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Effect of salicylic acid and indole acetic acid on growth, physiological fluctuations and proline content of varieties of tomato (*Lycopersicum esculentum*) under induced cadmium and NaCl stress

ZAHID AHMAD MALIK[1] AND EUGENIA P. LAL[1]

Department of Biological Sciences, Sam Higginbottom University of Agriculture Technology and Sciences. Allahabad (U.P) 211007 India

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ABSTRACT

Two sets of experiments (seed treatment and foliar spray) were conducted at Allahabad during rabi season of 2016-17 to study the effect of salicylic acid and indole acetic acid on growth, physiological parameters and proline content in tomato (Lycopersicum esculentum) under induced NaCl and cadmium stress. NaCl and cadmium in each pot was added 100mM and 20 mg kg^{-1} soil against salicylic acid (SA) and indole acetic acid (IAA). The experiment was conducted in factorial randomized design with 16 treatments and three replications. Results revealed that plant height of both the varieties did not differ markedly under various treatments. In general, tallest plants of both the varieties of tomato were recorded under 2 mM (SA) + 2 mM (IAA) treatment. Seed treatment of SA and IAA provided better result than that of foliar spray in respect of plant height. Similar trend was also recorded for number of leaves under various treatments. Plant height and number of leaves were recorded minimum under control treatment. Physiological parameters like chlorophyll a and b, carotenoids were recorded maximum under 2 mM (SA) + 2 mM (IAA) treatments in the both the varieties of tomato. On the other hands, proline content in the tomato plant was maximum under control and minimum under 2 mM (SA) + 2 mM (IAA). Both, seed treatment and foliar application proved more or less similar in respect of proline content. Stress produced by NaCl and cadmium decreased growth and plysiological parameters, whereas applications of SA and IAA enhanced the values of these parameters.

Keywords: Tomato, varieties, NaCl, cadmium, proline

INTRODUCTION

Salt stress is major environmental constraint limiting plant productivity. Salt-tolerant crops require an examination of the behaviour of the plant development including seed germination stage. Salinity shows the negative impacts on growth and flowering of marigold (Chuahan and Ambast 2014). Contamination of the soil by toxic elements such as heavy metals is a major environmental concern. Cadmium (Cd) is probably one of the most toxic heavy metals, particularly at high concentrations, inhibiting plant growth and development, whereas at low concentrations Cd may also stimulate growth depending on the plant species (Wahid and Ghani 2008). Cadmium also shows diverse effect on growth and yield parameters of vegetable crops (Zahid *et al.*, 2014). Heavy metals like cadmium etc on soil profile may prove harmful not only to plants, but also to consumers of the harvested crops (Ashiq *et al.,* 2013). Salicyclic acid (SA) plays a vital role for protecting plants against multiple stresses, including cold, salinity, and drought stress (Patel and Hemantaranjan, 2012). Seeds with SA have been reported to ameliorate the effects of Cd-induced heavy metal toxicity via enhanced activities of reactive oxygen species (ROS)-scavenging enzymes (Agami and Mohamed, 2013). Indolea cetic acid (IAA) plays a vital role in maintaining plant growth under salt stress conditions (Iqbal and Ashraf 2007). The growth-promoting phytohormone auxin (indole-3 acetic acid, IAA) alleviating the toxic effects of metals on plants and improving them towards normal conditions (Erika *et al.*, 2010). Hence, an experiment was conducted using tomato as test crop with SA and IAA under NaCl and Cd stress.

MATERIALS AND METHODS

The pot experiments were conducted at Department of Biological Sciences, Sam Higginbottom University of Agriculture Technology and Sciences Allahabad during rabi season of 2016-2017. Two varieties (PKM-1 and Udayveer) were taken from the local market for conducting the experiments. Out of two different experiments, one is based on seed treatment

and another on foliar spray. The total numbers of treatments were 16 for both the experiments individually and experiments were conducted in factorial randomized design. NaCl and cadmium was added as 100mM and 20 mg kg^{-l} in every pot (5kg soil) to contaminate the soil. In seed treatment experiment seeds were treated with SA and IAA before sown in to the contaminated pots under different treatments. Whereas in foliar spray experiment, seeds were directly sown in to the contaminated soil and after 30 DAS salicylic acid and indole acetic acid were applied on seedlings as foliar spray. Parameters like plant height, number of leaves, chlorophyll a, b and carotenoids were evaluated. All the growth parameters were recorded at regular intervals of time. Physiological parameters like chlorophylls a, b and carotenoids were determined as per method of Arnon (1949). The fresh leaves (0.5g) were relatively cut into segments and extracted over night with 80 % acetone at -10°C. The extract was centrifuged for 5 minutes and the absorbance of filtrate was recorded at 645, 663 and 470 nm for chlorophyll a, b and carotenoid, respectively under Uv/ Visible Spectrophotometer. Extraction and determination of proline were done following Bates *et al.* (1973). Leaf samples were extracted with 3% sulphosalicylic acid. Extract was treated with acid ninhydrin and acetic acid, boiled for 1 h at 100 ◦C under water bath. The reaction mixture was extracted with 4mL of toluene. Absorbance of chromophore containing toluene was determined at 520 nm under UV/ visible spectrophotometer.

RESULTS AND DISCUSSION

The growth parameters like plant height, was maximum (40.0 cm) in PKM-1 with T_{15} (A_3B_3) and minimum in control (24.5) (cm). In foliar application, maximum height was recorded in T_{15} (40.7cm) and minimum at control (27.1cm). The maximum plant height of Udayveer variety was recorded at T_{15} (47.4 cm) and minimum at T_0 (27.1 cm). The maximum number of leaves per plant in PKM-I variety was recorded at T_{15} (45.3 cm) and minimum with T_0 (22.3 cm). Maximum numbers of leaves of both the varieties were recorded under foliar application (Table 1). Maximum number of leaves was recorded in T_{15} (45.6 cm) and minimum in T_0 (24.6 cm). In case of V_2 variety, maximum and minimum number of leaves were found in T_{15} as (55.0 cm) and T_0 (24.6 cm) under seed treatment. Stress in any form (salinity or heavy metals etc) showed negative impact on growing crops with reducing the normal growth parameters where as under such conditions salicylic acid and indole acetic acid not only alleviate the stress but also gave best results under any stressed environment (Rasmia and Darwesh 2014 and Babu *et al.* 2012)**.**

Table 1: Plant height and number of leaves/plant in tomato varieties under various treatments

Treatments	Plant Height (cm)				Number of Leaves /Plant			
	V_1 F.S	V_1 S.T	V_2 F.S	V_2 S.T	V_1 F.S	V_1 S.T	V_2 F.S	V_2 S.T
T_0	24.5	24.5	27.1	27.1	22.3	22.3	24.6	24.6
T_1	31.3	38.3	31.8	38.7	27.6	32.6	29.0	33.6
T_2	32.2	39.2	32.7	39.8	29.6	35.3	31.3	37.0
T_3	33.5	40.5	33.8	40.9	31.3	37.0	32.6	38.3
T_4	32.0	38.8	32.1	39.2	29.3	33.6	30.3	35.6
T_5	33.8	41.3	34.6	41.6	33.6	37.6	34.6	40.3
T_6	35.0	43.9	35.6	42.7	36.3	42.3	37.3	44.3
T_7	36.0	43.1	37.1	43.6	40.6	47.0	41.3	47.6
T_8	32.6	39.6	32.9	40.0	31.0	36.0	32.2	38.6
T_9	35.7	42.9	36.1	43.2	37.3	44.0	38.6	45.6
T_{10}	36.2	43.4	37.0	44.0	40.3	47.3	41.3	49.0
T_{11}	37.1	45.1	37.8	45.3	41.6	49.6	42.6	50.6
T_{12}	33.8	41.5	34.5	41.6	33.6	38.3	35.3	40.6
T_{13}	36.8	43.9	37.3	44.3	41.0	48.3	42.6	49.6
T_{14}	37.6	45.3	39.4	45.9	42.6	50.3	44.3	52.3
T_{15}	40.0	47.2	40.7	47.4	45.3	53.6	45.6	55.0
C D (P=0.05)	0.26	0.32	0.63	0.36	0.15	1.03	1.28	1.09

$T_{0=}$ Control, $T_{1=}$ 1 mM IAA, $T_{2=}$ 1.5 mM IAA, $T_{3=}$ 2 mM IAA, $T_{4=}$1 mM SA, $T_{5=}$1 mM IAA + 1 mM SA, $T_{6=}$1 mM SA+ 1.5 mM IAA, $T_{7=}$1 mM SA +2 mM IAA, $T_{8=}$1.5 mM SA, $T_{9=}$2 mM SA + 1 mM IAA, $T_{10=}$1.5mM SA+1.5mM IAA, $T_{11=}$1.5mM SA + 2 mM IAA, $T_{12=}$2 mM SA, $T_{13=}$2 mM SA +1 mM IAA, $T_{14=}$2mM SA + 1.5 mM IAA, $T_{15=}$2 mM SA + 2 mM IAA

Date on physiological parameters like chlorophyll a and b are presented in Table 2. Chlorophyll a in PKM-I variety was maximum and minimum in T_{15} (0.97 mg/g f.wt.) and in T_0 (0.54 mg/g f.wt.), respectively. Under foliar spray and seed treatment in PKM-I variety maximum amount of chlorophyll a was recorded in T_{15} (1.73) (mg/g f.wt.) and the minimum (0.54) (mg/g f.wt.) under control. In Udayveer variety, under foliar application, the maximum and minimum amounts of chlorophyll a were recorded in T_{15} (0.987 mg/g f.wt.) and T_0 (0.585 mg/g f.wt.), respectively. In seed treatment, the maximum amount of chlorophyll a was recorded in T_{15} (1.73 mg/g f.wt.) and minimum in T_0 (0.58 mg/g f.wt.). Similarly, the maximum amount of chlorophyll b in PKM-I variety under foliar application were recorded by T_{15} (0.12 mg/g f.wt.) and minimum in T_0. In seed treatment of same variety, the maximum amount of chlorophyll b was found in T_{15} (0.608 mg/g f.wt.) and minimum in T_0 (0.128 mg/g f.wt.).

Table 2: Chlorophyll a and b (mg/g f.wt.) in tomato crop as affected by various treatments

Treatments	Chlorophyll (a) (mg/g f.wt.)				Chlorophyll (b) (mg/g f.wt.)			
	V_1 F.S	V_1 S.T	V_2 F.S	V_2 S.T	V_1 F.S	V_1 S.T	V_2 F.S	V_2 S.T
T_0	0.54	0.54	0.58	0.58	0.12	0.12	0.16	0.16
T_1	0.67	1.12	0.68	1.14	0.19	0.28	0.21	0.30
T_2	0.71	1.24	0.72	1.25	0.22	0.32	0.24	0.35
T_3	0.78	1.31	0.79	1.32	0.28	0.37	0.30	0.39
T_4	0.67	1.14	0.69	1.15	0.21	0.33	0.22	0.31
T_5	0.78	1.33	0.80	1.33	0.29	0.38	0.31	0.39
T_6	0.82	1.39	0.83	1.39	0.33	0.43	0.35	0.45
T_7	0.88	1.50	0.89	1.51	0.38	0.48	0.40	0.49
T_8	0.73	1.45	0.73	1.46	0.23	0.35	0.25	0.36
T_9	0.83	1.45	0.84	1.46	0.34	0.44	0.36	0.46
T_{10}	0.86	1.52	0.89	1.52	0.39	0.49	0.40	0.50
T_{11}	0.92	1.62	0.92	1.62	0.44	0.54	0.47	0.57
T_{12}	0.79	1.32	0.80	1.33	0.30	0.39	0.32	0.40
T_{13}	0.89	1.51	0.90	1.52	0.39	0.49	0.42	0.51
T_{14}	0.92	1.62	0.93	1.63	0.45	0.55	0.48	0.58
T_{15}	0.97	1.73	0.98	1.73	0.49	0.60	0.50	0.64
CD (P=0.05)	0.56	0.21	0.58	0.22	0.14	0.20	0.16	0.20

In Udayveer variety, maximum amounts of chlorophyll b were recorded by T_{15} (0.50 mg/g f.wt.) and minimum in T_0 (0.16 mg/g f.wt.) under foliar spray. In seed treatment of same variety, maximum amount of chlorophyll b was recorded at T_{15} (0.64 mg/g f.wt.) and the minimum in T_0 (0.16 mg/g f.wt.). The data on carotenoids and proline are given in table 3. In PKM-I variety, maximum amount of carotenoids was recorded in T_{15} (0.81 mg/g f.wt.) under foliar application and minimum in T_0 (0.51 mg/g f.wt.). In seed treatment of same variety, the maximum and minimum amounts of carotenoids were recorded in T_{15} (1.48 mg/g f.wt.) and in T_0 (0.51mg/g f.wt.), respectively. Under foliar application, Udayveer variety showed maximum and minimum amounts of carotenoids in T_{15} (0.83 mg/g f.wt.) and T_0 (0.54 mg/g f.wt.), respectively. In the same variety, the maximum amount of carotenoids was found in T_{15} (1.50 mg/g f.wt.) and minimum in T_0 (0.54 mg/g f.wt) under seed treatment. SA and IAA individually or combined alleviate the stress and resumes the normal functions in terms of physiological parameters, (Alexander *et al.,* 2008 and Al-aghabary *et al.*, 2014). The maximum and minimum total amounts of proline in PkM-I variety under foliar application, were recorded in T_0 **(**0.35) and T_{15} (0.57 mg/g f.wt.). In seed treatment of same variety, the minimum and maximum amounts of proline were recorded with T_0 and T_{15} as (0.264 and 0.571 mg/g f.wt.), respectively. In Udayveer variety under foliar applications, the minimum amount of proline were recorded in T_0 (0.33 mg/g f.wt.) and maximum in T_{15} (0.556 mg/g f.wt.). In same variety minimum and maximum amounts were recorded with T_0 and T_{15} as (0.323 and 0.556 mg/g f.wt.) under seed treatment respectively. Stress increased the concentration of proline in plants, whereas applications of SA and IAA decreased it (Sakhabutdinova *et al.*, 2003, Alexander et al 2008 and Babu *et al.*, 2012).

Table 3: Carotenoids (mg/g f.wt.) and proline content (mg/g f.wt.) in tomato plant under various treatments

Treatments	Carotenoids (mg/g f.wt.)				Proline content (mg/g f.wt.)			
	V_1 F.S	V_1 S.T	V_2 F.S	V_2 S.T	V_1 F.S	V_1 S.T	V_2 F.S	V_2 S.T
T_0	0.51	0.51	0.54	0.54	0.57	0.57	0.55	0.55
T_1	0.55	1.11	0.58	1.13	0.54	0.49	0.53	0.52
T_2	0.59	1.18	0.62	1.19	0.52	0.45	0.51	0.50
T_3	0.63	1.22	0.64	1.23	0.50	0.42	0.50	0.55
T_4	0.56	1.12	0.59	1.13	0.53	0.48	0.52	0.51
T_5	0.64	1.23	0.66	1.25	0.49	0.41	0.48	0.47
T_6	0.68	1.28	0.70	1.29	0.46	0.37	0.45	0.44
T_7	0.72	1.32	0.74	1.34	0.42	0.33	0.41	0.40
T_8	0.61	1.21	0.63	1.23	0.51	0.44	0.49	0.48
T_9	0.69	1.29	0.71	1.31	0.45	0.36	0.43	0.42
T_{10}	0.72	1.32	0.74	1.35	0.42	0.33	0.41	0.39
T_{11}	0.78	1.41	0.78	1.42	0.39	0.29	0.37	0.36
T_{12}	0.65	1.24	0.66	1.25	0.49	0.40	0.48	0.46
T_{13}	0.73	1.34	0.75	1.36	0.41	0.32	0.40	0.38
T_{14}	0.78	1.41	0.79	1.43	0.38	0.29	0.36	0.35
T_{15}	0.81	1.48	0.83	1.50	0.35	0.26	0.33	0.32
CD (P=0.05)	0.44	0.18	0.49	0.19	0.33	0.31	0.32	0.32

It can be concluded from the results that stress like salt or heavy metal showed the negative impacts on growth and physiological parameters of tomato plant. The SA and IAA alleviate the stress and tomato crop showed good results in terms of growth and physiological parameters.

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