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Effect of Salicylic Acid, Ascorbic Acid and Thiourea on Morphological Parameters of Okra (*Abelmoschus esculentus* L.) cv. Arka Anamika under Drought Stress

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ABSTRACT

An investigation on the effect of salicylic acid, ascorbic acid and thiourea on morphological parameters of Okra (*Abelmoschus esculentus* L.) cv. ArkaAnamika under drought stress was conducted at Regional Agricultural Research Station, Pilicode, Kerala Agricultural University, Kerala, during December 2019 – March 2020. The field experiment was laid out in a randomized block design (RBD) with eight treatments in three replications. The okra (*Abelmoschus esculentus L.*) cv. Arka Anamika was raised as per standard package of practices recommendations of Kerala Agricultural University and also under soil test based nutrient management system. Foliar applications of salicylic acid (1 mM and 2 mM), Ascorbic acid ((1 mM and 2 mM) and thiourea (500 and 1000 ppm) were given at 10, 15 and 30 days after sowing (DAS). Drought was induced 25 days after sowing (DAS) and irrigation given at 50% field capacity. The morphological parameters such as plant height, leaves per plant, branches per plant, root volume and duration of crop were recorded at 25, 50 and 75 DAS. The morphological parameters such as plant height, leaves per plant, branches per plant, root volume and duration of crop were significantly influenced by the foliar spray of salicylic acid, ascorbic acid and thiourea. Among these chemicals, salicylic acid 1 mM performed better followed by ascorbic acid 2 mM.

Introduction

Okra, or lady's finger, commonly known as 'Bhindi' (*Abelmoschus esculentus* L.) is an important summer vegetable crop belonging to the family Malvaceae, which is grown for its edible fruits. The crop is grown throughout the tropical and subtropical parts of the world and acceptable in the market. Okra fruits are harvested when immature and eaten as a vegetable. The green fruits are rich sources of carbohydrates (6.4 %), protein (1.9 %), fat (0.2 %), dietary fiber (1.2 g), vitamins, calcium (66 mg), potassium, and other minerals. The nutritional importance of okra aroused interest in bringing the crop into commercial production.

Vegetables are very sensitive to drought stress compared to most of the field crops because of their high water requirement. Growth, yield and quality of vegetable crops are significantly affected by drought stress. Okra is relatively drought tolerant but drought can reduce yield depending on its severity. Therefore, for higher yields, an adequate water supply and relatively moist soils are required during the total growing period.

Throughout the world, the ground water level is inadequate for the cultivation of crops and this water-limited condition is a threatening problem. Improvement of drought tolerance in plants is possible in various ways such as, application of plant growth regulators, antioxidants, bio stimulants etc. Utilization of growth regulating substances like salicylic acid, ascorbic acid and thiourea were easier and cheaper than the long-term and costly methods.

Salicylic acid or ortho- hydroxy benzoic acid is an endogenous plant growth regulator of phenolic nature that possess an aromatic ring with a hydroxyl group or its functional derivatives. Salicylic acid mitigate drought effects in plants under stress by adjusting the activity of antioxidant enzymes. Exogenous application of salicylic acid during drought stress was found effective in major crops because it can repair the damage caused by stress. SA treatment increased moisture absorption by plant roots and the amount of water loss by stomata was manipulated to decrease adverse effects of drought and it helped to regulate the availability of moisture in plants body (Keyvan, 2010).

Ascorbic acid (as vitamin) is a non-enzymatic water soluble antioxidant. It is one of the cheapest plant growth regulator and has significant positive effects on plant growth and development under stress or non-stress conditions. Ascorbic acid is a main compound in plants and reduces the harmful effects of drought stress by reducing the amount of free radicals. By increasing the activities of CAT, SOD, POD enzymes and proline content, minimizing the H2O2 production and elevating the levels of phenolics, ascorbic acid makes a plant resistant to different drought stress (Akram *et al.*, 2017).

Thiourea, chemically named as Thiocarbamide (NH2-CS-NH2), is a nitrogen and sulfur containing compound. Exogenous application of thiourea improves plant growth and productivity and stimulates defense mechanisms in plants under normal and stressful condition. Thiourea imparts drought tolerance in plants because of its high water solubility and quick absorption in living tissues (Garg *et al.*, 2006).

Keeping in view the importance of okra as a vegetable with respect to its nutritional value, area and production and alarming condition of drought occurrence in Kerala, a comprehensive study was conducted to assess the negative effects of drought on morphological parameters of okra and also to mitigate these negative effects through salicylic acid, ascorbic acid and thiourea.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Pilicode, Kerala Agricultural University, Kerala, during December 2019 – March 2020. The field experiment was laid out in a randomized block design (RBD) with eight treatments in three replications. The plot size was 3m x 3m (9 m2) and spacing followed was 60 cm × 30 cm. The crop was raised as per standard package of practices recommendations (PoP) of Kerala Agricultural University (KAU) and also under soil test based nutrient management system.

The experiment consisted of 8 treatments *viz*., Normal irrigation (T1) as control, drought stress (T2), T2 + Salicylic acid foliar spray @ 1 mM (T3), T2 + Salicylic acid foliar spray @ 2 mM (T4), T2 + Ascorbic acid foliar spray @ 1mM (T4), T2 + Ascorbic acid foliar spray

@ 2 mM (T5), T2 + Thiourea foliar spray @ 500 ppm (T7), T2 + Thiourea foliar spray @ 1000 ppm (T8). Foliar application of chemicals was given at 10, 20 and 30 DAS. Drought induced from 25 DAS, irrigation given at 50 % field capacity.

Soil samples were collected from the experimental plots prior to the crop sowing which were then dried in shade for estimation of pH, EC, available N, P, K, S, Ca and Mg. Soil test data showed that, soil was acidic in nature and elements like nitrogen, and potassium were deficient. Field capacity and permanent wilting point of the soil samples were determined using pressure plate extractor set up.

The experimental field was thoroughly ploughed, soil brought to a fine tilth and then the field was levelled. The plot size was 3m x 3m (9 m2) and spacing followed was 60 cm × 30 cm. Applied N, P2O5 and K2O @ 110:35:70 kg ha at the time of sowing as per Package of Practices Recommendations Crops (KAU, 2016) and soil test result. Foliar spray of chemicals namely, salicylic acid, ascorbic acid and thiourea was done at 10th, 20th and 30th DAS. Uniform daily irrigation was given to all the treatments for the first 25 days after sowing. Irrigation was withheld 25 days after sowing in treatments T2 to T8 and re-irrigation was given at 50 % field capacity.

Intercultural operations and hand weeding were carried out in okra crop to maintain weed free condition during crop season. The crop was free from major insect pests and diseases by taking suitable plant protection measures. Five plants were randomly selected from each plot and tagged permanently. Morphological observations such as plant height, number of leaves per plant, branches per plant, root volume and duration of crop were recorded at 25th 50th and 75th days after sowing. The data obtained from the experiment were subjected to statistical analysis.

Results and Discussion

Plant height (cm)

The data on plant height was recorded at 25, 50 and 75 DAS and are presented in Table 1. The plant height showed significant difference among treatments at 25, 50 and 75 DAS. At 25 DAS, maximum plant height was observed in the treatment T3 (25.8 cm) which was on par with treatments T6 (25.2 cm), T5 (24.7 cm) and T1 (24.4 cm). At 50 DAS, maximum plant height (85.5 cm) was observed in the treatment T3 followed by T1 (81 cm). T1 was on par with T6 (79.1 cm) and T7 (77.7 cm). The lowest plant height was recorded for drought stressed plants T2 (70.4 cm). At 75 DAS, maximum plant height was observed in the treatment T3 (153.5 cm) which was on par with T1 (152.8 cm) and the lowest plant height was recorded for T2 (141.3 cm). Therefore, the highest and the lowest plant height were recorded in treatment T3 and T2 respectively at all the crop growth stages.

Number of leaves per plant

The data on number of leaves per plant was recorded at 25, 50 and 75 DAS and are presented in Table 2. At 25 DAS, T3 (11.99) recorded maximum number of leaves per plant which was on par with T6 (11.55), T4 (11.39) and T5 (11.1). The minimum number of leaves per plant was obtained in the T8 (10.0). At 50 DAS, the maximum number of leaves per plant was observed in the treatment T3 (28.16) which was on par with treatments T6 (11.55), T1 (25.85) and T4 (24.73) followed by T7 (23.91). The lowest mean number of leaves per plant was observed in the treatment T2 (21.35). At 75 DAS, the maximum number of leaves was observed in

T3 (24.6) which was on par with that of T6 (23.21). The minimum number of leaves per plant (19.48) was obtained in (T2) which was on par with that of T8 (19.86), T5 (20.35) and T7 (20.45).

Number of branches per plant

The data on branches per plant was recorded at 25, 50 and 75 DAS and are presented in Table 2. At 25 DAS, the maximum number of branches (1.27) per plant was recorded with treatment T3, which was on par with T5 (1.26), T2 (1.25) and T1 (1.24). At 50 DAS, the maximum number of branches per plant was observed in treatment T1 (2.34) which was on par with T3 (2.33) and T6 (2.30). The lowest number of branches per plant was observed in treatments T2 (2.20) and T8 (2.20). At 75 DAS, T1 (3.14) and T3 (3.13) recorded the maximum value for number of branches per plant followed by T6 (3.00), T4 (2.96), T5 (2.89) and T7 (2.87). T2 (2.66) recorded the lowest number of branches per plant.

Root volume (cm3)

The data on mean root volume was recorded at 25, 50 and 75 DAS and are presented in Table 3. At 25 DAS, the maximum root volume was observed in the SA foliar spray @ 1 mM treatment *i.e.*, T (9.00 cm3) and minimum root volume was recorded in T5 (7.99 cm) and T8 (7.95 cm) . At 50 DAS, the control plants (T1) showed the higher root volume (21.66 cm3) which was on par with T (20.66 cm3), T (20.33 cm3), T (19.66 cm3) and T (18.66 cm3). The lowest root volume (15.66 cm3) was observed in drought stressed treatment (T2). At 75 DAS, maximum root volume was observed in treatment T3 (26.36 cm) and T1 (26.08 cm) which were on par with T6 (24.68 cm) and T5 (23.58 cm) . The lowest root volume was observed in the treatment T (22.12 cm3).

Table.1 Effect of chemicals on mean plant height at various crop stages of okra

Treatments	Mean plant height (cm)		
	25 DAS	50 DAS	75 DAS
T_1	24.4^{abc}	81.0^{b}	**152.8^{ab}**
T_2	23.9^{bc}	70.4^{e}	**141.3^{d}**
T_3	25.8^{a}	85.5^{a}	**153.5^{a}**
T_4	23.3^{c}	70.6^{de}	**144.4^{cd}**
T_5	24.7^{abc}	70.6^{c}	**146.3^{c}**
T_6	25.2^{ab}	79.1^{bc}	**148.5^{bc}**
T_7	23.3^{c}	77.7^{bc}	**147.9^{c}**
T_8	23.3^{c}	74.9^{cd}	**145^{cd}**
SEM (±)	0.51	1.42	**1.47**
CD (0.05)	**1.59**	**4.34**	**4.52**

Table.2 Effect of chemicals on number of leaves per plant and branches per plant at various crop stages of okra

Treatments	Number of leaves per plant			Number of branches per plant		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
T_1	10.46^{bcd}	25.85^{abc}	21.4^{bc}	1.24^{a}	2.34^{a}	$\mathbf{3.14^{a}}$
T_2	10.54^{bcd}	21.35^{d}	19.48^{c}	1.25^{a}	2.20^{d}	$\mathbf{2.66^{c}}$
T_3	11.99^{a}	28.16^{a}	24.6^{a}	1.27^{a}	2.33^{ab}	$\mathbf{3.13^{a}}$
T_4	11.39^{ab}	24.73^{abcd}	20.72^{bc}	1.17^{b}	2.24^{bcd}	$\mathbf{2.96^{ab}}$
T_5	11.1^{abc}	23.06^{cd}	20.35^{c}	1.26^{a}	2.22^{cd}	$\mathbf{2.89^{abc}}$
T_6	11.55^{a}	26.93^{ab}	23.21^{ab}	1.16^{b}	2.30^{abc}	$\mathbf{3.00^{ab}}$
T_7	10.2^{cd}	23.91^{bcd}	20.45^{c}	1.15^{b}	2.21^{cd}	$\mathbf{2.87^{abc}}$
T_8	10.0^{d}	22.32^{cd}	19.86^{c}	1.12^{b}	2.20^{d}	$\mathbf{2.79^{bc}}$
SEM (±)	0.31	1.26	0.84	0.01	0.02	**0.09**
CD (0.05)	**0.96**	**3.88**	**2.57**	**0.05**	**0.08**	**0.28**

Table.3 Effect of chemicals on mean root volume (cm3) and duration of the crop

Treatments	Mean root Volume (cm^3)			Duration of the crop
	25 DAS	50 DAS	75 DAS	
T_1	8.98^{a}	21.66^{a}	26.08^{a}	$\mathbf{106.66^{a}}$
T_2	8.94^{a}	15.66^{c}	22.81^{b}	$\mathbf{98.33^{c}}$
T_3	9.00^{a}	20.66^{ab}	26.36^{a}	$\mathbf{107.66^{a}}$
T_4	8.47^{ab}	17.66^{bc}	22.12^{b}	$\mathbf{103.00^{abc}}$
T_5	7.99^{b}	18.33^{bc}	23.58^{ab}	$\mathbf{103.66^{abc}}$
T_6	8.67^{a}	20.33^{ab}	24.68^{ab}	$\mathbf{105.00^{ab}}$
T_7	8.68^{a}	19.66^{ab}	22.52^{b}	$\mathbf{98.66^{c}}$
T_8	7.95^{b}	18.66^{abc}	22.65^{b}	$\mathbf{100.33^{bc}}$
SEM (±)	0.20	1.07	0.99	**1.90**
CD (0.05)	**0.61**	**3.30**	**3.03**	**5.82**

Fig.1 Effect of chemicals on mean plant height at various crop stages of okra

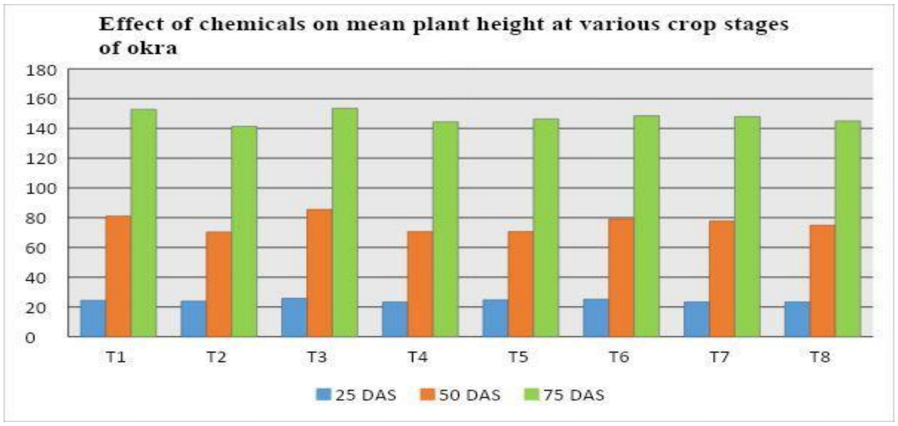


Fig.2 Effect of chemicals on mean number of leaves per plant at various crop stages of okra

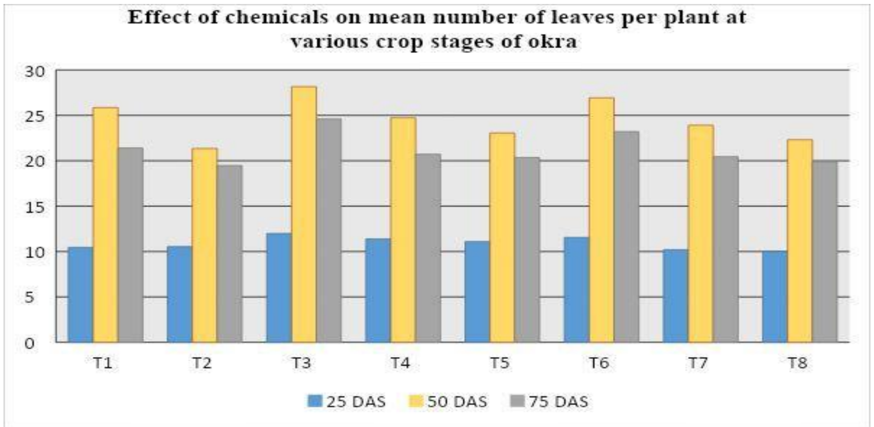


Fig.3 Effect of chemicals on mean number of branches per plant at various crop stages of okra

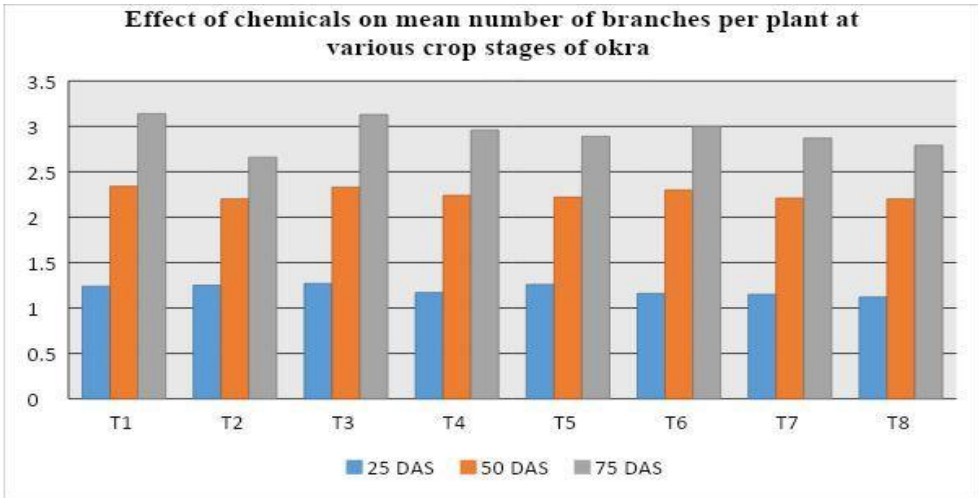
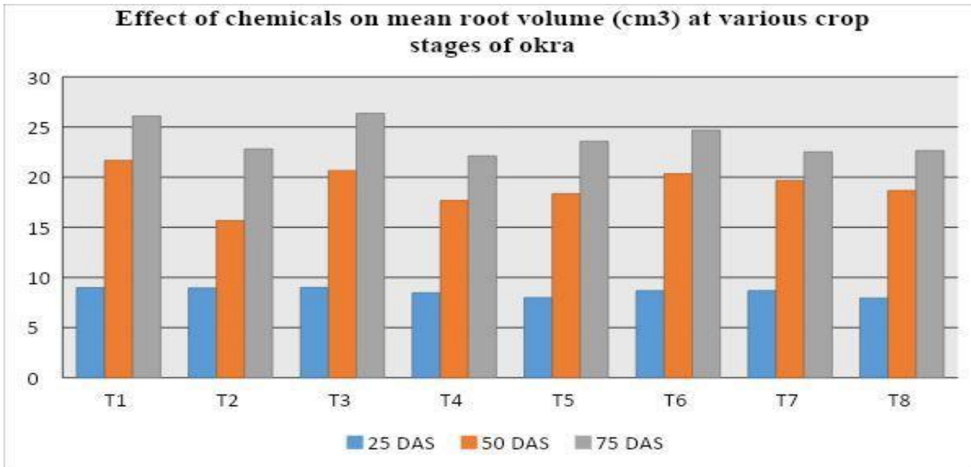


Fig.4 Effect of chemicals on mean root volume (cm3) at various crop stages of okra



Duration of the crop (days)

The data on the on duration of the crop was recorded at 25, 50 and 75 DAS and are presented in Table 5. The duration of the crop was highest in treatment T3 (107.66) which was on par with T1 (106.66), T6 (105.00), T5 (103.66) and T4 (103.00). The minimum duration of the crop was recorded in treatments T2 (98.33) and T7 (98.66).

Similar results of salicylic foliar spray enhancing plant height (Figure 1.) under drought stress were reported by Amin *et al.*, (2008) in wheat and Munir *et al.*, (2016) in okra. Salicylic acid increases the water content in the plant and raise the efficiency of photosynthesis and increase the concentration of hormones such as Indole-acetic acid (IAA) and reduction of the concentration of abscisic acid (ABA) and ethylene which accelerate aging, which ultimately results in increase in the plant height when sprayed with salicylic acid (Sakhabutdinova *et al.*, 2003 and Yonova, P., 2010). Ascorbic acid foliar spray of 2 mM (T6) and thiourea foliar spray of 500 ppm (T7) increased the plant height by 5.1 % and 4.67 % over drought stressed plants.

The maximum number of leaves per plant and branches per plant was in plants treated with salicylic acid @ 1 mM under drought stress (T3) followed by ascorbic acid foliar spray of 2 mM (T6) (Figure 2. and Figure 3.). All the three chemicals performed well when compared with drought stressed plants without foliar spray. Foliar spray of thiourea @ 500 ppm and 1000 ppm also increased plant height, number of leaves per plant and number of branches per plant, when compared with drought stressed plants. Many workers like Amin *et al.*, (2014) in faba bean, Singh (2017) in lentil, Shakoor *et al.*, (2019) in maize and Uddin *et al.*, (2020) in okra reported the favourable influence of foliar spray of thiourea on plant height, number of leaves per plant and number of branches per plant. Thiourea delay leaf ageing and senescence and increased the net photosynthetic rates, concentration of total chlorophyll and starch in leaves leading to increased plant height, number of leaves and branches (Patel *et al.*, 2016 and Singh and Singh 2016).

Root volume at the final harvest was significantly influenced by spraying of chemicals and the highest root volume was observed with spraying of salicylic acid @ 1 mM (T3) (Figure 4.). This is also in agreement with the findings of Hayat *et al.*, (2010) in tomato and Munir *et al.*, (2016) in okra, wherein there was an increase in root length and root dry matter by spraying of salicylic acid.

Perusal of results revealed that foliar spray of salicylic acid 1 mM to field grown okra under both stressed and non-stressed condition was found to be the ideal treatment. Ascorbic acid foliar spray of 2 mM was found to be the next promising one. Foliar spray of these chemicals improved the plant morphological characters and which would influence on the yield parameters also. Hence, foliar spray of salicylic acid (1 mM) and ascorbic acid (2 mM) mitigated the harmful effects of drought stress in okra.

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