ISSN 2320-5407 International Journal of Advanced Research (2016), Volume 4, Issue 2, 723-727

ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Effect of seed priming of tomato with salicylic acid on growth, flowering, yield and fruit quality under high temperature stress conditions.

Shruti Kirti Singh, Pramod Kumar Singh*
Department of Botany, Udai Pratap Autonomous College, Varanasi, India

Manuscript Info

Manuscript History:

Received: 14 December 2015
Final Accepted: 16 January 2016
Published Online: February 2016

Key words:
Fruit quality, growth, tomato, salicylic acid, yield.

***Corresponding Author**

Pramod Kumar Singh.

Abstract

In order to improve the germination of tomato seeds under high temperature stress conditions seed priming by salicylic acid was investigated. The experiment was conducted to study the effect of salicylic acid on the tomato vegetative growth, yield and fruit quality. The experiment was completely randomized experimental design with three replications. These factors included salicylic acid in three levels (0.25mM, 0.5mM and 0.75mM) applied on tomato. Results indicated that germination and vegetative & reproductive growth of tomato severely reduced by high temperature. Seeds primed with 0.5mM salicylic acid not only improved germination percent but also reduced germination time under stress conditions. The TSS, TA, vitamin C and lycopene content of tomato fruit had significantly affected by application of salicylic acid. The exogenous applications of salicylic acid improved the yield contributing factors that resulted in significant increases in tomato fruit yield.

Introduction:

Abiotic stress has now been recognized as the biggest and potential threat for agricultural productivity all over the world. Nevertheless, anthropogenic activities in the developmental era have aggravated the degradation of agricultural system and its productivity due to major abiotic stresses (such as metals/metalloids (here after termed as 'metals'), salinity, ozone, UV-B radiation, nutrient (deficiency and excess), drought, and extreme temperatures (Khan and Khan, 2013; Anjum et al., 2014a). One of the most studied of these stresses is high temperature induce numerous adverse effects in plants, impair biochemical/physiological and molecular processes, and eventually cause severe reductions in plant growth, development and overall productivity. Rising in temperatures may lead to altered geographical distribution and growing season of agricultural crops (Porter, 2005). Tomato is one of the most popular and widely grown vegetable crop in throughout the world, ranking second in importance to potato (FAOSTAT, 2005). Tomato is an important condiment in most diets and a very cheap source of vitamins A, C and E and minerals that are very good for body and protect the body against diseases. A drastic decrease in tomato yield is recorded during summer season in India due to high temperature. Reproductive development has been affected more adverse ly at high temperature stress than vegetative development (Sato et al., 2002; Abdelmageed et. al., 2003). High temperature during reproductive development has been reported to limit the flower bud initiation with significant increment in flower drop (Hana and Harnandez, 1982) and significant decrease in fruit set (Berry et. al., 1988) leading to a sharp decrease in tomato fruit yield. It is therefore, highly desirable to explore possible ways and means to enhance the productivity of this important crop employing cost-effective and easy to use techniques. Plant growth regulators play important role in the regulation of plant developmental processes and signaling networks as they are involved either directly or indirectly in a wide range of biotic and abiotic stress responses and tolerance in plants (Khan et al., 2012a,b,c; Asgher et al., 2015). Salicylic acid (SA) is a phenolic compound involved in the regulation of growth and development of plants, and their responses to biotic and abiotic stress factors (Raskin, 1992; Khan et al., 2012a, b, c, 2013b; Miura and Tada, 2014). Salicylic acid can also play a significant role in plant water relations (Barkosky ad Einhelling, 1993) under abiotic stress conditions. Plants produce proteins in response to abiotic and biotic stress and many of these proteins are induced by phytohormones such as ABA (Jin et al, 2000) and salicylic acid (Hoyos and Zhang, 2007). SA is involved in the regulation of important plant physiological processes such as photosynthesis, nitrogen metabolism, proline (Pro) metabolism, production of glycinebetaine (GB), antioxidant defense system, and plant-water relations under stress conditions and thereby provides protection in plants against abiotic stresses (Khan et al, 2010, 2012a,b,c, 2013b, 2014; Nazar et al., 2011; Miura and Tada, 2014). Apart from its involvement in the induction of defense-related genes and stress resistance in biotic stressed plants (Kumar, 2014), SA has been shown to improve plant tolerance to major abiotic stresses such as metal (Zhang et al., 2015), salinity (Khan et al., 2014; Nazar et al., 2015), osmotic (Alavi et al., 2014), drought (Fayez and Bazaid, 2014), and heat stress (Khan et al., 2013b). Exogenously sourced SA to stressed plants, either through seed soaking, adding to the nutrient solution, irrigating, or spraying was reported to induce major abiotic stress tolerance-mechanisms (Horváth et al., 2007; Khan et al., 2012a,b,c, 2013b, 2014; Anwar et al., 2013; Palma et al., 2013). Salicylic acid mediated improved plant tolerance to heat stress has also been reported (He et al., 2002; Larkindale et al., 2005; Wang et al., 2010; Khan et al., 2013a,b). The objective of this study is to investigate the protective impact of SA on growth, yield and fruit quality of tomato plant under high temperature stress conditions.

Materials and Methods:

Seeds of tomato plants were surface sterilized with 0.01% $HgCl_2$ for 10 minutes washed thoroughly with distilled water again surface sterilized with 0.1% cetramide solution. Followed by another thorough washing with glass distilled water. Homogenized surface sterilized seeds were presoaked in different treatments as control in distilled water and three concentrations of SA (0.25%mM, 0.5mM% and 0.75%mM). For high temperature, seeds were sown in third week of February, 2015 on nursery bed and transplanted in the third week of March, 2015 in Botanical garden of Udai Pratap Autonomous College, Varanasi. The experiment was carried out in complete randomized block design with three replicates and supplied with 20ml of 50% of Hoagland's nutrient solutions at alternate days (Hoagland and Arnon, 1950). Another experiment was conducted under control environment in which tomato genotypes were grown in growth chamber at 32/ 26^0C under 12/12 hours day/night cycle. The aim of the experiment was to study the effect of seed priming with salicylic acid on plant height, number of fruits per cluster, total yield, mean fruit weight, soluble solid content, total titrable acid and vitamin C in fruits of tomato under high temperature. The total yield for each treatment was calculated by weighing the fruit picked in each replication and converting the weight to $Mg.ha^{-1}$. The average fruit weight was estimate by weighing 10 fruits in each treatment, with the help of an electronic balance measuring in grams to third decimal place and then converting to average fruit weight. Sub samples were pressed through cheese cloth to extract the juice. Total soluble solids were determined on a portable refractometer (NC-1, Atago Co., Japan) standardized with distilled water. Total titrable acid and vitamin C was measured by NaOH (0.1 M) titration and indophenols methods according to Horvitz et. al.,1970. The fruit firmness was recorded with the help of a pressure meter (OSK 10576 Co, Japan). For this purpose, 5 fruits from each treatment were taken and penetration force was measured by gently inserting the probe into the equatorial region of the fruit. The readings for all 5 fruits were averaged to represent the corresponding treatments.

Statistical Analysis:

The experiments were repeated twice with three replicates (n=5) and the data presented are mean ± standard errors (SE). The result was subjected to analysis of variance and means were compared by the least significant difference test at the 0.05% level of significance.

Table 1. Influence of SA on Plant height, number of flower branch per plant, number of fruit per plant, mean fruit weight, dry weight and yield of tomato

Treatments	Plant height (cm)	Number of flower branch per plant	Number of fruit per plant	Mean fruit weight (g)	Dry weight (I/100g F.W)	Yield (Mg. ha^{-1})
Control	120.14a	7a	35.12a	95.94a	6.89a	170.32a
HT	72.3a	4.31a	17.36ac	85.39b	2.89c	105.58a
HT+0.25m MSA	72.11cd	2.64c	14.12c	66.02c	4.21b	105.41c
HT +0.5m MSA	120.31a	6.12a	30.1a	90.6a	5.97a	165.12a
HT+0.75m MSA	115.41ab	5b	24.12b	70.12bc	4.5c	152.4ab

Table 2. Influence of SA on TSS, TA Fruit Firmness, Vitamin C and Fruit Lycopene					
Treatments	**TSS (^{0}Brix)**	**Vitamin (Mg.100g Fresh Fruit $^{-1}$)**	**TA (%)**	**Fruit Firmness (Kg Cm^{-1})**	**Fruit Lycopene content (Mg/l00 g)**
Control	6.41a	15.16a	4.8a	3.56a	2.93a
HT	3bc	9.9b	3.04b	2.42ab	1b
HT+0.25m MSA	4.32c	8.14c	2c	2c	1acd
HT+0.5m MSA	5.89b	11.6ab	3b	2.49b	1.78b
HT+0.75mMSA	5.01b	11.86b	5a	2.9b	1.39b

Means followed by same letter are not significantly different at 5% probability using Duncan's test.

Result and Discussions:

Vegetative and reproductive growth

The experiments were conducted in which tomato genotype was tested under two sets of temperature conditions. At controlled condition (15.15^{0}C-27.12^{0}C) genotype produced the highest percentage of plant height, fruit weight and total yield. The result indicated that 0.5 mM concentration of SA caused a significant increase in vegetative and reproductive growth under stress conditions. The plants height increased to its maximum 120.31cm. A very low concentration of SA had no effect on plant height. The maximum number of flower branch per plant is 6.12 and fruit per plant is 30.1 was recorded with 0.5 mM SA application (Table 1). Salicylic acid (SA) is a growth regulator which participates in the regulation of physiological processes in plants. It stimulates flowering in a range of plants, increases flower life, control ions uptake by roots and stomatal conductivity (Bhupinder et. al., 2003). Previous studies have demonstrated that a wide range of responses might appear after exogenous SA application as follows: height plants increases, fruit weight and fruits per plant (Khodary et al., 2004; EI Tayab, 2005). The mechanism of salicylic acid was reported by Oata (1975) and Pieterse and Muller (1977) who concluded that salicylic acid induced flowering by acting as a chelating agent. This view was supported by Ruskin (Ruskin et. al, 1987) who conform that salicylic acid functioned as endogenous growth regulators of flowering and florigenic effects. SA-supplementation has been reported to differentially benefit several plant species exposed to high temperatures stress (He et al., 2002; Larkindale and Knight, 2002; Clarke et al., 2004; Shi et al., 2006; Wang and Li, 2006; Wang et al., 2010; Khan et al., 2013a).

Fruits per cluster, number of branches per plant, yield, fruit weight, fruits per plant and fruit quality

Application of SA significantly increased reproductive growth parameters. The maximum number of flower branch per plant (6.12), and number of fruits per plant (30.1) were obtained with 0.5mM SA (Table1).The results indicated that application of 0.5mM SA caused a meanful increase in fruit quality compared to other levels. Highest means of yield (165.12 Mg ha^{-1}) and fruit weight (90.6 g) were found in tomato treated with 0.5mM SA. The maximum TSS (5.89 ^{0}Brix), TA (3.0%) and vitamin C (11.69) was recorded with 0.5mM SA application. The fruit yield in cucumber and tomato, enhanced significantly when the plants were sprayed with lower concentration of salicylic acid. Singh and Singh (2008) reported that SA treatments at lower concentrations (50µM) showed significant increase in chlorophyll content and total non-structural carbohydrate (TNC). However, higher concentrations of salicylic acid had inhibitory effect.

Conclusion:

Based on the results of this study, high temperature stress severally reduced germination and tomato plantlet growth. Pretreatment of tomato seeds by salicylic acid considerably improve germination and plantlet growth in stress condition and will increase the speed and germination percentage. Pretreatment of tomato seeds with 0.5mM salicylic acid was the best alleviation of heat stress. It is concluded that SA could be a very promising compound for the reduction of the heat stress sensitivity of tomato plants, because under certain conditions it has been found to mitigate the damaging effects of stress factors in plants.

References:

- Abdelmageed, A, H, Gruda N., Geyer B. 2003. Effect of high temperature and heat shock on tomato (lycopersicon esculentum Mill.) genotypes under controlled condition. Conference on International Research for deportment. Deutscher Tropentag, Gottingen, October, 8-10.
- Anjum N. A., Gill S. S., Gill R. (2014a). Plant Adaptation to Environmental Change: Significance of Amino Acids and their Derivatives, 1st Edn. Wallingford: CABI; 10.1079/9781780642734.0000.
- Alavi S. M. N., Arvin M. J., Kalantari K. M. (2014). Salicylic acid and nitric oxide alleviate osmotic stress in wheat (Triticum aestivum L.) seedlings. J. Plant Interac. 9 683–688.
- Anwar S., Iqbal M., Raza S. H., Iqbal N. (2013). Efficacy of seed preconditioning with salicylic and ascorbic acid in increasing vigor of rice (Oryza sativa L.) seedling. Pak. J. Bot. 45 157–162.
- Berry SZ, Rafique Ud-Din M (1988). Efft of high temperature on fruit set in tomato cultivars and selected germplasm. Hort. Sci 23:606-608.
- Barkoshy RR, Enhelling FA. 1993. Effect of salicylic acid on plant water relationship. J Chem. Ecol. 19:237-247.
- Bhupinder, S. and K. Usha, 2003. Salicylic aciud induced physiological and biochemical changes in wheat seedlings under water stress. **Plant growth Regulation**. 39: 137-141. http:// cat.inist.fr/ ?aModele=afficheN&cpsidt=14590326.
- Clarke S. M., Mur L. A., Wood J. E., Scott I. M. (2004). Salicylic acid dependent signaling promotes basal thermo tolerance but is not essential for acquired thermo tolerance in Arabidopsis thaliana. Plant J. 38 432–447. 10.1111/j.1365-313X.2004.02054.
- EI- Tayeb, M. A., 2005. Response of Barley grains to the Interactive Effect of salinity and Salicylic acid. Plant Growth Regulation, 45:215-224.
- FAOSTAT. FAO Stastical databases food and agriculture organization of the United Nations, statics Division, Rome, Italy, 2005.
- Fayez K. A., Bazaid S. A. (2014). Improving drought and salinity tolerance in barley by application of salicylic acid and potassium nitrate. J. Saudi Soc. Agri. Sci. 13 45–55. 10.1016/j.jssas.2013.01.001.
- Hanna HY, Hernadeg TP (1982). Response of six tomato genotypes under summer and spring weather conditions in Louisiana. Hort. Sci. 17: 758-759.
- He Y. L., Liu Y. L., Chen Q., Bian A. H. (2002). Thermo tolerance related to antioxidation induced by salicylic acid and heat hardening in tall fescue seedlings. J. Plant Physiol. Mol. 28 89–95.
- Hoagland, D.R. and Arnon, D,I. (1950). The water-culture method for growing plants without soil. Plants Cell Env. 23, 853-862.
- Horváth E., Pál M., Szalai G., Páldi E., Janda T. (2007). Exogenous 4- hydroxybenzoic acid and salicylic acid modulate the effect of short-term drought and freezing stress on wheat plants. Biol. Plant. 51 480–487. 10.1007/s10535-007-0101-1.
- Hoyos M. E., Zhang S. (2000). Calcium-independent activation of salicylic acid-induced protein kinase and a 40-kilodalton protein kinase by hyperosmotic stress. Plant Physiol. 122 1355–1364. 10.1104/pp.122.4.1355.
- Jin S. Chen CCS, Plant AL,2000. Regulation by ABA of osmotic stress induced changes in protein synthesis in tomato roots. Plants Cell Environ.,23: 51-60.
- Khan N., Syeed S., Masood A., Nazar R., Iqbal N. (2010). Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mungbean and alleviates adverse effects of salinity stress. Intl. J. Plant. Biol. 1:e1 10.4081/pb.2010.
- Khan M. I. R., Khan N. A. (2013). Salicylic acid and jasmonates: approaches in abiotic stress. J. Plant Biochem. Physiol. 1:e113 10.4172/2329-9029.1000e113.
- Khan M. I. R., Asgher M., Khan N. A. (2013a). Rising temperature in the changing environment: a serious threat to plants. Climate Change Environ. Sustain. 1 25–36. 10.5958/j.2320-6411.1.1.004.
- Khan M. I. R., Iqbal N., Masood A., Per T. S., Khan N. A. (2013b). Salicylic acid alleviates adverse effects of heat stress on photosynthesis through changes in proline production and ethylene formation. Plant Signal. Behav. 8:e26374 10.4161/psb.26374.
- Khan N. A., Nazar R., Iqbal N., Anjum N. A. (2012a). Phytohormones and Abiotic Stress Tolerance in Plants. Berlin: Springer; 10.1007/978-3-642-25829-9.

- Khan M. I. R., Syeed S., Nazar R., Anjum N. A. (2012b). "An insight into the role of salicylic acid and jasmonic acid in salt stress tolerance," in Phytohormones and Abiotic Stress Ttolerance in Plants, eds Khan N. A., Nazar R., Iqbal N., Anjum N. A., editors. (Berlin: Springer;), 277–300. 10.1007/978-3-642-25829-9_12.
- Khan M. I. R., Iqbal N., Masood A., Khan N. A. (2012c). Variation in salt tolerance of wheat cultivars: role of glycinebetaine and ethylene. Pedosphere 22 746–754. 10.1016/S1002-0160(12)60060-5.
- Khan M. I. R., Asgher M., Khan N. A. (2014). Alleviation of salt-induced photosynthesis and growth inhibition by salicylic acid involves glycinebetaine and ethylene in mungbean (Vigna radiata L.). Plant Physiol. Biochem. 80 67–74. 10.1016/j.plaphy.2014.03.026.
- Khodary,S.E.A. 2004. Effect of salicylic acid on the growth, photosynthesis,and carbohydrate metabolism in salt-stressed Maize plants**. Journal agriculture biology,** 6: 5-8.
- Kumar D. (2014). Salicylic acid signaling in disease resistance. Plant Sci. 228 127–124. 10.1016/j.plantsci.2014.04.014.
- Larkindale J., Hall J. D., Knight M. R., Verling E. (2005). Heat stress phenotypes of Arabidopsis mutants implicate multiple signaling pathways in the acquisition of thermo tolerance. Plant Physiol. 138 882–897. 10.1104/pp.105.062257.
- Larkindale J., Knight M. R. (2002). Protection against heat stress induced oxidative damage in Arabidopsis involves calcium, abscisic acid, ethylene, and salicylic acid. Plant Physiol. 128 682–695. 10.1104/pp.010320.
- Miura K., Tada Y. (2014). Regulation of water, salinity, and cold stress responses by salicylic acid. Front. Plant Sci. 5:4 10.3389/fpls.2014.00004.
- Nazar R., Iqbal N., Syeed S., Khan N. A. (2011). Salicylic acid alleviates decreases in photosynthesis under salt stress by enhancing nitrogen and sulfur assimilation and antioxidant metabolism differentially in two mungbean cultivars. J. Plant Physiol. 168 807–815. 10.1016/j.jplph.2010.11.001.
- Oata Y. (1975). Short day flowering of Lemna gibba G3 induced by salicylic acid. Plant Physiol., 16:1131-1135.
- Palma F., López-Gómez M., Tejera N. A., Lluch C. (2013). Salicylic acid improves the salinity tolerance of Medicago sativa in symbiosis with Sinorhizobium meliloti by preventing nitrogen fixation inhibition. Plant Sci. 208 75–82. 10.1016/j.plantsci.2013.03.015.
- Pieterse,A.H. & Muller,L.J. (1977). Induction of flowering in Lemna gibba G3 under short day conditions. Plant Cell Physiol., 18:45-53.
- Raskin I., Ehmann. A. Melandar WR & Meeuse, BJD. (1987). Salicylic acid a natural inducer of heat production in Arum lilies. Science. 237:1545-1246.
- Sato, S. Peet. M.M. Thomas, J. F. (2002).Physiological factors limit fruit set of tomato (Lycopersicon esculentum mill) under cronic mild heat stress. Plant, Cell and Environment 23:719-726.
- Singh, A., and P.K. Singh 2008. Indian journal agriculture biochemical, 21(1&2):35-38
- Shi Q., Bao Z., Zhu Z., Ying Q., Qian Q. (2006). Effects of different treatments of salicylic acid on heat tolerance, chlorophyll fluorescence, and antioxidant enzyme activity in seedlings of Cucumis sativa L. Plant Growth Regul. 48 127–135. 10.1007/s10725-005-5482-6.
- Wang L. J., Li S. H. (2006). Salicylic acid-induced heat or cold tolerance in relation to $Ca2^{+}$ homeostasis and antioxidant systems in young grape plants. Plant Sci. 170 685–694. 10.1016/j.plantsci.2005.09.005.
- Wang L. J., Fan L., Loescher W., Duan W., Liu G. J., Cheng J. S., et al. (2010). Salicylic acid alleviates decreases in photosynthesis under heat stress and accelerates recovery in grapevine leaves. BMC Plant Biol. 10:34 10.1186/1471-2229-10-34.
- Zhang Y., Xu S., Yang S., Chen Y. (2015). Salicylic acid alleviates cadmium-induced inhibition of growth and photosynthesis through upregulating antioxidant defense system in two melon cultivars (Cucumis melo L.). Protoplasma 252 911–924. 10.1007/s00709-014-0732-y.