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Study on Effect of Foliar Spray with Phytohormones on Crop Growth and Yield Attributes of Maize COH (M) 8 Under Drought Stress Condition

Nivethitha Manavalagan[1], Manonmani Velusamy[1]*, Jerlin. R[1], Kalarani M. K[1], Kokiladevi Easwaran[3]

[1]Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore, India
[2]Directorate of Crop Management, Tamil Nadu Agricultural University, Coimbatore, India
[3]Department of Plant Biotechnology, Centre for plant molecular biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore, India

ABSTRACT

The study aimed to assess the effects of foliar spray using different phytohormones, such as salicylic acid and brassinolides, on various plant growth and yield parameters of maize. The experiments were conducted on COH(M) 8 maize seeds to identify suitable phytohormones and optimize their concentrations for improving its yield under drought-stress conditions. Foliar spray treatments involved different concentrations of salicylic acid (50, 75 ppm) and brassinolides (0.2, and 0.5 ppm) along with a control group. The findings indicated that seeds treated with salicylic acid at a concentration of 75 ppm exhibited better performance outperforming the control and other treatments, regardless of the drought stress conditions.

Keywords: Climate change, *Maize, crop growth and development, drought stress, phytohormones, yield*

INTRODUCTION

In India, maize is a prominent cereal grain crop and is recognized as the "Queen of cereals" due to its high genetic yield potential and versatility. It contributes approximately 40% to global food production among cereal crops annually. However, climate change has led to rising air temperatures, which exacerbates the negative impact of drought stress on maize yields [1]. This increase in temperature poses significant risks to food security, as this stress can cause severe damage to plants. It is a destructive abiotic stress factor that limits growth at various stages of development and leads to the overproduction of reactive oxygen species, resulting in cellular damage. Changes in photosynthesis and respiration further decrease plant productivity. To address these challenges and improve maize productivity and quality, mitigation strategies are necessary [4]. One effective approach is foliar spray with phytohormones, which offers protection against drought stress and enhances plant growth and development. Plant hormones play a crucial role in plant growth, development, and response to various abiotic stresses, including drought stress [5]. Therefore, it is crucial to optimize the concentration of phytohormones used for exogenous applications in maize. To address this issue, the present study aims to determine the optimal concentration of foliar spray treatments using different phytohormones for maize seeds based on various morphophysiological quality parameters.

**Corresponding Author: Manonmani Velusamy*
Email Address: vmano_2004@yahoo.com

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Materials and Methods:

The field trial was conducted during the month of post-kharif season 2022 at Tamil Nadu Agricultural University, Coimbatore with the aim to expose the plants to drought stress conditions. The crop was foliar sprayed with the following phytohormones using a knapsack sprayer at two growth stages viz., 40 and 47 days after sowing (40 and 47 DAS) to find out the effects of phytohormone on mitigating the drought stress. The following growth and yield parameters were recorded.

Treatment details

Foliar spray with phytohormones	Concentration
Control	Without any treatment
Salicylic acid	50 ppm
	75 ppm
Brassinolides	0.2 ppm
	0.5 ppm

Plant height (cm)

The height of ten plants was measured at random from the ground to the tip of the top leaf and recorded in centimeters.

Days to first flowering

The number of days taken for first flowering was computed and the mean value is expressed in days

Days to 50% flowering

The number of days taken from sowing to 50% flowering was recorded and the mean value is expressed in days.

Chlorophyll content (mg/g)

The leaf chlorophyll extraction was made using dimethyl sulfoxide followed by the non-maceration method given by Hiscox and Israelstam. The sample was analyzed using the spectrophotometer at a light absorption of 663 nm and 645 nm. The chlorophyll content was calculated using the absorption coefficient. The freshly collected leaf samples of 0.5 g were taken in a test tube and 5 ml of dimethyl sulfoxide was added and kept in an oven at 65°C for 4 hrs. The extract containing chlorophyll in a test tube was made up to a volume of 10 ml using dimethyl sulfoxide. The optical density of the extract was measured at 663 and 645 nm using a spectrophotometer. The chlorophyll content was measured using the formula given by Arnon (1949).

Chlorophyll 'a'

$$= \frac{(12.7 \times OD @ 663\ nm) - (2.69 \times OD @ 645\ nm)}{1000 \times W} \times V\ (mg/g)$$

Chlorophyll 'b'

$$= \frac{(22.9 \times OD @ 645\ nm) - (4.68 \times OD @ 663\ nm)}{1000 \times W} \times V\ (mg/g)$$

$$\textbf{Total chlorophyll} = \frac{(OD @ 652\ nm)}{1000 \times W} \times V\ (mg/g)$$

Cob length (cm)

The length of the cob was measured from the bottom to the tip and the average was calculated in centimetres.

Cob weight (g)

The individual weight of the cob was measured in an electronic balance and the mean value was expressed in grams.

Number of rows/cob

A number of seeds produced per cob was calculated and the average value of four cobs was expressed in whole number.

Number of seeds/row

A number of seeds produced per row was calculated and the average value was expressed in whole numbers.

Number of seeds/cob

Number of seeds produced per cob was calculated and the average value of four was expressed.

Shelling (%)

The shelling percentage was calculated using the weight of cob and seed. It is the ratio between the seed weight and cob weight and expressed in percentage.

$$\text{Shelling (\%)} = \frac{\text{Weight of seed}}{\text{Weight of cob}} \times 100$$

1000 seed weight (g)

Four replicates of 1000 seeds were drawn from each treatment after drying the cobs to 10-12 percent, weighed in an electronic balance and the mean was expressed in grams.

Seed yield/plot (kg)

Seeds from the plant of each plot was separated and weighed using a spring balance and expressed in kg/plot.

Seed yield/ha (kg)

The seeds from all plots was computed to hectare seed yield and expressed in kg/ha.

Statistical analysis

The significance of data from several studies was determined using the DMRT analysis, using SPSS 2.0 software. Before analysis, the percent data was converted to angular (Arc-sine) values when necessary. The data obtained was analyzed for statistical significance.

Results:

The plant height was significantly influenced by the foliar spaying with phytohormones. Salicylic acid 75 ppm recorded the highest plant height of 200.5 cm and 234.5 cm at both 60 and 90 DAS respectively. The lowest plant height was observed in control 175.5 cm and 209.3 cm at 60 and 90 DAS respectively. Days taken to first flowering was significantly influenced by the foliar spraying treatments. Plants foliar sprayed with salicylic acid 75 ppm flowered 3 days earlier (49 days) when compared to control (52 days). Statistically significant variation was noticed for days taken to 50% flowering among the foliar application with phytohormones. (Table.1). The plants foliar sprayed with salicylic acid 75 ppm recorded the maximum chlorophyll 'a' of 0.445 mg/g, chlorophyll 'b' of 0.612 mg/g and total chlorophyll of 0.956 mg/g whereas the content of chlorophyll 'a' of 0.370 mg/g, chlorophyll 'b' of 0.528 mg/g and total chlorophyll of 0.852 mg/g content was minimum in control. (Figure.1). Cob length was significantly influenced by the foliar spraying treatments. The cob length was longest for the plants foliar sprayed with salicylic acid 75 ppm (20.7 cm) whereas the shortest cob length was recorded by the control seeds (17.8 cm). The difference in cob weight was statistically significant among the foliar spraying treatments. Among the foliar application, foliar spraying with salicylic acid 75 ppm recorded the highest cob weight (171.50 cm) when compared to the control (158.8 cm). The difference in the number of seeds per row was statistically significant among the foliar spraying treatments. Among the foliar application, salicylic acid 75 ppm (38) recorded more seeds per row compared to the control (32). The number of rows per cob was statistically nonsignificant among the foliar spray treatments (Table. 2)

The difference in the number of seeds/cob was statistically significant among the foliar spraying treatments. More number of seeds/cob was recorded for the plants foliar sprayed with salicylic acid 75 ppm (532) whereas the minimum no. of seeds/cob was recorded in control (448 seeds). Statistically significant influence was observed on the shelling (%) due to the foliar spraying with phytohormones. Among the foliar application, shelling (%) was maximum for the plants foliar sprayed with salicylic acid 75 ppm (77%) while the minimum shelling percent was observed for control (71%). Foliar spraying with phytohormones had no significant influence on the seed weight (Table 2)

The grain yield plot-1 differed significantly among the foliar spraying treatments. Foliar application of salicylic acid 75 ppm (8.5 kg) registered higher seed yield compared to control (7.5 kg). The seed yield per ha showed statistically significant variation due to the foliar spraying treatments. Among the foliar spraying treatments, plants foliar sprayed with salicylic acid 75 ppm (7083 kg) recorded the higher seed yield whereas minimum seed yield was recorded in control (6250 kg) (Table 3)

Table 1: Effect of foliar spray with phytohormones on plant height (cm), days to first flowering and 50% flowering COH (M) 8 under field condition

Foliar spray treatments		Plant height (cm)		Days to first flowering	Days to 50% flowering
		60 DAS	90 DAS		
Control		175.5 ± 1.13 e	209.3 ± 2.14 e	52 ± 0.55 e	54 ± 0.15 e
Salicylic acid	50 ppm	188.8 ± 1.28 d	214.3 ± 0.44 d	50 ± 0.49 d	52 ± 0.55 d
	75 ppm	200.5 ± 2.39 a	234.5 ± 0.72 a	49 ± 0.22 a	51 ± 0.31 a
Brassinolides	0.2 ppm	190.2 ± 2.38 c	214.5 ± 2.63 c	51 ± 0.26 c	53 ± 0.85 cb
	0.5 ppm	191.1 ± 1.17 b	217.8 ± 3.11 b	50 ± 0.66 b	52 ± 0.39 b

Figure 1. Effect of foliar spray with phytohormones on chlorophyll content (mg/g) in maize COH (M) 8 under field condition

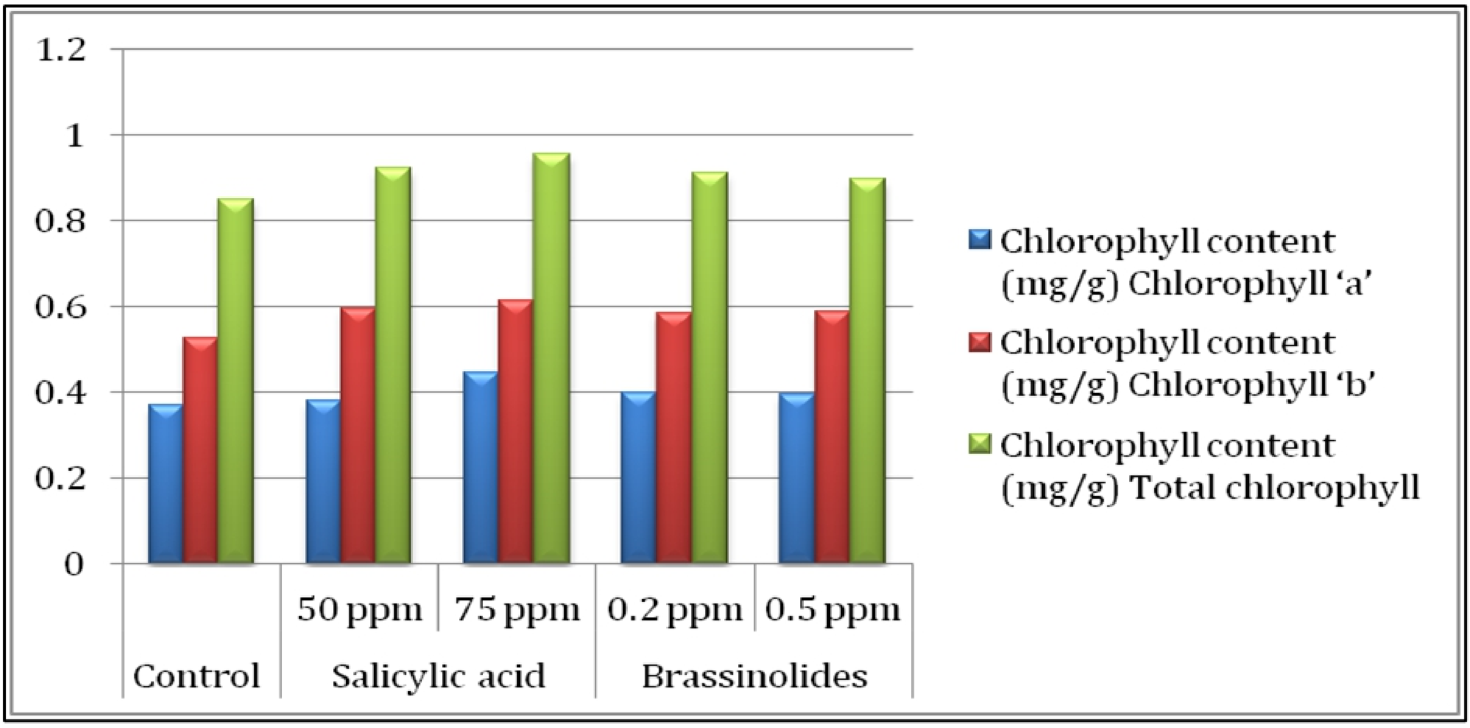

Table 2. Effect of foliar spray with phytohormones on cob length (cm), cob weight (g), number of seeds/ row and number of rows/cob in maize COH (M) 8 under field condition

Foliar spray treatments		Cob length (cm)	Cob weight (g)	No. of seeds/row	No. of rows/cob
Control		17.8 ± 0.22 e	158.80 ± 0.97 e	32 ± 0.29 e	14 ± 0.10 e
Salicylic acid	50 ppm	20.0 ± 0.15 c	168.67 ± 0.75 b	37 ± 0.13 b	14 ± 0.07 b
	75 ppm	20.7 ± 0.09 a	171.50 ± 0.47 a	38 ± 0.01 a	15 ± 0.14 a
Brassinolides	0.2 ppm	18.1 ± 0.30 d	159.28 ± 0.54 d	32 ± 0.04 d	14 ± 0.02 d
	0.5 ppm	20.4 ± 0.31 b	160.71 ± 1.91 c	32 ± 0.40 c	13 ± 0.16 c

Table 3. Effect of foliar spray with phytohormones on shelling (%), 1000 seed weight (g), seed yield/plot (kg) and seed yield/ha (kg) in maize COH (M) 8 under field condition

Foliar spray treatments	Shelling (%)	1000 seed weight (g)	Seed yield/plot (kg)	Seed yield kg/ha (kg)
Control	71 (57.41) ± 0.36 e	288.54 ± 0.29 d	7.5 ± 0.09 e	6250 ± 76.5 e

Salicylic acid	50 ppm	76 (60.66) ± 0.16 [b]	290.65 ± 4.45 [ab]	8.3 ± 0.00 [b]	6916 ± 7.11 [b]
	75 ppm	77 (61.34) ± 1.00 [a]	286.32 ± 2.53 [b]	8.5 ± 0.07 [a]	7083 ± 21.7 [a]
Brassinolides	0.2 ppm	73 (58.69) ± 0.67 [d]	280.10 ± 4.67 [c]	7.8 ± 0.06 [d]	6500 ± 37.6 [d]
	0.5 ppm	75 (60.00) ± 0.28 [c]	290.55 ± 0.10 [a]	8.1 ± 0.39 [c]	6750 ± 85.0 [c]

Discussion

Plant yield is very important in the agricultural point of view to feed food for the growing population. Heat stress is considered as major factor for all important agricultural crops [7]. The present study clearly examined that the plants foliar sprayed with phytohormones performed well by recording the yield attributing parameters in the field conditions when compared to control under drought stress conditions [6].

[13] noted that the application of 100, 200 and 400 ppm salicylic acid increased plant height, number of tillers/plants and shoot dry weight in wheat seedlings. Foliar application of salicylic acid 100 mg/L resulted in the highest increase in yield and its components (Amin et al., 2008). Drought stress has an adverse effect on the plant's yield due to the negative effect of heat on grain development as assimilate translocation, duration and the grain filling rate. It hastens the crop development thereby resulting in smaller, shrunk and lightweight kernels and adversely affect the yield [10, 12]. It was also observed that increased proline content is accompanied with improved grain yield which is an effective selection tool for the stress tolerant genotypes [13].

Exogenous application of salicylic acid could effectively increase the growth and yield of wheat plants under salt stress [8]. The increase in plant growth and grain yield is positively correlated with the salicylic acid which mitigates salt-induced overproduction of reactive oxygen species possibly by upregulating the antioxidant enzymes [9]. Exogenous application of salicylic acid as seed priming treatment was also found effective in maintaining the plant water relations by upregulating the proline synthesis when salicylic acid 75 ppm was applied. Overall, it is recommended that a comparatively low concentration of salicylic acid can be used as a seed priming treatment in wheat for better growth and yield in salt-stressed conditions [2]). Yield components recorded the highest values in plants foliar sprayed with phytohormones; No of grains, spikelet per plant, grain weight per plant except in 1000-grains weight, which showed non-significant difference with all other plants irrigated by different salinity levels [10]. Our results were in harmony with [3] who found that foliar spray with salicylic acid significantly increased yield per plant and number of seeds per plant in wheat and improved grain yield per plant under salt stress [11]. The present study proved that, the plants foliar sprayed with salicylic acid 75 ppm at 40 and 47 DAS recorded the maximum yield parameters viz., cob length, cob weight and seed yield.

Future scope of the study

Since this study contributes about the effect of phytohormones only in maize crop future study can focus into identifying its effect on other crops like pulses and oilseeds. Mode of action of these phytohormones can be studied in future through molecular approach

Conflict of Interest

There is no conflict of interest between the authors

Acknowledgement

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Conclusion

Foliar spray with phytohormone enhances the physiological growth characteristics and yield parameters of maize and also its drought tolerance characteristics, making it a cost-effective solution to abiotic stress. The exogenous application of phytohormones/polyamines through seed priming can enhance the antioxidant system and mitigate photosynthetic damage in maize seedlings. This method can improve crop growth and development without any negative effects on cop plants under drought stress. Overall, this study suggests that foliar spray with phytohormones can be a promising technique for sustainable agriculture in the phase of climate change.

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