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Effect of salicylic acid and indole acetic acid on growth, yield, lycopene and soluble sugar content of tomato (*Lycopersicum esculentum*) varieties under cadmium and salinity stressed environment

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ABSTRACT.

Two set of experiments (seed treatment and foliar spray) were conducted at Allahabad during the rabi season of 2016-17 to study the effect of salicylic acid and indole acetic acid on growth, yield, lycopene and total sugar in tomato (Lycopersicum esculentum) under cadmium and salinity stressed environment. Cadmium and NaCl in each pot was added 20 mg and 100mM per kg soil against salicylic acid (SA) and indole acetic acid (IAA). The experiment was conducted in factorial randomized design under 16 treatments and three replications. Results releaved that number of branches and leaf index area of both the varieties did not differ markedly under various treatments. In general, maximum values of both the varieties of tomato were recorded under 2 mM SA + 2 mM IAA treatment. Seed treatment with SA and IAA proved better than of foliar spray in respect of total number of fruits and fruit diameter. The minimum values of all the parameters were recorded under control. Lycopene was recorded maximum under 2 mM SA + 2 mM IAA treatments in both the varieties of tomato. On the other hand, soluble sugar content in the tomato plant was maximum under control and minimum under 2 mM SA + 2 mM IAA.

Keywords: Tomato, varieties, cadmium, salinity, lycopene

INTRODUCTION

Cadmium (Cd), a non essential heavy metal contaminant mainly released into soil, water and air by natural and unnatural sources such as metal containing rocks, metal industries, leather tanning and dyeing industries etc. It inhibits photosynthetic pigment biosynthesis, interrupts the photosynthetic and respiratory electron transport flow and also interacts with enzymes of Calvin cycle (Qian *et al.,* 2009; Groppa *et al.,* 2012). Cadmium causes severe morphological, physiological and biochemical effects on plants such as stunted growth (Hasan *et al.,* 2008), leaf rolling and chlorosis (Ghani and Wahid *et al.,* 2007). The abiotic stress causes loss of hundred million dollars annually, because of reduction and loss of products (Mahajan and Tuteja, 2005). Cadmium also shows diverse effect on growth and yield parameters of vegetable crop (Zahid *et al.*, 2014). Particularly, at high concentrations, it adversely affects plant growth and development. Salinity is amongst the major environmental determinant for plant growth and productivity (Delavari *et al.,* 2010). It has been reported that salinity decreases pepper and melon yield. While excessive salt exposure reduces tomato fruit size, total yield, and photosynthesis and increases blossom end rot (Saito *et al.*, 2006). Salicylic acid (SA) is an endogenous growth regulator and belongs to a group of phenol compounds. It participates in the regulation of physiological processes (Hayat *et al*, 2010) and also provides protection against biotic and abiotic stress such as salinity. Treatment with salicylic acid decreases the effect of cadmium on photosynthesis in maize plants (Alexander *et al.,* 2008). Pre-sowing wheat seeds with plant growth regulators like IAA alleviated the growth inhibiting effect of salt stress (Afzal *et al.,* 2005). 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). Salicylic acid and indole acetic acid individually and combined showed positive impacts with growth and physiological fluctuations of tomato varieties under induced Nacl and cadmium stress (Zahid and Eugenia 2018). Hence the experiment was conducting using tomato as test crop with SA and IAA under salinity and Cd stress.

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MATERIALS AND METHODS

A pot experiment was 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 Tomato 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 experiment was conducted in factorial randomized design. NaCl and cadmium were 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 sowing in to the contaminated pots under different. Whereas in foliar spray experiments, seeds were directly sown in to the contaminated soil and after 30 DAS salicylic acid and indole acetic acid was applied on seedlings as foliar spray. Parameters like number of branches, leaf area index, fruit diameter, number of fruits, lycopene and total sugar were evaluated. Number of branches, leaf area index has been taken with regular intervals of time, fruit diameter and number of fruits has been taken after harvest. Lycopene was spectrophotometrically estimated according to the method of Fish *et al.* (2002). Approximately 0.3– 0.6 g samples were added to 5 mL of 0.05% (w/v) BHT in acetone, 5 mL of ethanol, and 10 mL of hexane. The recipient was introduced in ice and stirred on a magnetic stirring plate for 15 min. After shaking, 3 mL of deionised water were added, and the samples were shaken for 5 min on ice. Samples were then left at room temperature for 5 min. to allow the separation of both phases. The absorbance of the hexane layer (upper layer) was measured at 503 nm blanked with hexane. For sugar 0.05 g of fresh tissue of leaf was weighted by laboratory subtle scale (satrius) BP211D model with 0.0001 g accuracy. Each sample was grinded with 10 ml deionized water in a china mortar, then the mortar content was transferred to small container and located on a heater to boil. After that, the container contents were filtered by watmann filter paper (No. 1), for plant extraction. 2 ml of each extraction was transferred to a test tube and 2 ml copper sulfate solution was added to each of the tube. Then, the tube caps were closed with cotton. Each of these tubes was kept in warm water bath with 100°C temperature. In this term, CU^{++} was reduced to Cu^{+} by monosacarido aldehyde; here a brick red color was observed in the bottom of the test tube. After cooling the pipes, 2 ml phosphomolybdic acid solution was added to them; after a moment, blue color appeared, and the test pipe was well shaken to spread the color within the test pipe. The solution absorption in 600 nm, was determined by spectrophotometer system, and then the sugar concentration was measured by using of standard curve. For spectrophotometer setting, a solution instead of plant extraction, which includes deionized water and the rest solution with sugar values, was measured and presented by using of relevant standard curve based on mg/g f.wt.

RESULTS AND DISCUSSION

The growth parameters like leaf area index was maximum (91.7cm^2) in PKM-1 variety with 2 mm SS + 2 mm IAA and minimum with control (28.5 cm^2) under foliar application. In seed treatment the maximum leaf area index was recorded in T_{15} (92.4 cm^2) and minimum in T_0 as (28.5 cm^2). The maximum leaf area index of Udayveer variety was recorded at T_{15} (94.5cm^2) and minimum at T_0 (29.8 cm^2) under foliar application. In seed treatment maximum leaf area index were recorded in T_{15} (94.8 cm^2) and minimum in T_0 (29.8cm^2). The maximum number of branches / plant under foliar applications in PKM-I variety was recorded at T_{15} (18.0) and minimum T_0 (8.33). The maximum and minimum values were recorded in T_{15} (22.3) and T_0 (8.33) under seed treatment, respectively. In Udayveer variety the maximum number of branches / plant were recorded in T_{15} (18.0) and minimum in T_0 (9.00) under foliar application. In seed treatment, the maximum and minimum number of branches / plant were recorded in T_{15} (22.6) and T_0 (9.00), respectively (Table 1). Stress in any form (salinity or heavy metals etc) showed negative impact on growing crops with reducing the normal growth parameters whereas under such conditions salicylic acid and indole acetic acid not only alleviate the stress but also gave best results under any stressed environment (Shah and Asghari 2012 and Babu *et al.*, 2012).

Table 1: Leaf area index and number of branches/plant in tomato varieties under various treatments

Treatments	Leaf area index (cm^2)				Number of branches/ 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	28.5	28.5	29.8	29.8	8.33	8.33	9.00	9.00
T_1	29.3	29.7	31.5	31.9	14.0	18.3	14.3	18.6
T_2	29.5	30.4	35.4	35.8	14.0	18.3	14.3	18.6
T_3	36.7	37.3	40.4	41.4	14.6	18.6	15.0	18.6
T_4	39.7	41.0	43.6	44.9	14.3	18.3	14.6	18.6
T_5	49.3	50.0	52.7	53.5	15.0	19.3	15.6	19.6
T_6	60.7	62.7	63.5	65.2	15.3	19.0	15.3	19.6
T_7	82.5	83.4	86.3	87.8	15.3	20.0	15.3	20.3
T_8	42.6	43.3	45.9	47.6	14.3	18.6	14.6	18.6
T_9	52.8	53.2	57.2	57.5	15.6	19.6	16.0	20.0
T_{10}	71.5	73.2	76.4	77.5	15.6	19.6	16.0	20.0
T_{11}	86.0	87.5	90.5	91.5	16.3	20.3	16.6	20.3
T_{12}	47.8	48.2	49.6	50.6	15.0	19.3	15.667	19.6
T_{13}	59.0	59.5	61.8	62.5	16.0	20.3	16.3	20.6
T_{14}	77.2	78.7	81.0	82.0	16.6	20.6	17.0	20.6
T_{15}	91.7	92.4	94.5	94.8	18.0	22.3	18.0	22.6
C.D (P=0.05)	2.09	2.13	2.83	3.01	0.72	0.82	0.84	0.92

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

The date on number of fruits and fruit diameter are presented in Table 2. Number of fruits / plant in PKM-I variety were maximum and minimum in T_{15} (8.3) and in T_0 (2.3) respectively under foliar application. In seed treatment of PKM-I variety, maximum number of fruits / plant were recorded in T_{15} (10.3) and minimum (2.3) in control. In Udayveer variety, foliar application produced, maximum and minimum number of fruits in T_{15} (9.3) and T_0 (3.0), respectively. In seed treatment, the maximum number of fruits / plant was recorded in T_{15} (11.6) and minimum in T_0 (3.0). Similarly, the maximum fruit diameter in PKM-I variety with foliar application was found in T_{15} (36.2 cm) and minimum in T_0 (22.8 cm), respectively.

Table 2: Number of fruits/ plant and fruit diameter in tomato varieties under various treatments

Treatments	Number of fruits/ plant				Fruit diameter (cm)			
	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	2.3	2.3	3.0	3.0	22.8	22.8	24.3	24.3
T_1	3.3	5.3	4.0	6.0	24.6	28.0	26.2	28.8
T_2	3.3	5.3	4.3	6.0	25.8	29.8	27.8	30.6
T_3	3.6	6.6	4.6	7.3	27.9	31.0	29.8	31.8
T_4	3.3	5.6	4.3	6.3	25.0	28.4	27.0	29.6
T_5	3.6	6.3	4.6	7.0	28.4	32.0	30.0	32.4
T_6	4.6	6.3	5.6	8.0	29.4	33.7	32.8	34.7
T_7	5.6	8.0	6.3	8.6	30.9	36.0	34.1	36.6
T_8	3.6	6.0	4.3	6.3	26.4	30.3	28.2	31.1
T_9	4.6	7.6	5.6	8.6	29.7	34.3	33.2	35.1
T_{10}	5.6	8.0	6.3	8.6	31.8	35.3	34.8	36.7
T_{11}	7.0	8.6	9.0	9.6	33.6	37.4	36.0	39.1
T_{12}	4.0	7.0	5.0	7.6	28.6	32.2	30.3	32.8
T_{13}	6.0	8.3	6.6	9.3	32.4	36.8	35.0	37.1
T_{14}	7.3	9.0	8.3	10.3	34.5	38.6	37.1	39.8
T_{15}	8.3	10.3	9.3	11.6	36.2	41.0	36.2	42.1
C.D (P=0.05)	0.81	0.73	1.11	0.90	0.55	0.69	0.27	0.35

In seed treatment of same variety, the maximum diameter was found in T_{15} (41.0 cm) and minimum in T_0 (22.8 cm). In Udayveer variety, foliar application gave maximum fruit diameter with T_{15} (36.2 cm) and minimum in T_0 (24.3 cm). In seed treatment of the same variety, maximum values were recorded by T_{15} (42.1 cm) and the minimum was shown by T_0 (24.3cm). In PKM-I variety, maximum amount of lycopene was recorded in T_{15} (4.94 mg/100g. f.wt.) under foliar application and minimum in T_0 (3.25 mg/100g. f.wt.). In seed treatment of same variety the maximum and minimum amounts of lycopene were recorded in T_{15} (5.34 mg/100g. f.wt.) and in T_0 (3.25 mg/100g. f.wt.), respectively. Under foliar applications of Udayveer variety maximum and the minimum amounts of lycopene were recorded in T_{15} (5.12 mg/100g. f.wt.) and T_0 (3.47 mg/100g. f.wt.) whereas in same variety the maximum amount of lycopene was found in T_{15} (5.47 mg/100g. f.wt.) and minimum in T_0 (3.47 mg/100g. 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). The amounts of soluble sugar under PkM-I variety with foliar application, were maximum and minimum in T_0 (3.31 mg/g f.wt.) and T_{15} (0.83 mg/g f.wt.). In seed treatment of same variety, the maximum and the minimum amounts of soluble sugar were recorded in T_0 and T_{15} as (3.31 mg/g f.wt.) and (0.32 mg/g f.wt.), respectively. In Udayveer variety under foliar applications, the maximum amount of soluble sugar were recorded in T_0 (3.11) (mg/g f.wt.) and minimum in T_{15} (0.57) (mg/g f.wt.). In same variety, maximum and minimum amounts were recorded by T_0 and T_{15} as (3.11 mg/g f.wt.) and (0.25 mg/g f.wt.) under seed treatment, respectively. The soluble sugar in oat organ plant (leafs) increased with NaCl but salicylic acid and indole acetic acid decreased the soluble sugar (Shahba *et al.*, 2010, Majid *et al.*, 2011).

Table 3: Lycopene and soluble sugar in tomato varieties under various treatments

Treatments	Lycopene (mg/100gm. f.wt.)				Soluble sugar (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	3.25	3.25	3.47	3.47	3.31	3.31	3.11	3.11
T_1	3.65	4.05	3.76	4.14	3.00	2.66	2.93	2.50
T_2	3.85	4.29	3.92	4.38	2.64	2.22	2.53	2.07
T_3	4.00	4.50	4.08	4.61	2.25	1.95	2.02	1.77
T_4	3.75	4.10	3.86	4.19	2.92	2.50	2.81	2.40
T_5	4.03	4.55	4.13	4.64	2.44	2.11	1.89	1.67
T_6	4.22	4.74	4.33	4.83	2.10	1.39	1.58	1.25
T_7	4.39	4.91	4.49	4.97	2.11	1.05	1.21	0.92
T_8	3.92	4.34	3.98	4.41	1.86	2.11	2.29	1.91
T_9	4.28	4.78	4.36	4.86	1.41	1.36	1.53	1.21
T_{10}	4.40	4.94	4.52	5.03	1.91	1.01	1.16	0.88
T_{11}	4.64	5.13	4.80	5.24	1.43	0.68	0.84	0.48
T_{12}	4.04	4.58	4.14	4.68	1.16	1.71	1.86	1.62
T_{13}	4.45	4.98	4.55	5.06	1.47	0.97	1.10	0.86
T_{14}	4.74	5.19	4.88	5.28	1.20	0.61	0.78	0.46
T_{15}	4.94	5.34	5.12	5.47	0.83	0.32	0.57	0.25
C.D (P=0.05)	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01

CONCLUSION

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

REFERENCES

Afzal I, Basra S, Iqbal A (2005) The effect of seed soaking with plant growth regulators on seedling vigor of wheat under salinity stress. *Journal of Stress Physiolology and Biochemistry* **1:** 6-14

Alexander Krantev, Rusina Yordanova, Tibor Janda, Gabriella Szalai and Losanka Popova. (2008) Treatment with salicylic acid decreases the effect of cadmium on photosynthesis in maize plants. *Journal of Plant Physiology* **165**: 920—931.

Babu, Singh. D and Gothandam. K. M. (2012) The effect of salinity on growth, hormones and mineral elements in leaf and fruit of tomato cultivar pkm1. *The Journal of Animal & Plant Sciences* **22**: 159-164.

Delavari, P.M., Baghizadeh, A., Enteshari, S.H., Kalantari, M., Yazdanpanah, Kh. A. and Mousavi, E.A. (2010) The effects of salicylic acid on some of biochemical and morphological characteristic of *Ocimum basilicucm* under salinity stress. *Australian Journal of Basic &Applied Science* **4** (10): 4832-4845.

Erika, Fässler ., Michael, W. Evangelou ., Brett, H. Robinson and Rainer, S. (2010) Effects of indole-3-acetic acid (IAA) on sunflower growth and heavy metal uptake in combination with ethylene diamine disuccinic acid (EDDS). *Chemosphere* **80**: 901–907.

Fish WW, Perkins-Veazie P, Collins JK (2002). A quantitative assay for lycopene that utilizes reduced volumes of organic solvents. *Journal Food Composition and Analysis* **15**: 309–317.

Ghani A. and Wahid A. (2007) Varietal difference for cadmium induced seedling mortality and foliar toxicity symptoms in mungbean (*Vigna radiate*). *International Journal of Agriculture and Biol*ogy **9**: 555-558.

Groppa, M.D., Ianuzzo, M.P., Rosales, E.P., Vázquez, S.C., Benavides, M.P., 2012Cad-mium modulates NADPH oxidase activity and expression in sunflower leaves. *Biolgia Plantarum* **56**: 167–171.

Hayat Q, Hayat S, Irfan M, and Ahmad A. (2010) Effect of exogenous salicylic acid under changing environment: A review. *Environmental and Experimental Botany* **68**: 14–25.

Qian, H., Li, J., Sun, L., Chen, W., Sheng, G.D., Liu, W., Fu, Z. (2009) Combined effect ofcopper and cadmium on Chlorella vulgaris growth and photosynthesis-relatedgene transcription. *Aquatic Toxicology* **94**: 56–61.

Saito T, Fukuda N, Nishimura S (2006) Effects of salinity treatment duration and planting density on size and sugar content of hydroponically grown tomato fruits. *Journal of the Japanese Society for Horticultural Science* 75: 392–398.

Shah Fahad and Asghari Bano. (2012) Effect of salicylic acid on physiological and biochemical characterization of maize grown in saline area. *Pakistan Journal of Bot*any **44**: 1433-1438

Shahba Zahra, Baghizadeh Amin, Vakili Seid Mohamad Ali, Yazdanpanah Ali and Yosefi Mehdi. (2010) The salicylic acid effect on the tomato (*Lycopersicum esculentum* Mill.) sugar, protein and proline contents under salinity stress (NaCl*). Journal of Biophysics and Structural Biology* **2**: 35-41.

Zahid, A. Malik., Eugenia. Lal. P and Zahoor Mir. A . (2014) Diverse effect of cadmium and lead on growth and yield of carrot (Daucus carota). *Inernational Journal of Pharma and Biosciences* **5**: 231-236.

Zahid, A. Malik and Eugenia Lal, P. (2018) Effect of salicylic acid and indole acetic acid on growth, physiological fluctuations and proline content of two varieties of tomato (*Lycopersicum esculentum*) under induced cadmium and NaCl Stress. *Annals of Plant and Soil Research* **20**(3).