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RESEARCH ARTICLE

SALICYLIC ACID AND VEGETATIVE GROWTH OF PEARL MILLET

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ABSTRACT

The effect of Salicylic Acid (SA) on the shoot growth (length, fresh weight, diameter, and dry weight) root growth (length, fresh weight, diameter, and dry weight) and foliar growth (plant fresh weight, leaves per plant and leaf area) of bajra plants grown in the drought stressed Telangana State was studied. Telangana State is a semi –arid tropic comprising of saline land black soil wherein the plants usually experience drought and saline stresses. Application of 0.5 mM, 1.0 mM, 2.0 mM and 4.0 mM of SA was very effective in stimulating the shoot growth, root growth as well as the foliar growth of bajra plants though 3.5mm and 4.0 mM were not that effective or even reducing the growth parameters. The promotion of shoot, root and foliar growth is an indicator that SA mitigated the negative effect of the semi-arid conditions of the soil.

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INTRODUCTION

The genus, *Pennisetum* is considered as one of the important genera of Poaceae family. This genus comprises of numerous species viz., *Pennisetum glaucum, P. americanum, P. purpureum*, etc. and is found widely distributed in tropical and subtropical regions (Brunken, 1977). The millets are the oldest cultivated commercial crops that include pearl millet, candle millet, cattail millet, proso, foxtail, browntop, bulrush, etc. Of these, bajra or pearl millet (Pearl millet *glaucum*), an annual taxon, has high importance as commercial crop and yield high amount of production (Chatterjee and Kumar, 1964). Salicylic acid (SA) is a phenolic compound which, despite its broad distribution in plants, has basal levels differing widely among species, with up to 100-fold differences having been recorded (Raskin et al., 1990). This disparity of application of SA and plant growth can be observed within members of the same family. For example, in the case of the family Solanaceae, the genus *Nicotiana tabacum* contains low basal levels of SA around <100 ng g^{-1} fresh weight in leaves (Malamy et al., 1992) whereas, the genus *Solanum tuberosum* might contain up to 10 µg of total SA g^{-1} fresh weight (Navarre and Mayo, 2004) *Arabidopsis thaliana*, the model plant for most experimental studies showed that the basal values of total SA ranges from 0.25 µg to 1 µg/g fresh weight (Broderson et al., 2005).

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MATERIALS AND METHODS

Bajra (*Pennisetumglaucum* (L.) R.Br.) seeds were procured from Natural Seeds Corporation, Madikonda, Warangal Urban district, Telangana State, India during the *Kharif* - 2014 and *Rabi* – 2015 seasons. One popularly used local variety of seeds viz., *Ananta*was employed in the present experiment work. The present work is focused on the effect of a natural PGR - salicylic acid (SA) on the growth, development and metabolism of bajra. SA (SD-fine) was procured from Dwarakamai Enterprises, Hyderabad, TelanganaState, India. The experiments were conducted in the field plot beds in Warangal, Telangana State. Individual plots were prepared with a size of 5×5 m. The plots were uniformly mixed with 25 kg conventional compost. The plants were grown in field (5×5 m - length and width) containing fresh sieved red soil mixed with well-rotten farm yard manure. The seeds of bajra (variety *Ananta*) were surface sterilized with 0.5% (v/v) sodium hypochlorite and washed thoroughly with several changes of sterile distilled water. They were soaked for 24h in *Rhizobium* inoculums. 30 Seeds of bajra were sown in each row keeping a gap of about 40 cm between each row and a total of twelve rows (treated nine rows for three different concentrations of SA and three rows as controls) were prepared in the field and totally 300 seeds were sown in 5×5 m well prepared plot. Germination started around3-4 days after sowing. On the 7th day (3-4 leaves stage) after the germination, approximately 75% of plants (ca. 225 individuals) were retained in the soil. Bajra crops were grown under natural day length and observed initiation of panicle in 4th week (22nd day onwards). Salicylic

acid (SA) was supplied at six different concentrations viz., 0.5 mM, 1.0 mM, 2.0 mM, 3.0 mM, 3.5mM and 4.0 mM and three rows (total nine rows) were maintained for each concentration of SA in the bajra field. Three rows were maintained as controls which were supplemented with water. SA was applied as foliar spray to bajra crop and the spraying was done in the early hours of the day by using plastic sprayers. SA was sprayed three times to the plants on 20th, 40th and 50th (from the day of sowing of seeds) whereas the untreated bajra controls were supplied with distilled water. Growth parameters in terms of root and shoot length, fresh and dry weights of roots and shoots as well foliage(number of leaves/plant, length of leaves, width of leaves, average leaf area and total leaf area)of bajra crops were recorded on the 55th day. The different vegetative parameters grown in drought – stressed Telangana State were recorded on the 65th day are mentioned below.

ROOT AND SHOOT LENGTH OF BAJRA CROP: The field plots were adequately watered and the bajra plants were gently removed. All necessary precautions were taken to see that the root system was intact. The shoot and root of bajra plant were measured using a meter scale and their values were expressed in centimetres (cm).

ROOT AND SHOOT FRESH WEIGHT OF BAJRA: The fresh weights of the bajra root and shoot were recorded. A meter balance was used for this purpose. The root and shoot fresh weights of bajra crop were expressed in grams (g).

ROOT AND SHOOT DRY WEIGHT OF BAJRA CROP: The roots and shoots of bajra crop were dried in the oven at 110ºC for 24 hand their dried weights (biomass) were recorded. The root and shoot dry weights of bajra crop were expressed in terms of grams (g).

FOLIAGE OF BAJRA CROP GROWN IN DROUGHT – STRESSED TELANGANA STATE: The foliage of bajra crop grown in drought – stressed Telangana State was calculated as the number of leaves/plant, leaf length, leaf width, average leaf area and total leaf area.

NUMBER OF LEAVES/BAJRA PLANT: The number of leaves per bajra plant was calculated. The leaf parameters were recorded on the 55th day.

LENGTH AND WIDTH OF LEAVES/BAJRA PLANT: All necessary precautions were taken to see that the leaves were intact. The leaves were washed with tap water (twice). The water droplets adhering to the leaves were removed with the help of blotting paper. For the present study, the position of the leaf at 5th point of the stem was standardized. The length and width of 5th leaf of bajra plants were measured using a meter scale and their values were expressed in centimetres.

AVERAGE LEAF AREA (ALA) OF BAJRA CROP: The leaf area of bajra crop was determined following the formula of Carleton and Foote (1965).

Leaf area (cm) = Maximum leaf length × Maximum leaf width × 0.75

(0.75=Correction factor)

TOTAL LEAF AREA (TLA) OF BAJRA CROP: The total leaf area per bajra plant was determined following the formula of Carleton and Foote (1965). The leaf area was multiplied by total number of leaves to calculate total leaf area per plant.

Leaf area (cm) = Maximum leaf length × Maximum leaf width × 0.75 × number of leaves
(0.75=Correction factor)

RESULTS

SHOOT GROWTH: The foliar supplementation of six concentrations of salicylic acid (SA) viz., 0.5 mM, 1.0 mM, 2.0 mM, 3.0 mM, 3.5 mM and 4.0 mM showed varying results on the shoot growth of bajra. The four treatments of salicylic acid (SA) viz., 0.5 mM, 1.0 mM, 2.0 mM and 3.0 mM substantially increased the shoot growth in terms of shoot length, shoot fresh and dry weight of bajra over untreated controls. Application of 3.0 mM concentration of SA caused a maximum enhancement in growth of the shoot followed by 2.0 mM, 1.0 mM and 0.5mM conc. of SA over untreated control plants. The application of other two concentrations of SA viz., 3.5 mM and 4.0mM resulted in decreased shoot length, shoot fresh and dry weight of bajra compared to untreated controls.

ROOT GROWTH: The foliar supplementation of six concentrations of salicylic acid (SA) viz., 0.5 mM, 1.0 mM, 2.0 mM, 3.0 mM, 3.5 mM and 4.0 mM showed varying results on the root growth of bajra. The four treatments of salicylic acid (SA) viz., 0.5 mM, 1.0 mM, 2.0 mM and 3.0 mM substantially increased the root growth in terms of root length, root fresh and dry weight of bajra over untreated controls. Application of 3.0 mM concentration of SA caused a maximum enhancement in growth of the root followed by 2.0 mM, 1.0 mM and 0.5mM conc. of SA over untreated control plants. The application of other two concentrations of SA viz., 3.5 mM and 4.0mM resulted in decreased root length, root fresh and dry weight of bajra compared to untreated controls.

FOLIAR GROWTH: The foliar supplementation of six concentrations of salicylic acid (SA) viz., 0.5 mM, 1.0 mM, 2.0 mM, 3.0 mM, 3.5 mM and 4.0 mM showed varying results on the foliar growth of bajra. The four treatments of salicylic acid (SA) viz., 0.5 mM, 1.0 mM, 2.0 mM and 3.0 mM substantially increased the foliar growth in terms of number of leaves/plant, leaf length, leaf width, average leaf area and total leaf area of bajra over untreated controls. Application of 3.0 mM concentration of SA caused a maximum enhancement in growth of the folaige followed by 2.0 mM, 1.0 mM and 0.5mM conc. of SA over untreated control plants. The application of other two concentrations of SA viz., 3.5 mM and 4.0mM resulted in decreased foliar growth in terms of number of leaves/plant, leaf length, width, average leaf area and total leaf area of bajra compared to untreated controls.

DISCUSSION

Aqueous solutions of SA applied as a spray to the shoots of soybean (*Glycine max* (L.) *Merr*. cv. *Cajeme*) significantly increased the growth of roots and shoots as measured after seven days of treatment cultivated either in the greenhouse or in the field wherein SA induced increases in root growth to 100% in the field (Gutie´rrez-Coronado et al., 1998).

Table. 1. Effect of Salicylic Acid (SA) on the shoot growth of bajra grown in Drought –stressed Telangana State

Treatment	Shoot Length (cm)	Shoot Fresh Weight (gm)	Shoot Dry Weight (gm)
Control	43.37 ± 2.31	33.41 ± 0.70	18.10 ± 2.12
0.5 mM SA	50.33 ± 4.24	41.08 ± 6.03	21.20 ± 3.24
1.0 mM SA	55.88 ± 2.22	46.83 ± 7.10	24.10 ± 1.44
2.0 mM SA	57.52 ± 1.13	50.61 ± 6.65	25.80 ± 10.16
3.0 mM SA	62.11 ± 4.11	56.83 ± 9.16	28.55 ± 6.75
3.5 mM SA	42.53 ± 0.99	32.22 ± 5.71	17.90 ± 2.50
4.0 mM SA	41.43 ± 1.32	30.29 ± 3.45	16.55 ± 1.30

*The results presented are the mean values of 9 replicates. One-way analysis of variance (ANOVA) was carried out using. The differences were considered significant if p was ≤ 0.05.

Table. 2. Effect of Salicylic Acid (SA) on the root growth of bajra grown in Drought–stressed Telangana State

Treatment	Root Length (cm)	Root Fresh Weight (gm)	Root Dry Weight (gm)
Control	10.88 ± 1.07	3.59 ± 0.95	1.95 ± 0.70
0.5 mM SA	12.22 ± 0.73	4.19 ± 2.13	2.54 ± 0.62
1.0 mM SA	13.66 ± 0.97	5.11 ± 1.38	3.14 ± 0.56
2.0 mM SA	15.53 ± 1.25	8.46 ± 0.75	4.55 ± 0.14
3.0 mM SA	18.11 ± 1.29	12.99 ± 2.02	6.35 ± 1.48
3.5 mM SA	9.25 ± 0.55	3.45 ± 0.70	1.21 ± 0.35
4.0 mM SA	08.36 ± 1.32	2.66 ± 1.23	1.46 ± 0.13

*The results presented are the mean values of 9 replicates. One-way analysis of variance (ANOVA) was carried out using. The differences were considered significant if p was ≤ 0.05.

Table. 3. Effect of Salicylic Acid (SA) on the Foliage growth of bajra grown in Drought–stressed Telangana State

Treatment	Number of leaves /Plant	Leaf Length (cm)	Leaf Width (cm)	Average Leaf Area (cm)	Total Leaf Area
Control	6.68 ± 0.75	75.53 ± 0.66	3.33 ± 0.88	125.13 ± 1.23	251.51± 7.365
0.5 mM SA	7.66 ± 0.52	87.63 ± 0.88	4.13 ± 1.15	181.29 ± 3.26	361.91 ± 11.042
1.0 mM SA	8.66 ± 1.05	99.88 ± 1.15	5.00 ± 1.01	249.16 ± 3.44	499.40 ± 9.75
2.0 mM SA	9.01 ± 0.85	104.56 ± 0.93	5.58 ± 1.38	249.16 ± 3.44	583.44 ± 5.65
3.0 mM SA	9.66 ± 1.09	112.23 ± 0.57	6.13 ± 1.15	343.31 ± 3.87	687.97 ± 12.15
3.5 mM SA	6.23 ± 0.54	71.20 ± 0.12	3.03 ± 0.87	122.29 ± 2.33	248.74 ± 6.89
4.0 mM SA	4.94 ± 1.01	63.44 ± 2.31	3.27 ± 1.46	109.44 ± 1.16	236.29 ± 9.33

*The results presented are the mean values of 9 replicates. One-way analysis of variance (ANOVA) was carried out using. The differences were considered significant if p was ≤ 0.05.

Exogenous application of SA (1 and 2 mM) enhanced shoot, root and total plant dry weight in *C. officinalis* (Bayat et al., 2012). Root drenching with 0.1 mM SA protected tomato (*Lycopersicon esculentum*) plants against 200 mM NaCl stress (Stevens et al., 2006). Application of SA not only delayed the senescence of leaves but also prevented premature fall of leaves in Huang Kum pear (Imran et al., 2007). Zhou et al. (1999) also indicated that SA increased the leaf area in corn plants. Spraying of SA to leaves of wheat genotypes C 306 and Hira after sowing under moderate water stress (-0.8 MPa) imposed by adding PEG-6000 in nutrient solution resulted in increased relative water content, membrane stability index, leaf area and total biomass over control plants (Agarwal et al., 2005). Foliar application of SA (100, 200, 400 mg L) and AsA to wheat plants resulted in enhancement of growth characters (plant height, flag leaf area, leaf blades area/plant) and total carbohydrates (Amin et al., 2008). Application of SA increased in number of branches and leaves per plant in canola (Salarizdah et al., 2012), sunflower (Dawood et al., 2012) and mungbean (Ali and Mahmoud, 2012). Application of SA stimulated the growth of leaf rosettes and roots of *Matricaria chamomilla* plants by 32% and 65% respectively (Kova´cik et al., 2009) which is in tune with the present research study which clearly proved that the ability of four different concentrations of salicylic acid, namely, 0.5 mM, 1.0 mM, 2.0 mM and 3.0 mM SA to enhance the root, shoot and foliage growth (number of leaves/plant, length and width of leaves, average and total leaf area) of bajra (*Pennisetum glaucum* (L.) R.Br.) grown in the drought stresses Telangana Region where as the other two concentrations of SA viz., 3.5 mM and 4.0 MM to only slightly increase or even reduce the root, shoot and foliage growth (number of leaves/plant, length and width of leaves, average and total leaf area) of bajra.

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