International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 484-486

Received: 22-10-2020
Accepted: 03-12-2020

Rajan Saini
School of Agriculture,
Department of Agronomy,
Lovely Professional University,
Phagwara, Punjab, India

Anaytullah Siddique
School of Agriculture,
Department of Agronomy,
Lovely Professional University,
Phagwara, Punjab, India

Corresponding Author:
Anaytullah Siddique
School of Agriculture,
Department of Agronomy,
Lovely Professional University,
Phagwara, Punjab, India

Effect of salicylic acid on growth and yield under abiotic stress: An overview

Rajan Saini and Anaytullah Siddique

DOI: https://doi.org/10.22271/chemi.2021.v9.i1g.11277

Abstract
Biotic and abiotic stresses are the major constraint to limit the production of crops in agriculture. Biotic stress includes attack of insect, pest, bacteria, virus and fungus while extreme and low temperature, drought, flood, salinity and heavy metal stress are the major cause of abiotic stress. The reduction in the performance of plant growth was started from the negative effect of chlorophyll synthesis or degradation under wide range of environmental stress. The generation of harmful free radicles or reactive oxygen species (ROS) like O2, H2O2 and OH. Salicylic acid (SA) improves plant growth and development by improving rate of photosynthesis by protecting the damage of chloroplast, protein and DNA against the wide range of environmental stress including both biotic and abiotic stress. Application of SA also accelerate the production of osmolyte like proline and antioxidant enzymes like CAT, POD, SOD that help to scavenge free radicles safely from the cell.

Keywords: Catalase, heat stress, peroxidase, SOD, salicylic acid, salinity, water stress

Introduction
Biotic and abiotic stresses are very dangerous constraints to limit the production of crops around the word. Biotic stress caused by the attack of insect, pest, fungus, bacteria and virus on the plant while the cause of abiotic stress is heat, cold, drought, salt, flood and heavy metals etc. To avoid such a drastic situation from the field of cultivated land, it is an urgent need to develop either stress tolerance genotypes for specific type of environmental stress or manage / manipulate the adverse situation to cope up with availing situation (Khan *et al.*, 2013b; 2014; Nazar *et al.*, 2015; Fayez and Bazaid, 2014 and Jini and Joseph, 2017) [11, 10, 16, 6, 9]. Hence the production of harmful radicles dissipates safely during the growth and development of plants. There are many chemical compounds, enzymes and hormones are endogenous present inside the plant that may help to ameliorate the adverse situation like Proline, mannitol, sorbitol, salicylic acid, catalase (CAT), peroxidase (POD), and superoxide dismutase (SOD) (Khan *et al.*, 2012 b and Farooq *et al.*, 2009) [12, 5].
Salicylic acid (SA) is a member of phenolic group compound produce automatically inside of the plant that helps to modify physiological, biochemical and molecular events like Photosynthesis, chlorophyll, nitrogen, protein, proline content, SOD, CAT and POD in favour of plants under diverse stress condition both biotic and abiotic situation (Miura and Tada, 2014 and Khan *et al.*, 2013b) [11]. The exogenous application of salicylic acid as seed priming or foliar application is also very effective in same mode of action at each and every stage of plant life from seed germination to the harvesting of crop. Even though the concentration of SA is also having both positive and negative roles against the environmental conditions (Csiszár *et al.*, 2014; Saruhan *et al.*, 2012 and Awate and Gaikwad, 2014) [4, 19, 2].

Role of SA on seed germination, seedling growth and yield under stress condition
Seed germination is one the dynamics phase of plant life and on it's the performance of crop depends. Whereas during this period the morphological, physiological and biochemical changes occurs frequently due to diverse environmental situation. However, the roles of different growth regulator are well known for seed germination like gibberellic acid (GA3), Auxin, ABA, cytokinin and Ethylene (Vishal and Kumar, 2018) [23]. The salicylic acid is one of the members of phenolic group compound having the ability to accelerate or maintain pace of seed germination under adverse environmental stress like salinity and drought stress

(Borsani *et al.*, 2001 and Silva *et al.*, 2017) [3, 21]. However, its molecular mechanism is still unclear. The optimum concentration of salicylic acid need to trigger the seed germination and their related metabolic process otherwise it reverse the same process hence shows inhibitory effect (Alonse-Ramirez *et al.*, 2009; Csiszár *et al.*, 2014) [4]. A compound known as catechol, produce as an end product of salicylic acid have antioxidant properties. It might be possible that reactive oxygen species (ROS, 1O2, H2O2, and *OH) produced during adverse environmental stress condition controlled by this compound (Zhu, 2001) [25].

The wide range of antioxidative enzymes is involved to safely dissipate the ROS species during its production like Catalase (CAT), Peroxidase (POD), Ascorbate and superoxide dismutase (SOD). Hence it helps to overcome the drastic condition during seed germination and seedling establishment (Sharma *et al.*, 2012) [20]. Salicylic acid act as a signaling molecule therefore it has a long term effect in the life of plant up to the yield. It is now well established that to combat the plant with adverse environmental conditions, require a balance amount of antioxidant defense system in terms of catalase, peroxidase and superoxide dismutase. These antioxidative enzymes are reported well in plant in stress condition while treated with salicylic acid at optimum concentration that leads to protect the plant throughout the life up to the harvest though the yield of crop would up to mark under stress condition (War *et al.*, 2011 and Idrees *et al.*, 2011 and Rajjou *et al.*, 2006) [24, 8, 18].

Effect of SA on rate of photosynthesis

As a signaling molecule, salicylic acid (SA) plays a fruitful role on the rate of photosynthesis. It is reported in many crop like wheat and mustard that SA have positive effect on increasing the concentration of total chlorophyll and the ratio of chlorophyll a and b results accelerated rate of photosynthesis. Furthermore, the activity of important enzymes PEPC and Rubisco responsible for the photosynthetic process elevated by the exogenous application of salicylic acid including the the photosynthetic apparatus including PSI, PSII and D1 protein (Qui *et al.*, 2011 and Krantev *et al.* 2008) [13].

ROS and production site: Free radicles like 1O2, H2O2, and *OH are the member of reactive oxygen species (ROS) that produced in both the conditions stress and unstressed condition at various sites like chloroplast, mitochondria, cell wall, peroxisome and ER. Within the chloroplast and mitochondria the major site of ROS production is PSI and PSII and ETC. The defense system of a cell needs at least equilibrium regarding the generation and scavenging of reactive oxygen species for normal cellular function. Enhanced concentrations of ROS lead to degrade lipid, protein and Deoxyribonucleic acid results production of free radicles while the antioxidative enzymes help to break these free radicles in to safe molecules like H2O2 in to water and oxygen by catalase enzyme (Krieger-Liszkay, 2005; Starkov, 2008 and Lobo *et al.*, 2010) [14, 22, 15].

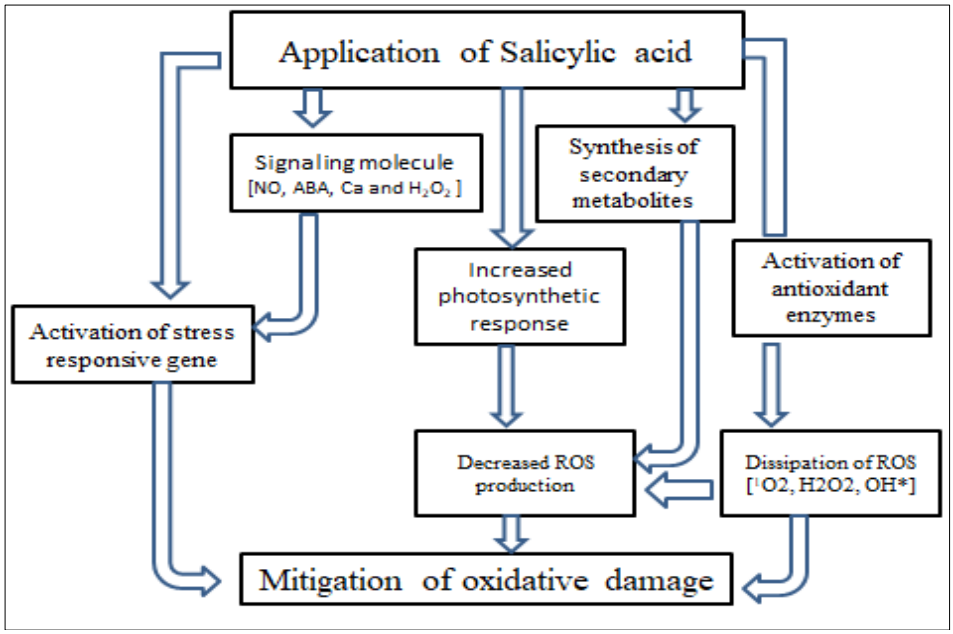

Fig 1: Effect of salicylic acid induced possible pathway to mitigate the environmental stress [Adopted from Hasanuzzaman *et al.*, 2017]

Conclusion

Salicylic acid is considered a member of phenolic group compound and act as a anti biotic and abiotic stress growth hormone. It is effective in both the form seed priming and foliar application while the concentration of its use is a crucial to obtain desirable results. It also helps to protect the plant by using the network of antioxidant enzymes like catalase, peroxidase, ascorbate and SOD results better performance of plant under wide range of environmental stress.

References

1. Alonso- Ramírez A, Rodríguez D, Reyes D, Jiménez JA, Nicolás G, López- Climent M *et al*. Evidence for a role of gibberellins in salicylic acid- modulated early plant responses to abiotic stress in *Arabidopsis* seeds. Plant Physiology 2009;150:1335-1344.
2. Awate PD, Gaikwad DK. Influence of growth regulators on secondary metabolites of medicinally important oil yielding plant *Simarouba glauca* DC under water stress conditions. J. Stress Physiol. Biochem 2014;10:222-229.
3. Borsani O, Valpuesta V, Botella MA. Evidence for a role of salicylic acid in the oxidative damage generated by NaCl and osmotic stress in *Arabidopsis* seedlings. Plant Physiology 2001;126:1024-1030.
4. Csiszár J, Horváth E, Váry Z, Gallé Á, Bela K, Brunner S. Glutathione transferase supergene family in tomato:

salt stress-regulated expression of representative genes from distinct GST classes in plants primed with salicylic acid. Plant Physiol. Biochem 2014;78:15-26.
5. Farooq M, Wahid A, Kobayashi N, Fujita D, Basra SMA. Plant drought stress: effects, mechanisms and management. Agron. Sustain. Dev 2009;29:185-212.
6. Fayez KA, Bazaid SA. Improving drought and salinity tolerance in barley by application of salicylic acid and potassium nitrate. J. Saudi Soc. Agri. Sci 2014;13:45-55.
7. Hasanuzzaman M, Nahar K, Bhuiyan TF, Anee TI, Inafuku M, Oku H *et al*. Salicylic acid: an all-rounder in regulating abiotic stress response in plants. In: Phytohormones - Signaling Mechanisms and Crosstalk in Plant Development and Stress Responses 2017. DOI: 10.5772/intechopen.68213.
8. Idrees M, Naeem N, Aftab T, Khan MM, Moinuddin A. Salicylic acid mitigates salinity stress by improving antioxidant defense system and enhances vincristine and vinblastine alkaloids production in periwinkle. Acta Physiol. Plant 2011;33:987-99.
9. Jini D, Joseph B. Physiological mechanism of salicylic acid for alleviation of salt stress in rice. Rice Science 2017;24(2):97-108.
10. Khan MIR, Asgher M, Khan NA. Alleviation of salt-induced photosynthesis and growth inhibition by salicylic acid involves glycinebetaine and ethylene in mungbean (*Vigna radiata* L.). Plant Physiol. Biochem 2014;80:67-74.
11. Khan MIR, Iqbal N, Masood A, Per TS, Khan NA. Salicylic acid alleviates adverse effects of heat stress on photosynthesis through changes in proline production and ethylene formation. Plant Signal. Behav 2013b;8:e26374. doi: 10.4161/psb.26374.
12. Khan MIR, Syeed S, Nazar R, Anjum NA. An insight into the role of salicylic acid and jasmonic acid in salt stress tolerance," in Phytohormones and Abiotic Stress Ttolerance in Plants, eds N. A. Khan, R. Nazar, N. Iqbal, and N. A. Anjum (Berlin: Springer) 2012b,277-300. doi: 10.1007/978-3-642-25829-9_12.
13. Krantev A, Yordanova R, Janda T, Szalai G, Popova L. Treatment with salicylic acid decreases the effect of cadmium on photosynthesis in maize plants. J Plant Physiol 2008;165:920-931.
14. Krieger-Liszkay A. Singlet oxygen production in photosynthesis. Journal of Experimental Botany 2005;56:337-346.
15. Lobo V, Patil A, Phatak A, Chandra N. Free radicals, antioxidants and functional foods: Impact on human health. Pharmacognosy reviews 2010;4(8):118-126.
16. Nazar R, Umar S, Khan NA. Exogenous salicylic acid improves photosynthesis and growth through increase in ascorbate-glutathione metabolism and S assimilation in mustard under salt stress. Plant Signal. Behav 2015;10:e1003751. doi: 10.1080/15592324.2014.1003751.
17. Qiu C, Ji W, Guo Y. Effects of high temperature and strong light on chlorophyll fluorescence, the D1 protein, and Deg1 protease in Satsuma mandarin, and the protective role of salicylic acid. Acta Ecol. Sinica 2011;31:3802-3810.
18. Rajjou L, Belghazi M, Huguet R, Robin C, Moreau A, Job C *et al*. Proteomic investigation of the effect of salicylic acid on Arabidopsis seed germination and establishment of early defense mechanisms. Plant Physiol 2006;141(3):910-23.
19. Saruhan N, Saglam A, Kadioglu A. Salicylic acid pretreatment induces drought tolerance and delays leaf rolling by inducing antioxidant systems in maize genotypes. Acta Physiol Plant 2012;34:97-106.
20. Sharma P, Jha AB, Dubey RS, Pessarakli M. Reactive oxygen species, oxidative damage, and antioxidative defense mechanism in plants under stressful conditions. *Hindawi* Publishing Corporation Journal of Botany 2012;(Article ID 217037):26. doi:10.1155/2012/217037.
21. Silva, Adriana da C, Suassuna, Janivan F, Melo, Alberto de S *et al*. Salicylic acid as attenuator of drought stress on germination and initial development of sesame. *Revista Brasileira de Engenharia Agrícola e Ambiental* 2017;21(3):156-162.
22. Starkov AA. The role of mitochondria in reactive oxygen species metabolism and signaling. Annals of the New York Academy of Sciences 2008;1147:37-52.
23. Vishal B, Kumar PP. Regulation of seed germination and abiotic stresses by gibberellins and abscisic acid. Front. Plant Sci 2018. https://doi.org/10.3389/fpls.2018.00838.
24. War AR, Paulraj MG, War MY, Ignacimuthu S. Jasmonic acid- mediated induced resistance in groundnut (*Arachis hypogaea* L.) against *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae). J. Plant Growth Regul 2011. doi: 10.1007/s00344-011-9213-0.
25. Zhu JK. Plant salt tolerance. Trends in Plant Science 2001;6:66-71