canakci and Munzuroğlu *et al.* 2007). It contributes significantly to plant growth, ion uptake and transport, and tolerance against abiotic stresses by serving as a key signaling molecule.Salicylic acid, a phytohormone, is a promising substance that can regulate the antioxidant defense system, transpiration rates, stomatal movement, and photosynthetic rate in plants to lessen their sensitivity to environmental stresses. It is also clear that SA is a stress-signaling molecule that activates abiotic stress-responsive gene expression module and induces the expression of biosynthetic enzymes and proteins in plants under environmental stress (Nazar *et al.* 2015). In comparison to the control treatment under salt stress, SA decreased the uptake of Na by plants and/or increased the uptake of N, P, K, Ca, Mg, and other minerals. It was demonstrated that plants exposed to ozone, UV light, and after pathogen infection had higher levels of SA (Malamy *et al*. 1990, Rasmussen *et al.* 1991). An experiment was conducted to measure the magnitude of the role that salicylic acid plays through foliar application on maize (under rainfed conditions) and its potential positive effects on various physiological, biochemical and yield parameters such as plant height, protein content, chlorophyll content, total soluble sugar, membrane thermo-stability index, under abiotic stress such as moisture stress.

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Materials and Methods

In kharif 2022, the experiment was carried out outdoors at the Agricultural Research Farm of the Banaras Hindu University. The Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University provided healthy seeds of the CP-858 maize variety. To enhance maize germination and seedling growth, seed priming was additionally carried out. Different concentrations of Salicylic acid ($C_6H_4(OH)CO_2H$) was dissolved in double distilled water and four concentrations i.e., T1-50 ppm, T2-100 ppm, T3-150 ppm, T4-175 ppm were prepared by dissolving 50mg of SA (Salicylic acid) per 1litre of water, 100mg of SA per 1litre of water, 150mg of SA per 1litre of water, 175mg of SA per 1litre of water respectively. Healthy seeds were sowed during kharif season by dibbling method manually after ploughing the field with rotavator. Foliar application of Salicylic acid was performed at two growth stages of maize crop *i.e.* 30 DAE (Days after Emergence) and 60 DAE. The plot measured 5m X 4m. By using the 'dibbling' method, which involved making holes in the seed bed and filling them with soil, seeds were planted in the field. In this method, seeds were inserted into holes that have been made at precise depths and fixed intervals. Seed rate maintained was 19 kg/ ha. All the Experimental data like morphological, physiological and biochemical parameters were collected at 30 DAE and 60 DAE. Harvesting was done by hand manually based on maturity index like husk colour turns pale brown and moisture percentage should be less than 22 to 25 % in grain. The statistical design used was randomized block design (RBD). The physical parameter that was estimated are plant height (cm), test weight (grams), sink size, and yield per plot (in kg). The biochemical parameters that were estimated are total protein content, Chlorophyll ‘a’, ‘b’, and total chlorophyll content, MSI (Membrane Thermo-stability Index) and CSI (Chlorophyll Stability Index).All the parameters were analysed and tested by DMRT (Duncan’s Multiple Range Test) test.

Results and Discussion

Based on the above physiological and biochemical investigations, it was observed that there was a marked improvement in most of the phenological, physiological and biochemical observations taken in both control and treated plot. The foliar application of salicylic acid at 50ppm, 100ppm, 150ppm, and 175ppm completely reversed the percent decrease of chlorophyll content.According to this study with the increasing the foliar application of salicylic acid, chlorophyll, a, b and total chlorophyll content gradually increases at 30 and 60 DAE under rainfedcondition (Table 1).

Table 1. Effects of foliar application of salicylic acid on chlorophyll content (mg/g FW) of maize at different intervals.

Treatment	30 DAE			60 DAE		
	Chl. ‘a’	Chl. ‘b’	Total Chl.	Chl. ‘a’	Chl. ‘b’	Total Chl.
T0	1.33^{b}	0.821^{a}	2.158^{d}	1.898^{a}	0.602^{ab}	2.503^{c}
T1	1.515^{b}	0.813^{a}	2.332^{cd}	2.165^{a}	0.482^{b}	2.585^{bc}
T2	1.577^{ab}	0.919^{a}	$2.5b^{c}$	2.155^{a}	0.666^{ab}	2.827^{abc}
T3	1.571^{ab}	1.032^{a}	2.608^{ab}	2.063^{a}	0.837^{ab}	2.907^{ab}
T4	1.781^{a}	1.025^{a}	2.811^{a}	2.01^{a}	0.911^{a}	2.92^{a}
CD	0.242		0.272			
SE(m)	0.073	0.076	0.084	0.137	0.118	0.101
SE(d)	0.103	0.108	0.118	0.194	0.166	0.143
C.V	8.123	14.29	5.842	11.558	29.126	6.388

Where T_0 Distilled water, T_1 50 ppm, T_2 100 ppm, T_3 125 ppm, T_4 175ppm SA.

Table 2. Effects of foliar application of salicylic acid on plant height of maize at different intervals.

Treatments	30DAE(cm)	60DAE(cm)
T0	91.66^{d}	162.3^{b}
T1	106.6^{c}	166^{b}
T2	112b^{c}	175.3^{ab}
T3	117.3^{ab}	180.3^{ab}
T4	124.3^{a}	190^{a}
CD	9.86	18.023
SE(m)	2.98	5.442
SE(d)	4.214	7.696
C.V	4.675	5.392

Abbreviations are same as in Table 1.

The plant height was significantly increased by the foliar application (Table 2) of salicylic acid at 175ppm concentration compared to control plots for 30 and 60 DAE which corroborate with result of Khandaker *et al.* (2011).

With the foliar application of salicylic acid at 175 ppm concentration compared to the control plot for 30 and 60 DAE under rainfed conditions, certain parameters, such as protein content was found to be gradually increased which also suggest the positive modulaton effect of salicylic acid on protein synthesis in maize plant (Table 3).

Table 3. Effect of foliar application of salicylic acid on total protein content (mg/g/FW) of leaf of maize at different intervals.

Treatments	30DAE	60DAE
T0	1.631^{c}	1.481^{c}
T1	2.063^{b}	1.783^{b}
T2	2.257^{b}	1.933^{ab}
T3	2.625^{a}	1.995^{ab}
T4	2.738^{a}	2.122^{a}
CD	0.289	0.223
SE(m)	0.087	0.067
SE(d)	0.123	0.095
C.V	6.675	6.253

With the increasing doses of salicylic acid at 175 ppm concentration, the parameters like MSI (Membrane Thermo-Stability Index) were improved to 73 % for observations taken at 30 DAE and 75% for 60 DAE respectively as well as CSI (Chlorophyll Stability Index) also statistically increased to78% at 30 DAE and 85% at60 DAE (Table 4), which agrees with More *et al.* (2023).

Table 4.Effect of foliar application of salicylic acid on chlorophyll stability index (CSI) and membrane thermo-stability Index (MSI) of maize at different intervals.

Treatments	CSI (%)		MSI (%)	
	30DAE	60DAE	30DAE	60DAE
T0	64.135[d]	65.083[d]	64.567[b]	63.87[cd]
T1	65.01[d]	67.33[cd]	64.583[b]	62.683[d]
T2	69.243[c]	70.66[c]	66.337[b]	66.833[bc]
T3	77.58[b]	76.58[b]	70.54[a]	70.143[b]
T4	81.863[a]	83.95[a]	73.713[a]	75.317[a]
CD	3.341	4.491	3.846	3.911
SE(m)	1.009	1.356	1.161	1.181
SE(d)	1.427	1.918	1.642	1.675
C.V	2.537	3.23	2.96	3.01

Test weight was high at plots sprayed with 150ppm concentration of SA compared to control plot. However, significantcomparative reduction was observed in sink size in plants sprayed with high dose of salicylic acid (i.e175ppm) compared to a significant improvement at 150 ppm treated plots (Table 5).

Table 5. Effects of foliar application of salicylic acid on sink size, yield/plot (kg) and test weight (g) of maize .

Treatments	Sink size	Yield / plot (kg)	Test weight (g)
T0	3.213[c]	9.62[e]	19.46[b]
T1	3.897[bc]	12.07[bc]	24.01[a]
T2	4.133[ab]	14.57[abc]	23.41[ab]
T3	4.596[a]	16.24[ab]	23.29[ab]
T4	4.411[ab]	19.11[a]	22.45[ab]
CD	0.688	1.271	2.12
SE(m)	0.208	0.384	1.347
SE(d)	0.294	0.543	1.905
C.V	8.891	4.64	10.359

Thus, according to the present study, foliar application of salicylic acid at 175ppm overall increased the yield per plot compared to control plot under rainfed condition in maize variety CP-858 grown under north Indian condition.salicylic acid is a potent growth regulator which controls numerous physiological and biochemical processes, including progressive growth, seed development, productivity per unit land area of flower production, lowering the production of reactive oxygen species (ROS), and increasing the defense system to maintain the osmotic adjustment in stressful environments (Radwan 2012). SA helps to increase the plant height by regulating cell division and cell expansion (Sofy *et al*. 2020). Similar results were obtained in the research study where foliar application of salicylic acid at 175 ppm on maize produced the highest protein content amongst all treated and untreated plots (Table 3). Salicylic acid shows a better result on seed germination after application of different concentrations in maize under drought conditions (Afzal *et al*. 2022). As per findings of above study, it was observed that with increasing concentration of salicylic acid, Chlorophyll content and Chlorophyll Stability Index (CSI) both improved as salicylic acid mediate to synthesize different forms of chlorophyll and also reduces de-epoxydation of chlorophyll molecule as reported by Amujoyegbe *et al.*(2007). The effects of priming maize seed with salicylic acid were in detail investigated by Szalai *et al.* (2016) on grain yield under field conditions as well as salicylic acid and polyamine metabolism under controlled environmental conditions. The present research revealed that the test weight of maize was found to be higher in plants sprayed with 100 ppm SA concentration in comparison to control plots. According to the results of the study, foliar spraying of 175ppm salicylic acid to plants under rainfed condition produced better results than the control in terms of plant height, total chlorophyll content, MSI, CSI, and protein content. Also it was observed thattest weight significantly increased at 50 ppm salicylic acid concentration and sink size increased at 150 ppm salicylic acid concentration under rainfed conditions. Hence looking at overall set of morphological, biochemical and yield parameters, it can be better concluded that foliar application of salicylic acid at 175 ppm was found to be most effective treatment combination to improve growth, reproductive fitness and overall yield potential of maize crop grown under rainfed / moisture stress regimes.

Acknowledgement

The authors would like to acknowledge the financial support received from Faculty Seed Grant Project sanctioned by IoE-BHU.

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(Manuscript received on 22 November, 2023; revised on 03 June, 2024)