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Morphological, Physiological and Biochemical changes in Characters of Plants as Affected by Foliar Application of Salicylic Acid

Patel Saloni[1*], Jayswal Swati[2] and Maitreya Bharat[3]

[1] Department of Botany, Bioinformatics and Climate Change Impacts Managemant, Gujarat University, Ahmedabad- 380009, India.
[2] Department of Botany, Bioinformatics and Climate Change Impacts Managemant, Gujarat University, Ahmedabad- 380009, India.
[3] Department of Botany, Bioinformatics and Climate Change Impacts Managemant, Gujarat University, Ahmedabad- 380009, India.

ABSTRACT:

Plants produce some specific chemical substances, which are capable of moving from one organ to another and provide physiological control on growth. These substances, which are active in very small amount are called plant hormones or growth regulators. Salicylic acid is well known phytohormone, emerging recently as a new paradigm of an array of manifestations of growth regulators. As a signal molecule, it plays an essential role in regulating many physiological processes of plants, including flowering, seed germination, heat production, membrane permeability, defence responses. The level of SA varies from ng to mg per gram of fresh weight in different plant species and it will be changed under biotic and abiotic stresses for enhancing plants stress tolerance. The plant is exposed to all parameters like growth, development, morphological, biochemical, physiological and levels of chlorophyll. Plant significantly responses to all the parameters. When we treat plant with SA, plant becomes protected against the drought stress, cold stress also. SA is important for plant growth and development, defence response, germination, flowering, medicinally, etc. This review provides us different efficiency of SA in different plants, which will be helpful in plant's growth and development.

KEY WORDS: plant growth regulators; salicylic acid SA; foliar application; growth characteristics; biochemical constituents.

*Corresponding author

Saloni Patel

Department of Botany, Bioinformatics and

Climate Change Impacts Managemant,

Gujarat University, Ahmedabad- 380009, India.

Email:psaloni002@gmail.com, Mob no:9904613364.

INTRODUCTION:

The importance of mineral nutrition is known since ancient times. Woodward (1699) for the first time observed that plants grow better in muddy water than in rain water. De Saussure (1804) confirmed that inorganic mineral elements of the plant ash are obtained from the soil and atmosphere. The mineral elements presents in the soil are the most important for growth and development of plants. Most nutrition that plants have in the soil is absorbed by root system. Liebig (1804) for the first time observed the function of these plant elements. Plants are autotrophs and the nutrition is autotrophic. The heterotrophic organisms are depending on the plant inorganic nutrition for synthesis of complex organic compound. Plants derive nutrition form soil, water and air. Inorganic nutrients acquired in the form of inorganic ions from soil are known as mineral nutrients. The study of the uptake of mineral nutrients and their use by plants is called mineral nutrition. Plants require macro- and micronutrients, each of which is essential for a plant to complete its life cycle. Adequate provision of nutrients impacts greatly on plant growth and as such is of crucial importance in the context of agriculture. Minerals are taken up by plant roots from the soil solution in ionic form which is mediated by specific transport proteins. Recently, important progress has been achieved in identifying transport and regulatory mechanisms for the uptake and distribution of nutrients. Most of the plants require a relatively small or more number of nutrient elements in order to complete their growth and full fill their life cycle. In the deficiency of any one chemical element the plant cannot be survived. Plants require the nutrition in proper amount. If plants have absence of any elements they cannot be able to complete their life cycle and the nutrients are directly involved in plant metabolism and physiological activity. The elements cannot be replaced by other elements. There are mainly two types of mineral elements. 1.Macronutrients 2.Micronutrients. Some elements are essential for growth and development and some are not essential. Like nitrogen, phosphorus, hydrogen, potassium and other elements are present in the absorbed form of soil. Only two elements are present in the atmosphere are carbon and oxygen in all form of organic molecules.Fertilizer that is mixed with the soil for plant's better growth and developmentarefull with chemical elements that plant requires. Fertilizer is added for important nutrients into soil for vigorous growth and development, increase the fertility of soil and also for more yield of crops.

Nutrients Deficiency and Toxicity:

The absence of any of nutrients is called deficiency. This deficiency shows some symptoms on the any plant parts. This symptom indicates which elements are more or less. The concentration of the essential elements in the tissue below requirements, it is known as critical concentration. Such elements are associated with more specific structural and functional role in plants, in the deficiency of any elements plant shows morphological changes. Toxicity occurs when the elements are more than plant requirement and that decreases the growth, quality or development. In some plant the toxicity level is highthat plant cannot surviveand not able to complete their life cycle [1] (https://www.hydroponics.net/learn/deficiency_by_element.php).

Plant Growth Hormones:

Peter j Davies said that Plant hormones are a group of naturally occurring, organic substances which influence physiological processes at low concentrations. The processes influence the growth, differentiation and development through other processes, such as stomata movements, may also be affected. Plant hormones have also been refered to as “Phytohormones” though this term is seldom used.

Phytohormones as an organic compound are naturally produced in higher plants, controlling growth or other physiological function as a site remote from its place of production and active in minute amount. The term phytohormones distinguish from animal hormones.

The term “hormone” comes originally from the Greek and is used in animal physiology to denote a chemical messenger. Plant growth and development involves the integration of many environmental and endogenous signals that, together with the intrinsic genetic program, determine plant form. Fundamental to this process, several growth regulators are collectively known as the “plant hormones” or “phytohormones” [1].

Hormones are transported within the plant by utilizing four types of movements. For localized movement, cytoplasmic streaming within cells and slow diffusion of ions and molecules between cells are utilized. Vascular tissues are used to move hormones from one part of the plant to another.These include sieve tubes or phloem that move sugars from the leaves to the roots, flowers and xylem that moves water and mineral solutes from the roots to the foliage.Not all the plant cells respond to hormones, but those cells that do are programmed to respond at specific points in their growth cycle. The greatest effects occur at specific stages during the cell's life, with diminished effects occurring before or after this period. Plants need hormones at very specific times during plant growth and at specific locations. They also need to disengage the effects that hormones have when they are no longer needed. The production of hormones occurs very often at sites of active growth within the meristems, before cells have fully differentiated. After production, they are sometimes moved to other parts of the plant, where they cause an immediate effect; or they can be stored in cells to be released later. Plants use different pathways to regulate internal hormone quantities and moderate their effects; they can regulate the amount of chemicals used to biosynthesize hormones. They can store them in cells, inactivate them, or cannibalise already-formed hormones by conjugating themwith carbohydrates, amino acids, or peptides. Plants can also break down hormones chemically, effectively destroying them. Plant hormones frequently regulate the concentrations of other plant hormones.Plants also move hormones around the plant diluting their concentrations.

Plant hormones are small organic compounds, synthesized by specific plant cell/ tissues, active at low concentration and promote or inhibit growth and developmental processes. The concentrations required for plant are very from low 10-6 to 10-5 mol/L. Plant hormones are the naturally occurring organic substances. Hormones are important for yield, improve the quality and facilitate harvesting. Plant hormones regulate cellular processes in targeted cells locally and moved to other locations, in other functional parts of the plant. Hormones determine the formation of the flower, stem, leaves, the shedding of leaves, the development and ripening of fruit.

Types of Plant Growth Hormones:

The concept of plant hormones originates from a classical experiment on phototropism, the bending of plants toward light, carried out by Charles Darwin and his son Francis in 1880. The Darwin studied the bending of canary grass coleoptiles in response to unidirectional light. They demonstrated that a signal produces at the shoot apex travel downward and causes different cell elongation in the lower parts of the coleoptiles that resulted in its bending toward light source. The small number of plant hormones has been shown to influence the plant growth and development [1]. Based on the function or chemical structure, there are five major groups of plant hormones. These groups are: auxin, cytokinins, abscisic acid, gibberellins and ethylene. In addition, there is a variety of other plant hormones including the brssinosteroids, salicylic acid, polyamines, jasmonic acid and others.

SalicylicAcid:

Salicylic acid (fromLatin*Salix, willowtree*) is a lipophilic monohydroxybenzoic acid a, type of phenolic acid and beta hydroxyl acid (BHA). This colourless crystalline organic acid is widely used in organic synthesis and works as a plant hormone. It is derived from the metabolism of salicin. In addition to serving as an important active metabolite of aspirin, which acts in part as a prodrug to salicylic acid, it is probably best known for its use as a key ingredient in topical anti-acne products. The salts and esters of salicylic acid are known as salicylates.

The small phenolic compound, salicylic acid (SA) plays an important regulatory role in multiple physiological processes including plant immune response. Significant progress has been made during the past two decades in understanding the SA- mediated defence signalling network. Characterization of a number of genes functioning in SA biosynthesis, conjugation, accumulation, signalling and crosstalk with other hormones such as jasmonic acid, ethylene, abscisic acid, auxin, gibberellic acid, cytokinin, brassinosteroid and peptide hormones has sketched the finely tuned immune response network. Full understanding of the mechanism of plant immunity will need to take advantage of fast developing genomics tools and bioinformatics techniques.

White bark (*Salix Alba)* is the natural source of salicylic acid. In 2014, archaeologist indentified traces of salicylic acid on 7th century pottery fragments found in east central colorada. Salicylic acid is the phenolic phytohormones and is found in plants with roles in plant growth and development, photosynthesis, transpiration, ion uptake and transport. SA is involved in endogenous signalling, mediating in plants defence against pathogens. It plays a role in the resistance to pathogens by including the production of pathogen related proteins. It is involved in the systemic acquired resistance in which a pathogenic attack on one part of the plant induces resistance in other parts. The signal can also move to nearby plants by salicylic acid being converted to the volatile ester methyl salicylicte.

Recentyear's salicylic acid (SA) has been the focus of intensive research due to its function as an endogenous signal mediating local and systemic plant defence responses against pathogens. It has also been found that SA plays a role during the plant response to abiotic stresses such as drought, chilling, heavy metal toxicity, heat and osmotic stress. In this sense, SA appears to be, just like in mammals, an 'effective therapeutic agent' for plants. Besides this function during biotic and abiotic stress, SA plays a crucial role in the regulation of physiological and biochemical processes during the entire lifespan of the plant.

Effect of salicylic acid in plants:

Drought stress is becoming a major threat to plant productivity loss in agricultural system. The present study was carried out to evaluate the physiological and biochemical alterations induced by salicylic acid (SA) in mustard plant under moderate drought stress conditions. Therefore, a pot culture experiment was conducted to test whether SA application at concentration of 0.5 mM through foliar spray could protect the mustard (*Brassica juncea* L.) cultivar Pusa Jai Kisan subjected to drought stress on the basis of growth and photosynthesis. The treatments were as follows: (i) 100% FC + 0 mM SA, (ii) 50% FC + 0 mM SA, (iii) 100% FC + 0.5 mM SA and (iv) 50% FC + 0.5 mM SA. The control treatment received 100% field capacity (FC) irrigation, whereas moderate drought stress corresponded to 50% field capacity. Plants subjected to drought stress caused significant reduction in growth and photosynthetic parameters, activity of ribulose 1,5-bisphosphatecarboxylase (Rubisco), nitrate reductase (NR), ATP-sulfurylase (ATPS) which accounted for decreased nitrogen (N) and sulfur (S) assimilation.Where as, a pronounced increase was observed in proline metabolism. Exogenously applied 0.5 mM SA alleviated the stress by increasing the proline production through the increase in γ-glutamyl kinase (GK) and decrease in proline oxidase (PROX) activity. In addition SA application restricted the ethylene formation by inhibiting the 1-aminocyclopropane carboxylic acid synthase (ACS) activity more conspicuously under moderate drought stress than no stress. These findings reflect that SA application alleviates the drought-induced decrease in growth and photosynthesis through increased proline content. Higher proline content was a result of increased N and S assimilation and increased synthesis of proline synthesizing enzyme which lowers the oxidative stress in mustard.

Seeds of Indian mustard (*Brassica junceaL.*) were exposed to 0, 50, 100 and 150 mol/L NaCl for 8 h and seeds were sown in an earthen pot. These stressed seedlings were subsequently sprayed with 10 micromol/L salicylic acid (SA) at 30 d and were sampled at 60 d to assess the changes in growth, photosynthesis and antioxidant enzymes. The seedlings raised from the seeds treated with NaCl had significantly reduced growth and the activities of carbonic anhydrase, nitrate reductase and photosynthesis, and the decrease was proportional to the increase in NaCl concentration. However, the antioxidant enzymes (catalase, peroxidase and superoxide dismutase) and proline content was enhanced in response to NaCl and/or SA treatment, where their interaction had an additive effect. Moreover, the toxic effects generated by the lower concentration of NaCl (50 mmol/L) were completely overcome by the application of SA. It was, therefore, concluded that SA ameliorated the stress generated by NaCl through the alleviated antioxidant system [2].

The effect of sowing time, varieties and salicylic acid (SA) application on different physiological parameters (i.e. relative water content, photosynthetic rate, transpiration rate, stomatal conductance, leaf temperature, Membrane stability index, chlorophyll stability index, heat susceptibility index) of Indian mustard. The experiment was laid out in split plot deign and replicated thrice. The experiment consisted of three time sowing and four levels of Salicylic acid (Control, SA 50 ppm, SA 100 ppm and SA 150 ppm). Physiological traits like relative water content, photosynthetic rate transpiration rate, stomatal conductance, leaf temperature, chlorophyll stability index Content, heat susceptibility index and membrane stability index are directly correlate with heat stress tolerance in crop plant. Results were revealed that effect of different sowing time, varieties and concentration of SA has shown significant effect on all tested physiological parameters of Indian mustard and those are associated with high temperature stress tolerance [3].

Wheat is considered the first strategic food crop in Egypt. It has maintained its position during that time as the basic staple food in urban areas and mixed with maize in rural areas for bread making. In addition, wheat straw is an important fodder [4]. In Egypt wheat plants are sometimes exposed to drought at different periods of growth. A possible approach to minimize drought that induces crop losses is the foliar application with chemical desiccant on wheat plants [5, 6]. Salicylic acid (SA) naturally occurs in plants in very low amounts and participates in the regulation of physiological processes in plant such as stomatal closure, nutrient uptake, and chlorophyllsynthesisand protein synthesis, inhibition of ethylene biosynthesis, transpiration and photosynthesis [7, 8, 9]. It has been identified as an important signaling element involved in establishing the local and systemic disease resistance response of plants after pathogen attack [10].

The potent impact of salicylic acid and ascorbic acid on various areas of plant structure and function prompt many investigators to apply them to several crop plants. Aiming to control pattern of growth and development coupled with enhancement of systemic resistance against various hurtful agents which may appear in the surrounding environments. Salicylic acid promotes some physiological processes and inhibiting others depending on its concentration, plant species, development stages and environmental conditions [11, 12]. SA increased the number of flowers, pods/plant and seed yield of soybean [13] enhanced wheat growth [8] and maize growth [14, 15, 16] On the contrary, salicylic acid at relatively high doses inhibited plant growth and chlorophyll contents of tomato [17], lupine [18] and wheat plants[19, 20]. On the other hand, the beneficial effects of ascorbic acid upon growth and productivity have been reported on lemongrass [21]; cotton [22]; sugar beet [23]; cucumber[24] , sweet pepper [25] wheat [26] and on sunflower plants [27]. Thus salicylic acid and ascorbic acid could be expected to influence the growth and yield of wheat plants.

In Egypt, wheat plants are sometimes exposed to drought at different periods of growth. A possible approach to minimize drought that induces crop losses is the foliar application with chemical desiccant on wheat plants [28, 29]. SA treatments at 0.5 mM strongly or completely suppressed the Cd-induced up-regulation of the antioxidant enzyme activities of barley [30]. SA is a direct on physiological effect through the alteration of antioxidant enzyme activities. Certain enzymes were activated by SA treatment, while others, like catalase, were inhibited. Catalase seems to be a key enzyme in salicylic acid-induced stress tolerance, since it was shown to bind SA in vitro [31] and inhibited by SA in several plant species [32]. SA induces flowering, increase flower life, retards senescence and increases cell metabolic rate. The sustained level of salicylic acid may be a prerequisite. foliar application of salicylic at 100 and 200 mg L promoted -1 growth criteria of wheat plants height, number of tiller, number of spikes, flag leaf area (cm), blades 2 area/plant (cm), dry wight/plant (g) compared to corresponding untreated plants at milky and softy-dough stages of growth. In all cases, the increments in growth parameters were often highly significant in comparison with untreated ones. Salicylic acid at 100 mg L was the most effective treatment in increasing growth -1 parameters, whereas, growth characters of wheat plants significantly decreased by increasing salicylic concentration up to 400 mg L at milky and softy-dough stages. In this respect, many investigators found that -1 low concentrations of salicylic acid enhanced growth of soybean [13], maize

[14, 33, 34] and wheat plants [13, 35], whereas high concentrations caused an inhibitory effect on growth of tomato, lupine, wheat and maize plants [36,34,17,19]. Moreover, El-Bahay (2002) reported that salicylic acid has the potentiality to exert a suppressive or stimulative impact on various growth aspects of lupine seedlings through their direct interference with the enzymatic activities responsible for biosynthesis and/or catabolism of growth promoting and inhibiting substances. Interaction treatment of salicylic acid increase photosynthetic efficiency as reflected by increasing in both chl a, chl b and carotenoids content in the leaves of wheat plants. Data presented in this showed that foliar application of salicylic acid, especially at 100 mg L resulted -1 in the highest increase in yield and its components (i.e., plant height, number of tiller, number of spikes, grain index (g), spike length (cm), weight of spikes/plant (g) and grain and straw yield per plant and per fed). On the other hand, SA at 400 mg L recorded the lowest values of yield and its components compared to their -1 corresponding controls [37].

A Pot experiment was conducted at the greenhouse of the National Research Centre at Dokki, Cairo, Egypt. During the winter season of 2004/2005 to evaluate the effect of salinity and salicylic acid on growth of maize plants C.V. Single Hybrid 10. The treatment of salinity was done by irrigation with diluted Mediterranean Sea water: tap water (250 ppm) 2000 and 4000 ppm and spraying salicylic acid in 200 ppm twice after 3 weeks from sowing and two weeks later. A negative relationship was detected between vegetative growth parameters and the increase in salt concentration in irrigation water. The area of green leaves were mostly decreased from 5102 cm^2 in the plants irrigated by water contains 250 ppm salts (control) to be 2389 cm^2 in those irrigated by water contained 4000 ppm (53.18 %). Moreover, dry weight of stem, leaves and whole plant showed approximately similar response. The depression on stem, leaves and whole plants dry weight when irrigated by saline water of 4000 ppm amounted by 57.29, 47.43 and 51.43 % compare to the control. Spraying plants with salicylic acid in the rate of 200 ppm improved all growth characters i.e. plant height, number and area of green leaves, stem diameter and dry weight of stem, leaves and whole plant. The highest increment was shown in stem dry weight and the lowest in stem diameter. All amino acid concentrations were lowered by salinity except for proline and glycine. All determinate amino acid concentrations (except methionine) were increased with the application of salicylic acid (200ppm). On the other hand, methionine was negatively responded which slightly lowered. For plants irrigated with fresh water, SA gave its higher effect on cystine followed by that in arginine and tyrosine while the other amino acids were slightly affected. Serine phenyalanine and tyrosine showed approximately similar response. However, at 4000 ppm treatment, salicylic acid improved the concentration of arginine, lycine, serine and glutamic acid. Moreover, prolineconcentration increased when using salicylic acid foliar application and under salt stresses [38].

CONCLUSION:

As per this review we can conclude that the foliar application on the plants gives a progressive increase in plant height, number of tiller and spikes, flag leaf area, blades area/plant, spike length, grain index (g), grain, number and area of green leaves, stem diameter and dry weight of stem, leaves, n-p-k level and whole plant at high concentration. Photosynthetic -1 pigment in the leaves as well as some biochemical constituents in grains are significantly increased by increasing concentration of salicylic acid. Salicylic acid improves the concentration of arginine, lycine, serine and glutamic acid at high concentration.Salicylic acid is responsible for delay of ripening of fruits. This is very important for plant rapid growth and developmant. Plants represent defence against a varity of biotic and abiotic stesses through morphological, physiological and biochemical mechanisms.The plant exhibits drought stress resistance defence aganist pathogen.

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