IMPACTS OF FOLIAR FEEDING OF ZINC AND POLYAMINE ON THE PRODUCTIVITY OF WHEAT

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ABSTRACT

In the process of plant production, micronutrients are considered as one of the important factors for both plant growth and development. Foliar feeding of micronutrients is an important method for the crops to enhance their productivity as well as profitability by increasing the concentration of zinc in the grain. But due to narrow knowledge about the zinc-based foliar fertilizers limits the utilization, distribution, specification and mobility of zinc inside the leaves of the plant. Wheat crop during its growth stages is very responsive to the micronutrient application. Due to this response, it has more potential to increase productivity in terms of grain yield. The content of zinc can also be increased when zinc is provided to the plant in the form of foliar application. This element has the utmost importance in the plant's overall metabolism and also their physiology as it enhances many physiological and biochemical reactions inside the plants. The application of zinc in the foliar feeding not only elevates the deficiency of zinc but also enriches the grain quality when provided at a proper time for increasing its application efficiency. Both the yield as well as traits associated with the yield are also increased through zinc foliar feeding. On the other hand, polyamines (particularly putrescine) posses the two of more than two amino acids having low molecular weights and also aliphatic nitrogenous base. They are mainly available within all cells and are characterized through the products in the metabolic processes by the living organisms. Sometimes, they are also known to be behaving like a bio-stimulant as they are not only involved in general growth and developmental processes but also in responding to the abiotic stresses. This review mainly focuses on how zinc and polyamines (PAs) especially putrescine (Put) affects wheat productivity.

Keywords:

Micronutrients, productivity, zinc, mobility, grain yield, foliar, metabolism, physiological, biochemical, nitrogenous, putrescine.

INTRODUCTION

Among the cereals, wheat is considered as one of the most important crops and at the worldwide level, many countries use wheat as a staple food. Human beings consume wheat in many forms daily and are a key source of nutrition. If there is improper utilization of fertilizers, higher intensities of weeds along with the lesser water availability at various physiological growth stages and delayed sowings then there would be lower productivity of wheat. In crop production and plant nutrition, micronutrients have a huge role to play. Some micronutrients like copper, boron, iron and zinc have lower availability in the Indian soils. It might be due to the lesser application of these nutrients either in soil application or as a foliar application. Wheat is known to react during its growing phase to the application of multiple macro and micronutrients and to improve yields. These micronutrients are taken up by plants in very lesser quantity, for examples molybdenum, boron, copper, zinc, chlorine and manganese. They are equally as important as macronutrients like N, P and K. According to Arif, there will be an improvement in the production of wheat when these micronutrients are supplied in the form of foliar application at late tillering, late jointing and also at booting stages. The foliar application is important as it benefits the plants by the quick absorption of these nutrients by the plant's foliage. According to Abbas et al, the test weight, spikelet number on an individual spike, straw yield and spike length are affected by the various concentrations of Zinc. Wheat traits and their relative productivity is affected by sprays of zinc (Habib et al., 2009). When all parameters regarding yield are taken into consideration, the foliar application of micronutrients would give the highest mean values. In contrast to the control treatment, Ali indicated that there has been a significant increase in the number of spikes, the weight of 1,000 grains, grain yields and biological yield when Zinc and Boron are applied as a foliar spray and are taken as treatments. Ali said that spikes for zinc and boron leaf application compared to both control treatments showed significant increases in m^{-2} grain spike^{-1}, 1000-grain weight, organic yield, and grain yield. Zinc concentrations of plants are also influenced by organic matter, water conditions and soil texture. The primary functions of foliage are regulation of photosynthesis and transpiration. Due to their structure, nutrients can grow under certain conditions and to some extent only. The role of microelements zinc proved to be necessary for making more than 200 enzymes. Because of the increasing demand for wheat worldwide, the present study was undertaken to investigate the effects of different leaf applications of Zn and B on the growth and yield components of the wheat variety Pirbasak-2013. There are several ways to increase wheat production; one of them is a particularly balanced and suitable application of micronutrients with recommended N, P and K in newly reconstructed regions. (Jeedan et al., 2010). Zinc is known to play an important role as a metal component of enzymes or as a functional, structural or regulatory co-factor of a large number of enzymes (Hotz and Braun, 2004). Besides, Zn affects the life process of some plants, such as catabolism and metabolism of nitrogen, photosynthesis synthesis, resistance to biotic and abiotic stress, pollen activity and fertilization (Kekamak, 2008; Kaya and Higgs, 2002; Pandey et al., 2006). Wheat responds to the application of micronutrients during their growing stages and increases production in terms of yield.

Several studies have shown that one of the effective and productive methods for improving grains is the application of zinc fertilizer in soil or foliar application (El-Metvali et al., 2012). The Foliar Zn application represents an effective practice to improve productivity and grain Zn content up to three or four times (Cakmak, 2008). Besides, Bameri et al., (2012); Al-Habbasha et al. (2015) and Esfandiri et al. (2016) reported that foliar application of Zn has a positive effect on wheat grain yield and its components, as well as grain quality. Regarding genetic variation in response to leaf application of Zn, Al-Habbasha et al. (2015) and Sharifi-Soltani et al. (2016) they found significant differences between genetic variation in terms of wheat cultivation and growth traits, grain yield and yield components as well as quality in response to grain Zn and Fe content and Zn application. From the above results, Zn foliar application seems to be a promising way to increase grain Zn

content, but its effectiveness may depend on many factors, one of these factors being the development stage of foliar Zn application. In this context, the results obtained by Ozturkit al. (2006); Kakam et al. (2010) and Fattarakul et al. (2012) showed that the highest Zn concentration in wheat grains was obtained when foliar Zn was applied after the flowering stage compared to the application of transition stage. Besides, Kakam et al. (2010) showed that the highest grain Zn concentrations were obtained when Zn was applied fourfold (stem elongation + booting + milk + flour phases). Lee et al. (2014) showed that foliar Zn application in the primary grain filling period increased grain Zn content and Zn utilization efficiency by 82.9% and 49%, respectively, compared to the initial stages. Therefore, the present study was conducted to determine the effectiveness of foliar Zn application at different developmental stages with varying rates on grain yield and its components and nutritional quality of two bread wheat cultivated grains. Polyamines have organic compounds with two or more amino groups in their structure (Takahashi and Kakehi 2010). Plant polyamines occur in actively developing tissues and are synthesized under stressful conditions, including their cell division, root formation, fruit establishment and ripening, defence mechanisms and embryogenesis (Elkozer et al. 2010; Causano et al. 2008) plays an important role. In terms of salinity, polyamines metabolism depends on plant species, plant system, and duration of salinity exposure (Benavides et al 1997). Polyamines are synthesized by the precursor S-adenosyl methionine (SAM), which is also a precursor of ethylene synthesis (Cosano et al. 2008). Ethylene biosynthesis is inhibited by polyamines as they convert SAM to ACC (1-aminocyclopropane-1-carboxylic acid), which is converted to ethylene (Kumar et al. 2009). Hence polyamine and ethylene regulate each other either directly or be competition for SAM. The putrescine enzyme arginine decarboxylase is synthesized by ADC. (Takahashi and Kakehi 2010). In the case of *Arabidopsis thaliana heynh*, ADC is regulated by two genes ADC1 and ADC2. (Soyka and Heyer 1999). It is believed that ADC2 is responsible for the synthesis of polyamine during abiotic stresses (Perez-Amador et al. 2002).

Non-functioning of the ADC2 gene causes low levels of putrescine and no formation of spermine and spermidine (Soyka and Hair 1999). In such situations exogenously imposed putrescine is important to meet the threshold level of putrescine (Takahashi and Kakehi 2010) to overcome stress losses. This paper reports the effects of putrescine foliar sprays on wheat yield by growth, physiology, reducing osmotic stresses in plants and emphasizing salt or over-ripening and in potted or field conditions. Since no previous work is available on the reaction of putrescine exogenously applied to wheat under saline-sodic field conditions, the emphasis was laid on wheat physiology, nutrient accumulation and yield. Polyamines are found in various plant cells.They have an essential role in various cellular processes. Furthermore, they retard cellular degradation. Putrescine, spermine and spermidine are common polyamines found in higher plants. Polyamines are generally related to stress responses and have shown positive roles in drought tolerance. Besides, polyamines play an essential role in maintaining the integrity of membranes and nucleic acids under various stresses and a possible role that prevents the degradation of chlorophyll in leaf discs of various higher plants. Adding putrescine to bean plants leads to a significant increase in fresh and dried weight gain and is in agreement with 8 who have detected an increase in the yield of wheat plant grains by putrescine. Treatment of *Pisum sativum* plants with putrescine led to a significant increase in soluble protein 9. Besides, an increase of 10 in K and Ca accumulation in wheat root and shoot by polyamine application was found. Due to the stimulating effect of polyamines on yield, polyamines are considered primarily as a new class of growth substances and are common for their anti-deteriorating effects due to their antioxidant properties and membrane stabilization ability. Polyamines are small ubiquitous nitrogen compounds. Polyamine levels in stressed plants are of adaptive importance due to their involvement in the regulation of cellular ionic environments, maintenance of membrane integrity, protein synthesis, regulation of nucleic acids and protective alkaloids (Bouchereau et al. 1999; Kusanoetal). .2008). There are several known physio-stabilizers of membranes and reducing water stress of various cell types — the logical effects of polyamines (eg. Putrescine) in plant systems (Liu et al. 2007; Goyal and Astir 2010).

ROLE OF ZINC IN BIOLOGY OF WHEAT

It is observed and concluded that zinc is a very important micronutrient for the growth and development of the plant and enhance the several biochemical and physiological processes within the plant (Sommer and Lipman 1926; Marschner 2012). Zn is taken in the form of Zn^{2+} by the roots of the wheat predominantly (Sinclair and Kramer 2012), but when the complex of zinc is formed along with the organic chelating compounds example; phytosiderophores, specifically in alkaline soil it enhance the solubilization of zinc (Welch 1993). The concentration of zinc in wheat plants is different in every stage like when the leaves are young and still emerging the concentration of zinc is 14mg kg^{-1} dry weight (Brennan 2001), but at the stage of anthesis and tillering the concentration of zinc is 16.5 and 7mg kg^{-1} dry weight (Riley et al. 1992), and at the last stage in the whole grain is 10mg kg^{-1} (Riley et AL. 1992; Rengal and Graham 1995). In wheat, zinc is responsible for several physiological activities as we said earlier like activation of enzymes, synthesis of proteins and nucleic acid and metabolism of carbohydrate (Cakmak 2000; Palmer and Guerinot 2009). Zinc also control cell differentiation and proliferation as zinc is the structural component of finger proteins (Palmer and Guerinot 2009).
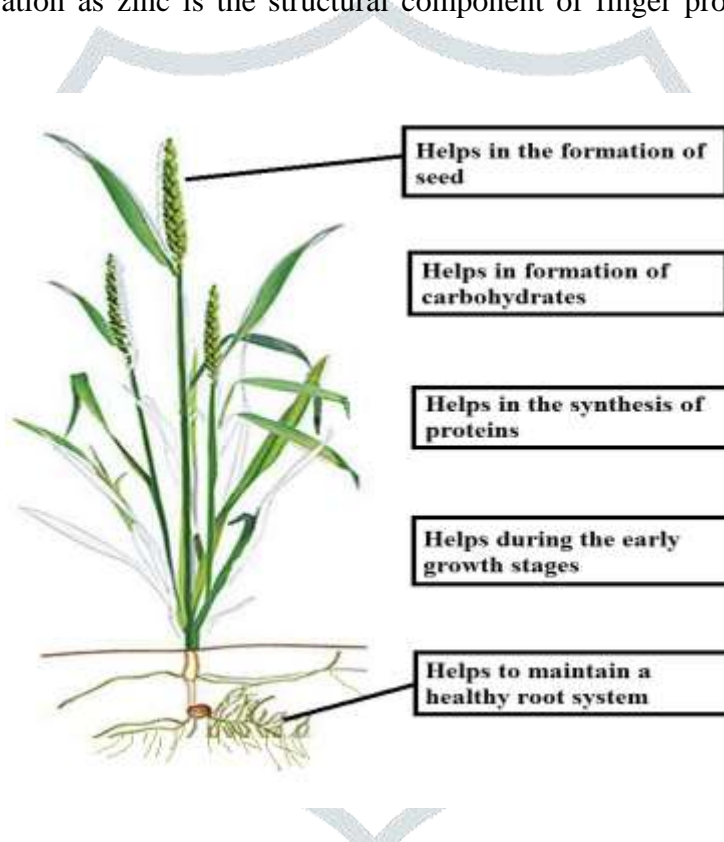

Figure 1: Role of zinc in the wheat plant

Synthesis of proteins

The plants have proteins which have zinc as an integral part (Broadley et al. 2012). If any plant is suffering from a deficiency of zinc then the accumulation of amides and amino acids takes place as a result there will be poor protein biosynthesis (Marschner 2012). The function and the 3-D structure of proteins are defined by the zinc (Broadley et al. 2007), e.g., Zinc finger proteins (Feinauer et al. 2013). Generally, there are types of the binding site;

- Catalytic
- Co- catalytic
- Structural
- Protein interface

Histidine is the most important zinc-binding ligand in the structure of protein along with cysteine, aspartic acid, glutamic acid and a molecule of water (Broadley et al. 2012). By increasing the levels of albumin, globulin, gliadins and glutenin in the wheat grains zinc fertilizers increase the content of protein (Liu et al. 2015). In the grain of wheat, the concentration of zinc is linked with both storage protein and gluten content (Pecket al. 2008). Protein synthesis can affect easily if the plant is zinc deficient because there will reduction in the biosynthesis of RNS due to some deformation in ribosomes (Alloway 2004). So for increasing the synthesis of protein zinc is needed

Abiotic stress resistance and activation of enzymes

In the regulation of some enzymes, zinc plays an important role (Barak and Helmke 1993). For around more than 300 enzymes i.e. zinc finger proteins, RNA and DNA polymerases zinc acts as a cofactor (Coleman 1998; LopezMillan et al. 2005). The availability of zinc decides the activity and function of the superoxide dismutase and carbonic anhydrase. In zinc efficient genotype of wheat, the expression of copper and zinc SOD is up-regulated while there is low copper/zinc SOD activity in zinc inefficient genotype of wheat (Hacisalihogly et al. 2003). Yield can be reduced if abiotic stress increases due to the vulnerability in the plants along with climate change. In the area like a semi and or arid especially where there is water is limited the deficiency of zinc is more (Bagci et al, 2007). If the soil is water deficient then root growth will be very poor and the uptake of nutrients especially zinc will be difficult (Marschner 2012). Several factors can offer the growth of the plant one of them is the temperature i.e. heat stress which affects the plant must it will reduce the growth and drastic change in cell membrane structure and function and function (Wahid et act, 2007; Barbabas et at 2008) along width chloroplast and machinery photosynthesis (Al-khalib and Paulsen 1990). The other factor is salt stress or we call it salinity stress it affects the plant by damaging the lipids, protein and nucleic acid due to the ROS production in large amount (Munns and Tester 2008). However, supplying zinc to the plants which are affected by the various stress (salt, drought and heat) by sustaining SOD activity zinc mitigate these effect by photosynthesis and of SOD activity is more, than automatically it detoxifies the ROS (Cakmak 2000). In the wheat plant, SOD acid phosphorus activity enhanced by the application of zinc by 96.8 and 75.8 (Bharti et al., 2014) to maintain and regulating the expression of the gene, and zinc is needed along with these it also cope with various abiotic stresses (Cakmak 2000). It is concluded by the above discussion zinc helps plants in many ways like cope up with various abiotic stresses regulating SOD and detoxification of ROS.

Structural and functional integration in the plasmalemma

The structure and function of the whole biological membranes are supported and upholds by the zinc. There is a higher concentration of phosphorus in the root exudates if the plant is suffering from zinc deficiency (Welch et al 1982). In the protection of lipids, proteins, DNA and other components of cell zinc play an important role (Cakmak 2000). By protecting protein and lipids from superoxide radicals also with other ROS zinc enhances and maintain the integrity of biological membranes (Cakmak & Marschner 1988), and across the plasma membrane altering of ions takes place if zinc is deficient (Cakmak 2000; Sinclair & Kramer 2012). If the wheat plant is zinc deficient then there is a decrease in the concentration of sulfhydryl group in the membrane of the cell and the membrane become leaky (Rengel 1995a), and this is the proof that zinc is required for the regulation and maintenance of ionic movement through the membranes by preventing a group of sulfhydryl peroxidation and transportation of ions in the plasma membrane of root cell (Cakmak 2000; Sinclair & Kramer 2012). This whole research concluded that zinc enhances integrity along with the maintenance of membranes.

Reproduction and cell division

Zinc not only enhances the cell integrity but also helps in the regulation to start the gametogenesis process and flowering as in the plant reproduction zinc is involved 40% of transcription factors (Colasanti et al. 2006) and also in the development of flower (Takatsuji et al. 1992). The growth, maturity and development of plant are influenced by zinc deficiency (Nautiyal et al, 2011). The plant has a low concentration of IAA (indole acetic acid) if it is deficient in zinc (Cakmak et al. 1989), by the action of superoxides radicals there is a reduction in IAA under the zinc-deficient condition not only this but also due to the increase in the level of ABA there could be poor seed setting which directly affects the flowering (premature), the pollen and anther structures disrupted (Brown et al. 1993). Due to the zinc deficiency, the cell integrity and stigma structure and function have some alteration which leads to the reduction in the number of grain (Pandey et al. 2006). In the tips of pollen tubes, the concentration of zinc can be high up to 150mg g^{-1} in the Easter lily (*Lilium longiflorum*) but in the region of basal, the concentration is up to 50mg g^{-1} (Ender et al, 1983). The endogenous gibberellin is triggered by the zinc if it is the inadequate amount (Sekimoto et al, 1997), which enhances the growth of the plant.

Photosynthesis

Zinc is an important component for the synthesis of chlorophyll. The content of chlorophyll only declines when the supply of zinc is very little (Cakman and Marschner 1993) due to some change in the structure of chlorophyll (Brown et al. 1993). The function and development are regulated by zinc in the chloroplast. By transferring the photodamaged protein D1 it regulates the repair of photosystem II (Hansch and Mendel 2009). It was reported that under the heat stress if zinc is applied it enhance and improve the ratio of chlorophyll fluorescence in zinc inefficient genotype (Graham and McDonald 2001). There is a key enzyme in photosynthesis called carbonic anhydrase for the activity of this zinc is also required. Zinc also limits the CA activity impaired with nutrition (Rengel 1995b; Salama et al. 2006). In the mesophyll cell of glumes and flags of the wheat carbonic anhydrase is present not only in this but the mesophyll cell of paleas and lemmas CA is present (Li et al. 2004). It is observed that the photosynthesis reaction is decreased due to the reduction in CA (Hacisalihoglu et al. 2003; Wolff et al. 2013). CA activity is measured by Rengel (1995b) in 2 of the genotypes under the deficiency of zinc; in the zinc-efficient wheat the activity of CA increased two-folds and it is observed that there is a higher rate of photosynthesis compare to the zinc- inefficient wheat. It is concluded that zinc is the most important in the photosynthesis activity it maintains the activity of CA.

Factors affecting the availability of zinc

According to the type of soil, the concentration of zinc varies from 17 to 125ug g^{-1} and for uncontaminated soil, the concentration of zinc is 64ug g^{-1} (KabataPendias 2001). The highest concentration of zinc found in solonchaks, alluvial and rendzinas soil while the lowest concentration of zinc is found in minerals and organic soil (Kabata-Pendias 2001). If the soil has less than 10ug g^{-1} of zinc then the soil is said to be zinc deficient but if the concentration of soil is more than 200ug g^{-1} then it can be contaminated by various anthropogenic sources (Alloway 2009). There are some physical properties of soils i.e. the content of zinc, organic matter, temperature and clay which determined the availability of zinc in the soil to the roots of the plant along with the microorganisms.

pH of soil

The availability of zinc in plants influence by soil Ph, if the pH of the soil is increased from 4.6 to 6.8 then it will affect the zinc uptake it will get decreased (Sumner and Farina 1986; Wilkinson et al 2000; Fageria et al. 2002). If the wheat is grown where there is high clay content or the pH of the soil is high then it will suffer the zinc deficiency (Qadar 2002) and due to high $CaCO_3$ concentration, the availability of zinc decreases. Zinc is retained through chemisorption as $CaCO_3$ is highly absorptive in nature (Kiekens 1995). Due to the chemisorption of $CaCO_3$, it is observed that there is lack of zinc availability. About 20% of the additional

sorbed zinc is desorbed by $CaCl_2$ in the zinc sufficient soil, but only 1% of zinc is sorbed in zinc-deficient soil (Cakmak et al. 1999; Cakmak 2008). Around more than 20% has $CaCO_3$ where the wheat is cultivated which comes under Central Anatolia, Turkey and 0.29mg kg^{-1} DTPA-extractable zinc. It is observed that zinc is lower than the critical limit in more than 90% of wheat growing soil i.e. 0.5mg kg^{-1} DTPA-extractable zinc (Eyupoglu et al. 1994). It is shown by others that doubling of Zn-binding strength to the $CaCO_3$ mineral calcite is due to the increase in the pH of the soil from 8.0 to 8.3. According to their efficacy the method of estimation of zinc varies and the method DTPA is not that much effective. The Zn-binding strength increased up to seven-fold with 0.05% Fe coating on calcite (Uygur and Rimmer 2000), which generally decreased Zn availability to plants, as a result, there is a higher incidence of Zn deficiency (Uygur and Rimmer 2000), due to the formation of some insoluble complexes along with hydroxides and carbonates the zinc availability reduces in high pH soil (Rupa and Tomar 1999). The zinc uptake can reduce if the concentration of calcite is more in loamy or heavily limed soil with a pH more than 7 (Fageria and Stone 2008). The production of cereal is increased in tropical regions if the soil has a low pH (Fageria and Stone 2008).

Soil organic matter

The organic matter present in soil plays an important role in the solubility and availability of zinc in growing plants (Harter 1991). The soil which has low or high carbon, waterlogged or light-textured there is zinc deficiency is prevalent (Ahmed et al, 2012). If any soil has low organic matter by increasing the concentration directly increases the uptake of zinc in plants (Ozkutlu et al. 2006), and the zinc bioavailability is enhanced by adding more organic matter to soils (Mandal et al 1998). The adsorption of zinc can itself influenced by the soil organic matter, if the organic matter is low then it will affect the zinc adsorption (Gurpreet Kaur et al 2013). Moreover, soil type affects Zn adsorption as peat soils are naturally deficient in Zn due to adsorption, and further liming of these soils reduces Zn availability to plants (Abat et al. 2012). The positive correlation is seen between both soil organic matter and extractable zinc by Alloway (2004). In the rice plant if we add more organic matter then the zinc bioavailability will also increase according to Mandal et al. (1988). The plants which grow more in calcareous soil have more zinc deficiency said by Clark (1982). The soil having low organic matter cannot ample reserves of available zinc and become more susceptible to zinc deficiency. As the depth increases the organic matter get a decrease in the mineral soils along with the DTPA-extractable zinc it also gets decline (Alloway 2008). The soluble complexes of zinc are formed if we add decomposable organic matter like manure which enhance the solubility and mobility of zinc by the roots of the plants (Alloway 2008). In contrast, Zn availability can be severely impaired in soils with high organic matter and low Zn content due to the formation of insoluble complexes with organic matter (Alloway 2008). The soil especially peat and organic in their horizons the zinc is more accumulated. In the mineral soils, organic matter is more bounded with zinc even after the complex of zinc-organic matter has low stability constant. The increase in exchangeable and soluble zinc can be help by adding manures i.e. sewage and sludge (Kabata-Pendias 2001), as the dissolved organic matter–metal complex is more photo available at the root – rhizosphere interface. The formation of insoluble oxides is resisted by the zinc chelation process by organic matter to make it more accessible for the rhizosphere present in the plant roots (Schulin et al. 2009). It is concluded and observed that zinc not only influenced by the organic matter present in the soil but also enhance the uptake of zinc and due to the formation of soluble zinc complexes organic matter increases the zinc availability.

Impact of the temperature of the soil, light intensity and moisture on the availability of zinc:

As we know that in most of the Indian soils, there is a tremendous deficiency of zinc. It becomes a major cause of concern both in the semi-arid and arid parts of the country (Cakmak et al. 1996a). The deficiency of zinc is also due to environmental factors. Under the rainfed situation, the amount of plant-available water is often low in most of the topsoils. In the parts of the country where water is found in lower quantities, the deficiency of

zinc is normally seen which in return makes the plant more sensitive to the zinc (Takkar and Walker 1993). The uptake of zinc by the plants is restricted due to the scarce water supply; hence its movement within the plant body is also restricted (Ekiz et al. 1998; Bagci et al. 2007; Hajiboland and Amirazad 2010). In most of the analysis, it is seen that when the plants are grown under poor water available situations then the growth of the plant is also poor in such zinc-deficient plants (Marschner 2012). Also, the drought conditions make the plant more sensitive to show the deficiency of zinc. In such conditions of drought, if we provide the irrigation along with the fertilization of zinc, there would be an increase in the yield (grain) of the crop (Moraghan and Mascagni Jr 1991). Another factor like the temperature of soil also affects the availability of zinc. Due to the lower mineralization (i.e. on a decomposition of organic matter librates Zinc) of soil rates in the wetter and cooler seasons, the availability of zinc is also low. In cool seasons, zinc deficiency is exacerbated as low temperatures restrict decomposition of organic matter, root growth (Alloway 2008) and mycorrhizal colonisation, further limiting uptake of plant Zn (Moraghan and Mascagni Jr 1991). The exposure to high light intensity and longer days also shows the symptoms of Zn deficiency (leaf chlorosis and necrosis) and some of the reactions related with the physiological aspects like impaired detoxification of reactive oxygen species (Marschner and Cakmak 1989). In short, environmental factors such as low soil temperature, lower precipitation and long-days, and high light intensity, due to poor root development or physiological deficiency due to ROS, are related to Zn inadequacies.

Soil salinity and interaction of Zn with other elements

In arid and semiarid environments, zinc deficiency is most common in saline terrain. Higher Ca and higher pH minimise Zn's plant supply (Alloway 2008). Owing to the high tension between Zn and salt cations at the root interface, zinc intake declines under saline soils (Tinker and Lauchli, 1984). In sodic saline soils, for example, the exchange sites occupy Na^+, which contributes to the liquidation of Zn, especially when the irrigated water is of high Na^+ (Alloway 2008). Zn absorption drops in Cd pollutant soils due to Zn's detrimental association with Cd and $CdCl_2$ (Khoshgoftaret al. 2004). Moreover, the main factors for poor Zn availability are high soil electroconductivity and pH and greater Ca, Na, Mg and HCO3 levels (Deckers et al., 1998). By limiting the uptake and translocation of Na^+, Cd^{2+} and Cl^- (Abd El-Hady 2007), the application of Zn to saline soil improves plant growth. Zinc is an interacting cation with almost all plant nutrients, particularly anions, that are present in the soil. For eg, Zn has a positive relationship with N in cereals (Lakshmanan et al. 2005) as increased N supplies have increased Zn concentration by affecting the abundance of Zn transporters and Zn chelating nitrogen compounds (Kutman et al. 2010). Zn is a positive associator in cereals. Erenoglu et al. (2011) state that e.g., Nitrogen applicability concentrations for wheat have increased absorption of Zinc in roots and shoots translocation about three hundred per cent. Kutman et al. (2011) said that the added Nitrogen rates also increased the concentration of zinc in wheat grain. Zinc has a poor association towards Phosphorous. Increased Phosphorous distribution concentrations around 0 to 400kg ha^{-1} decreased the dosage of Zinc in grain, for example, around 29 mg to 13mg kg^{-1}, while increased Phosphorous application levels increased the proportion of P: Zn molars to decrease the biological disponibility of Zn (Zhang et al. 2012). Phosphorous has been seen to be negatively affected by mycorrhizal diseases currently since the Phosphorous negative interactions on grain Zinc levels have been seen to never influence the grain Zinc supply if the soil is sterile to mycorrhiza (Ova et al. 2015). However, the relationship of Zinc with Potassium is favourable, although Zinc preserves membrane integrity & decreases amide and Potassium leakage (Cakmak & Marschner 1988). The use of sulphur raised the Zinc level for wheat (Cui and Wang 2005). Even then, Calcium (Kalyansundaram and Mehta 1970) was robbed of Zn. Increasing Calcium levels decreased the input and translocation of Zinc (1987 in Kawasaki and Moritsugu) although Zinc negatively interacted with Copper (1978 in Briar and Sekhon) as well as Mn (Gupta and Gupta 1984). Zinc can, however, aid in the overcoming of Boron toxicity (Mishra and Singh 1996) by reducing Boron intake. Because as Zinc application often reduces, raises or has no effect upon

its condition of iron (Loneragan and Webb 1993), the relationship between Zn and Fe is dynamic. Over Zinc insufficiency reductions in the MTP3 and HMA3 expression of a Fe deficient mutant demonstrated that Fe insufficiency is related to the acquisition of Zn (Colangelo and Guerinot 2006) because of inhibited growth and improved Zn chlorotic leaves (Gupta et al.2016). In brief, saline soils restrict Zinc absorption because of the greater percentage of sodium in places interchangeable with certain other ions i.e. Ca^{2+}, Cd^{2+} and Cl^- Ca^{2+}. Zn is having a good relationship with certain elements (Potassium, Nitrogen and Calcium and Magnesium) are effective although the existence and use of another while (Phosphorous, Copper, Mn and Boron) are suppressed.

Zinc interaction with mycorrhizal colonization/soil biota

Microorganisms present in soil can enhance crop absorption of Zinc. For example, the uptake of nutrients whose ingestion is restricted to dissemination from the ground solution to vegetable roots could significantly be improved with mycorrhizal (Fageria et al. 2011). Arbuscular mycorrhizal fungal enhances the absorption of Zn in different cultures, notably wheat (Ryan and Angus 2003). Increased Zn accumulation is related to AMF colonisation at plant roots which, over the root nutrient-deficient region, enhances the area of the hyphal channel (Smith & Read 2008). Besides, AMF aided in Zn's development of pores and soil patches not applicable to plant roots (Bolan, 1991). Pellegrino et al. (2015) stated in a meta-analysis of 33 field trials that the AMF production was improved and the Zinc concentrations of the wheat were improved. Soil bacteria also tend to increase the absorption of nutrients. PGPRs are the key essential in soil microbes, because of the signals transduced by the hosting plants and bacteria, which enhance nutrient absorption through the colonisation of the surface of the root (Biancotto et al. 2000). *Bacillus subtilis*, *Bacillus cereus*, *Flavobacterium spp*. were described in another analysis by Bolan et al. (2010) as well as the Zinc resistant bacteria Pseudomonas aeruginosa that greatly boost zinc soil supply as well as plant intake. *Bacillus aryabhttai* often strengthened zinc aggregation in wheat grains by solubilizing zinc-binding with natural also Calcium carbonate complexes and the soil-exchangeable zinc by enhancing soil microbes behaviour and growing the dissemination in the rhizosphere of the accessible zinc (Ramesh et al. 2014). Naz et al. (2016) stated that using it in conjunction with nitrogen and phosphorous fertilizer of Zn-Solubilizing Bacteria has enhanced zinc uptake and split-out of vegetative areas by increasing Zn concentration by inoculating Azospirillum; whereas the concentration of zinc is enhanced when inoculated with Rhizobium, Pseudomonas and Azospirillum.

Biofortified wheat through zinc application

Hotz and Brown(2004) said that the for the development and normal growth zinc is the main mineral required and also to improve immune system function, neurotransmitters function and reproductive health in limited quantities by humans and plants. While wheat is a massive food consumption source for masses every day, Zinc is poorly bioavailable. Zinc accumulation in wheat can be increased by agricultural or molecular methods for the production of genotypes of micro-element dense wheat (White and Broadley 2011; Veluet al. 2014). The accumulation of zinc from the leaves in wheat grains (Pearson and Rengel 1995). The key bottling experiences in the zinc biofortification include storage of excessive zinc in vacuoles of the root, (ii) zinc grain concentration based upon leaf translocation and (iii) discontinuous xylem at the bottom of each kernel in the kernel as a major obstacle to zinc transmission (Palmgren et al., 2008). Zinc is also a major translocating obstruction. Below is the discussion of the pathways to agronomic and genomic biofortification.

Approaches related to agronomy

Alloway (2009) said that the main cause behind the zinc deficiency in cereals is the deficiency of zinc in soil where wheat is grown which mainly results in the Zn insufficiency to humans also. According to Cakmak (2008), there is a faster-boosting solution for enhancing the concentration of zinc grain as well as decreasing

zinc deficiency that is the agronomic perspective which includes a strategy of fertilizer and when the application of zinc is done in the integration with N, O and organic fertilizers as well as good cultivars of crop it gives better results (de Valença et al. 2017). Zinc concentration of grains can be enhanced by enhancing the implementation of zinc fertilizers which can be organic as well as inorganic fertilizers. Knowledge of Zinc's sources and period of foliar implementation is important to aggregate zinc in grain efficiently. For eg, after flowering foliar fertilization seems to be more successful than adding the soil to increase Zn build-up of wheat seeds (Cakmak et al. 2010a, b). Zinc treatment by foliar spraying is enhanced concentrations of zinc seed above replication goals recommended by nutritionists (10 mg kg^{-1} from a baseline of crop varieties) (Velu et al. 2014). Bioaccumulation of zinc is somewhat more essential than those of the concentrations of grain Zinc, as much of zinc is contained in aleuron and wheat seed embryo (Cakmak et al. 2010b). The phytic acid content in germs and aleurons is also higher and accounts for 75% of seed P (Lott and Spitzer 1980). This accumulation is also greater. The foliar fertilization of zinc, for example, not just to increase the entire grain Zn level but also improved the concentration of Zn endosperm (Cakmak et al. 2010b) indicating that zinc is highly bioavailable to the human's body. Furthermore, Zn usage in earlier phases of grain growth raises the bioavailable Zn concentrations in the endosperm, as this seed fraction is exceptionally low in phytate (Cakmak et al. 2010b; Cakmak 2012). Zn bioavailability is measured by a phytate to Zn molar ratio as a phytic acid: Zn molar ratio >15 typically reflects a lower bioavailability of Zn in food (Gibson et al. 2010). The use of soil (9 mg Zn kg^{-1}) and leaf application (0.05 per cent Zn) by Zn post-flora increased Zn bioavailability by decreasing the phytate and phytate: Zn ratio for humans in a study by Hussain et al.). Likewise, in wheat at a reduced phytate and zinc ratio of concentrations, Bharti et al. (2013) observed that the concentrations of grain Zn increased. Recently Saha et al. (2017) have demonstrated the reduction in the phytate: Zn ratio through applying to the field + two foliar sprays of Zn or two Zn foliar sprays after flowering. Following are the main sources of zinc along with the content of Zn present in them:

Sources	Content of Zn
Zinc sulphate monohydrate	33-36%
Zinc sulphate heptahydrate	21-23%
Zinc oxide	55-70%
Zinc oxysulphate	40-55%
Zinc nitrate	22%
Zinc – HEDTA	9%
Zinc – EDTA	12-14%

Table 1- Commonly applied sources of Zinc fertilizers

Plant breeding & genetics approach

Breeding through conventional and selection methods

Bouis (2003) said that the plant breeding techniques have been used in genetic biological fortification to establish genotypes of staple foods which have been rich in many micronutrients whereas low in nutritional inhalers by increasing the concentrations of nutrient absorption and aggregation of grain. Agricultural interventions as a cost-effective and safe approach to the distribution of essential food microelements are augmented by biological fortification of zinc wheat cultivars by traditional cross-breeding (Stein et al. 2007). Traditional biological fortification involves the exploitation of genetically engineered mineral micronutrient compositions by conventional breeding of crops. This group covers gene detection and marker-supported selection (Grusak 2002). The susceptibility of the cereals to zinc deficiency varies widely (Graham and Rengel 1993; Cakmak et al. 1997a) which could be utilized for the discovery and production of zinc-efficient genetic variants. Amiri et al. (2015) have noted zinc amounts of 31,64-55,06 mg kg^{-1} DW in the genotypes of bread

wheat (*Triticum aestivum* L.). *Triticum turgidum* ssp. among some of the wheat family. The wild emmer wheat variability is large in Zinc (14–190 mg kg^{-1} DW) and iron (15–109 mg kg^{-1} DW), which are higher than modern wheat growing products (Cakmak et al., 2004). Roshanzamir et al. (2013) said that the concentrations of zinc grain in the population of recombinant inbred lines range around 44.4 to 95.6 mg kg^{-1}. The genotypes of wild emmer wheat have been confirmed to be genetically distinct for concentrations of seed nutrients (Chatzav et al. 2010). Tabigha (*Terra Rossa*) have promising properties for breeding programmes, including significant amounts of zinc, iron and seed protein, of the populations surveyed of wild emmer wheat. The relation amongst quantities of seed protein, iron and zinc offer the ability to evolve these 3 traits at the same time (Chatzav et al. 2010). Besides, the genes in rye accountable for the performance of zinc will produce the genes of efficient wheat (Rengel, 1999). The production of large zinc wheat genotypes involves specific phénotyping. However, ecological factors, specifically soil physical-chemical properties, have an impact on high zinc cultivars breeding (Trethowan 2005). The application of zinc fertilizers and the maintenance of a homogenous soil zinc abundance could solve this condition. The quantitative characteristics of wheat are zinc a well as iron (Trethowan 2005). Cakmak et al. 2004; Morgounov et al. (2007) states that the clear favourable association among the zinc and iron concentrations of new, wild & spelt wheat have been seen, which suggests that zinc and iron genetic and physiological influences are identical. In short, genetics must be utilized for the production of Zinc-dense wheat cultivars in various varieties of wheat and the wild and cultivated families for the accumulation of zinc grain.

METABOLISM AND DISTRIBUTION OF POLYAMINES INSIDE THE PLANTS

Distribution of PAs

In eukaryotic and prokaryotic cells polyamines are ubiquitous (Liu et al., 2016, 2017) and also formed in plant tumours along with plants RNA viruses. There are several forms of PAs and have potent biological activities, Pas are generally present in the free form in higher plants and Put, Spd and thermospermine are the common PAs found in them (Kim et al., 2014; Sobiszezuk-nowicka, 2017; Takahashi et at 2017b) and cadaverine (cad) (Regla morquez et at., 2015; Nahar et al., 2016). In the certain plant parts other PAs are present various patterns like tissue and organ distribution shown by polyamine for example the form of PA is put found in leaves which is most abundant in nature and it is 3 levels higher than other forms of PA i.e. Spd and Spm, whereas in other organs of plant Spd is found (Takashi et. Al., 2017b) various patterns of localization is shown by several types of PAs in the cell. In the plant of carrot inside cytoplasm put was found and accumulates these and in the cell wall Spm is found (Cao et al., 2006). According to its function and structure of PAs are distributed. If plant have high PA biosynthesis and content is also high of PA than it will have vigorous growth along with metabolism (Zhao et al., 2004; Cai et at, 2006)

Biosynthesis of Polyamine

The action of amine oxidase decides the PAs catabolism in plants. There are two groups of amino and a synthetic precursor of Spd and Spm (Xu et al., 2009). For the Put biosynthesis, there are 3 different pathways. In the 1st pathway, from arginine the carbon no. 8 is removed to form agmatine (Agm) and CO_2 with the help of arginine decarboxylase (ADC) than to form N -Carbamoyl Put (NCPAs) and NH_3 no. 2 atoms of nitrogen is removed by the help of N-carbamoyl putrescine amidohydrolase (NCPAH), NCPA is hydrolysed and to form Put, CO_2 and NH_3 carbamoyl group is removed. All these are the most important route of biosynthesis of Put in the plant (Docimo et al, 2012; Pegg,2016) and comes under the first route.
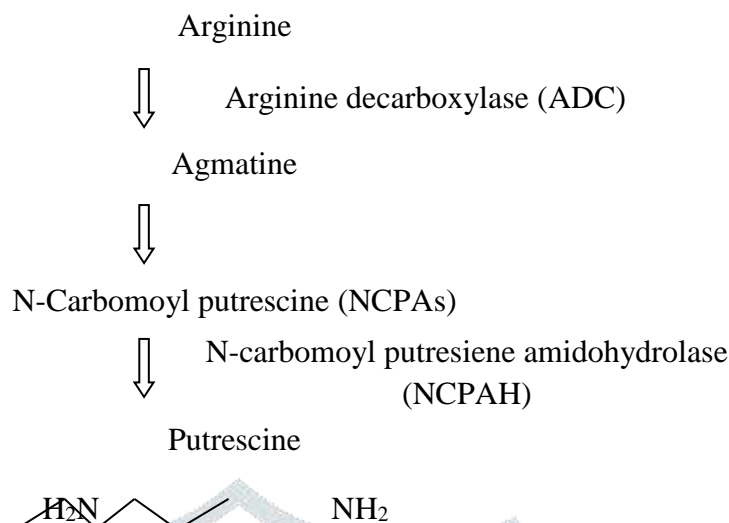
Arginine

⇓   Arginine decarboxylase (ADC)

Agmatine

⇓

N-Carbomoyl putrescine (NCPAs)

⇓   N-carbomoyl putresiene amidohydrolase
         (NCPAH)

Putrescine

H_2N NH_2

Figure 2: Formation of Putrescine from arginine

In second pathway from Arg by arginase the production of ornithine (Orn) is done, and then the removal of carboxyl group of the carbon atom No.1 ornithine decarboxylase (ODC) to form CO_2 and put (Docimo et at, 2012;Pegg,2016) from *Arabidopsis thaliana* the gene name ODC has been last a long with Brasicaeae (Hanfrey et at,2010). It indicates that for the normal growth ornithine pathway is not that much essential, Now in the 3rd Pathway, cittroline is formed after the conversion of Arg which is then decorboxylated by the help of citrulline decarboxylase (CDC) to form put (Han , 2016; Ouyang et at ,2017, De oliveria et at ,2018). In the sesame Cit pathway is found and the most common pathway in plants are the first two routes by the competitive inhibitors i.e, difluoromethyl) arginine (DFMA) ADC and ODC activities can be inhibited.

Catabolism of Polyamine

Both diamine oxidase (DAO) and PA oxidase (PAO) are the part of amines oxidases, they depend on Cu^{2+} and pyridoxal phosphate as its co-factor, and from Put it catalyzes the H_2O_2, ammonia and 4-aminobutanalformation. To form pyrroline 4-aminobutanal catalyzes, and by the action of pyrroline dehydrogenase (PYRR-DH) PYRR converted into ϒ-amino butyric acid (GABA), and after the conversion GABA enters into Krebs cycle. High content of DAO found in dicots but genes which are encoded found only in few species (Cona et al., 2006). In monocots PAO is linked to flavin adenine dinucleotide (FAD) not like DAO, by non-covalent bonds (Takahashi et al., 2017a; Hap et al., 2018). Spd, Spm and Tspm these are the advanced PAs and according to Takahashi al & Liu et al, a number plants will have PAO activity. There are few products of PAs metabolism in wheat plants produced at the end of the reaction like 1, 3- diaminopropane (DAP), 4- aminobutanal, H_2O_2, and 3-aminopropyl-4-aminobutanal. According to Liu et al and Cona et al. Spd and Spm is oxidized by PAO. Takahashi et al & Liu et al stated that during the pathway of back conversion of polyamines, there will be synthesis of polyamine at the time of catalyzation of few PAOs in reversible reaction. It is observed that exogenous Spd is transferred into Put if applied in the *Helianthus tuberosis* (Tassoni et al., 2000). In plant Arabidopsis the conversion of spm to spd can be possible by PAO1 & PAO4. During the catalyzation of PAO3 & PAO2, the Spm are converted into Spd, stated by Mosehao et al. Put is a result of Spd which is further formed from the Spm by the catalyzation of *Brachypodium distachyon*. Spm is utilized as substrate by BdPAO3 and the conversion of spd from tetramines is catalyzes by spm (Takahashi et al., 2017a). The metabolic pathway is somehow connected with Pas metabolism. According to the Melidou et al & Frietus et al, during the biotic and abiotic stresses the H_2O_2 production is mainly responsible for transducing of some signals which are only function in the availability of oxidation of polyamines. The induction of ABA will result

in the closing of stomata. According to Jon et al & Cuna et al, during the biosynthetic pathway of polyamines, there is production of SAM – sadeno sylmethionine. It also acts as precursor, and it has been seen in different studies that there is a competition between both PAs and ethylene synthesis (Lasanajak et al., 2014). And also the production of NO is related with PAs metabolism (Pal et al., 2015). By studying and exploring the relationship between PA metabolism and the growth of plant can give the basic idea of the growth and different pathways of PA and their forms affect the plant function and its metabolism.

PLANT DEVELOPMENT AND POLYAMINES

Flowering and Polyamines

In higher plants at the time when it reaches to reproductive growth phase after the vegetative growth phase i.e. the tissue of leaf buds changes and from simple flower bud converts into floral organs which is known as bud differentiation (Guo et al., 2015). The complex morphogenesis process lead to differentiation of flower bud. It is set off by different elements, for example, vernalization, water status, nourishment and photoperiod. In the year 2005, Xu et al stated that there is a proper coordination and association of polyamines and hormones, also in the development of plants, polyamines are regarded as one of the best controllers. Extrinsic polyamines as well as polyamines synthesis can influences the flower bud differentiation. Xuu in 2015 stated that the process of bud differentiation is boost up by the extrinsic polyamines as well as by elevated polyamines matter in apical buds were beneficial in Chrysanthemum for the beginning and hold up of flower bud differentiation. Polyamine was declared to be abundant in flower in the arabidopsis as compare to other organs of the plants, and the expansion of exogenous PAs to inadequately blooming plants altogether advanced their response in the process of flowering (Aplewhite et al., 2010). Taatte et al., in 2015 stated that the use of Spm (10 ppm) improved the quality of flower and expanded container life by 3 days in the flower of rose cut. Degrade materials of polyamines (mainly Put & Spd) in rapeseed were declared to be beneficial for the initiation of bud differentiation of flower , and an enlarged amount of polyamines were profitable for the improvement of buds of flower. Prior cresting of PA substance in tissues prompted before the time of bolting (Ai et al., 2011). Comparative outcomes were seen in *Dendrobium nobile*, large amount of buds of flowers are present where there is the significant amount of Put and Spd are used in the leaves as well as more number of flower are grown there, and a higher means botanic estimation stated by Lii et al., in 2014. According to Aplewhite et al., 2010; Imamura et al., 2015 the proteins of recombinant GtSPMS as well as GtSPDS from *Gentiana triflora* (homologs of two Arabidopsis polyamines biosynthetic substances) had SPMS as well as SPDS actions, individually. Aplewhite et al., 2010; Xuu et al. 2014b; Xuu, 2015 said that the GtSPDS and GTSPMS joint levels passingly developed first from plant to just the process of reproductive stage, and these qualities are articulated rapidly or quickly. Polyamine synthase inhibitors in Arabidopsis reduced the quality of SPD and fully limited catapult and blooming for the production medium. Catapulting and blooming were restored at the period when plants became transferred to medium without inhibitors. Therefore, taking care of Spd by means of the roots under lenient at the conditions of flowering brought about deferred flowering in *Arabidopsis* (Aplewhite et al., 2010; Ahmed et al., 2017). Plants generally show dwarf symptoms and delay in flowering if there is over expression of ADC brought about Put gathering in the leaves (Ahmed et al., 2017). Endogenous Put was discovered to be firmly identified with IAA and gibberellin (GA) substance, and significant levels of Put and Spd were not helpful for the aggregation of IAA and GA (Xu, 2015). In 2015, Xuu noted the impact of extracellular PAs and polyamine synthesis inhibitors on Gibberellin acid at the level of inflorescence differentiation and flora distinctions for both small as well as the late flowering phenotypes became mitigated by the application of gibberellic acid. eStochastic Spd formed completely advance PAO behavior and the lignin mixture throughout separation of the floral bud under a short day. Xuut al., 2014a reported that the D-Arginine

inhibits the isolation from the flower bud which decreases the PAO activity and the union of the lignin. Smita and Upendranath in 2008 stated that in plant growth and improval, Lignin is an auxiliary metabolite which is of unimaginable significance in forming, dividing, and obstructing cells of plants.

Plant Senescence and Polyamines

The functions of metabolic polyamine enzymes and polyamines are evolving across the entire process of plant growth. The activeness throughout the meristem and growing cells although least in senescent tissues in whole plant was seen to be strongest in intrinsic polyamines and polyamine synthetase. The volume of chlorophyll drops rapidly as senescence leaves however as production in ADC and ODC declines, PAOs and hydrolases including ribonucleases as well as proteases develop fastly. According to Duaan, 2000; Caii, 2009 All of such modifications would be removed by the introduction of exogenous polyamines. Duaan et al., in 2016 stated that the Polyamine decline in rates of polyamine appears to constitute a significant prelude to senescence, either a fall inolyamine efficiency in the senescence signals. Yang and He, 2001; Cao, 2010 reported that the exogenous Spd and Spm medications may enhance the polyamine material, prolong senescence and improve performance of the cutting flower. According to Siimões et al., 2018, By spray of Gibberellic acid + Spm, the presence of the cutting flower deposits at 20 C has been slowered, hence the inflorescence performance has improved. A higher Spm level, decreased development of reactive oxygen species (ROS) and increased NO levels were found to be correlated with delayed leaf senescence (Sobieszczuk-Nowicka, 2017). By inhibiting ethylene biosynthesis, polyamines tend to postpone senescence (Woo et al., 2013; Anwar et al., 2015). There will be delayed senescence shown in the Gerbera flowers when these are treated in vase water with foliar spray of 10 mM Spd or 0.1 mM Spd while on the other hand, it will be accelerated when applied with the spray of 0.1 mM Spm, 1 mM Spm, 1 mM Spd, 10 mM Spd, and also with the combination of 0.1 mM of Spm, Spd, Put. This will produce the yellow rims of petals and spots which are brownish in color after the second day of the treatment (Bagni and Tassoni, 2006). Serrafini - Fraacassini et al., 2010; Cai et al., 2015 stated that there will be huge loss of chlorophyll and degaradation of proteins when the Spm or Spd are added exogenously but during senescence, there is accumulation of Put and rapid degradation of chlorophyll in the plants. Hann has stated in 2016 that even the antagonist of Aminopenicillanic Acid in paeony has extended life expectancy or replaced the senescence of cut flowers, whereas polyamines have shortened the longevity also prolonged floral senescence.

EFFECT OF POLYAMINES AND CLIMATIC FACTORS

Stresses caused by polyamines & higher or lower temperatures

There are mainly two kinds of temperatures stresses are present viz; high & low. It is important to further separate low temperature stress into cold stress and freezing stress. There is only certain number of studies present for PA physiology associated with the higher temperature based stress. PA synthesis in the leaves of Chinese kale was greatly influenced by high temperature stress; the overall PAs and Put contents improved after a week of increased temperature. Yang in 2002 stated that for a longer duration of time, increased temperature is not maintained. There is more occurrence of photosynthesis when the temperature is high and is also facilitated by polyamines. Polyamine also helps to benefit the plant by raising the osmotic adjustment & antioxidation. In order to protect the peroxidation of membranes & to make membrane structure stable, antioxidant enzymes can scavenge ROS (Ouyang et al., 2017). Shao et al. stated that higher Spd content and lower Put and Spm content were related to the heat resistance of alfalfa (Shao et al., 2015). In plants, PAs have several different functions, and the major physiological processes of high temperature resistance vary between species of plants. This explains why, under high temperature stress, the different PAs exhibit different patterns of change in various plant species (Shao et al., 2015). Roy et al., by contrast, indicated that accumulation of

Putrescine will have chilling effect while the rise in the concentration of Spm will act as a shield to the chilling effect. According to them, when the loquat fruit is stored at lower temperature, the amount of Spd, Put and Spm would rise gradually. High levels of endogenous Spm and Spd were preserved by the application of exogenous Spm, which prevented aggregation of Put and minimized damage by chilling (Zhen et al., 2000; Roy and Wu, 2001). According to some researchers, in order to avoid the damage due to chilling conditions, there is accumulation of Put which acts as defensive agent as it is positively associated with the resistance of cold to plants (Wang et al., 2003b).

Water Stress and PAs

There are a lot of researches are performed on both the water stress & PAs and only few are focused on resistance to waterlogging. There are a lot of relationships are found to be associated with the water stress and PAs (Ebeed et al., 2017). The pores of the guard cell plasma membrane and size of the potassium channel can be regulated by polyamines (Spm, Spd, and Put) and therefore the pore opening and closure can be strongly regulated (Liu et al., 2000). PAs will therefore regulate plant water loss (Liu et al., 2000). A number of researches revealed that if the Put is applied in the form of foliar application then at a proper stage, there will be activation of various biosynthetic and physiological processes like proline, soluble sugars and free amino acids. This will counterfeit for the detrimental effects on biomass of plant for drought stress and boost the consistency and quantity of some substances having bioactive origin (Sánchezrodríguez et al., 2016; Mohammadi et al., 2018). A treatment of Put in alfalfa shows to enhance germination of seeds and raises every single growth index (shoot and root fresh dry mass, and hypocotyl length) when there is presence of stress caused by produced through various polyethylene glycol concentrations (PEG 4000), both in a pot experiment and in vitro (Zeid and Shedeed, 2006). Hypersensitive to high salt and drought is the Arabidopsis mutant acl5/Spms, which does not generate Spm. Yamguchi et al stated that the deficiency of Spm causes the more sensitivity to drought. The pretreatments with only Spm except Spd and Put will heal the Arabidopsis mutant. The drought tolerance of mycorrhizal masson pine (Xu et al., 2009) was correlated with a higher content of Spm along with the a lot more ratio of (Spd + Spm)/Put. Spm was most closely linked to drought tolerance apples among the three major endogenous PAs (Liu et al., 2010). Similar findings for cherry tomatoes have been obtained stated by Montesinos Pereira. According to Yeng, the inhibitory impacts of the stress due to the drought are removed by the content of Spm and Spd & improves the grain filling and drought resistance in cereals like wheat crop. On the other hand, putrescine does have opposite effects of it. Due to all these observations, Sen et al cleared that whether under osmotic stress or water stress, several plants or variable portions of a plant may have different roles of polyamines. Therefore different plant species also have different water stress and osmotic stress even when they are grown under the exogenously applied polyamines. There are mainly two stresses of abiotic origin affecting the agriculture - salt and drought stress, all of which contribute to decreased water capacity in plants. A dynamic environmental restriction is salinity. A high concentration of salt lowers the stability of the membranes, the various enzymatic activities are decreased and also affects the normal physiology of photosynthetic apparatus. Plants respond to such unfavorable environmental conditions when there is accumulation of osmolytes like polyamines and proline which are lower in molecular weights. It has been shown by Mishra and Verma et al. that there will be removal of stress due to sodium salts as a result of application of exogenously applied differential concentrations and forms of polyamines on different plant species. It also lowers the harmful effects to the plants. Li et al stated that there will be high salt tolerance in the plants which are richer in polyamines. According to Bozk and Muttu et al, there are also certain observations that a significant measure of salt tolerance is the degree of Spm in plants (Li and He, 2012). In leaf tissues of sunflower plants, there is increased activity of total Spm on or below fifty, hundred and one hundred & fifty milli molar sodium chloride treatment along with the free or acid-soluble Spm. Mang et al along with the Benisadi et al, there is improved plant growth and resistance to salt stress when the plants are grown under

exogenously applied polyamine specially Spd & Spm. In an analysis of soybean seedlings (Wang and Bo, 2014) similar findings were obtained. Li et al develops a line of cucumber having more regulation of expressions of SAMDC and lesser expressions of ODC & ADC resulting in increased Spd and Spm accumulation and decreased salt stress accumulation of Put. Takaheshi and Liu et al stated that in the transgenic seedlings growing under salt conditions, there is the removal of inhibitory effects of such salt stress on the plants. Spm and Spd are impaired by a variety of metabolic pathways (Paul and Roy Choudhury, 2017). Sun et al. have demonstrated that together, salt tension in grape seedlings is alleviated by PAs and ABA (Sun et al., 2018a).

Oxidative Stress and PAs

In the oxidative stress of plants, polyamines play a dynamic function (Minocha et al., 2014). There will be much more activity of several enzymes in plants which are antioxidant in nature due to the polyamines. It will help to elevate the stress due to oxidation produced through several abiotic factors and can be efficiently controlled in plants. Kadiglu & Durmu stated that pretreated maize leaves with Spm & Put have shown greater paraquat-induced resistance to stress by oxidation. The putrescine content is substantially reduced while the Spm & Spd becomes more applied with the exogenous Spd under hypoxia stress in the roots of cucumber seedlings. These improvements were linked to increased activity of the antioxidant enzyme, better ability to scavenge ROS and less membrane lipid peroxidation, which eventually resulted in increased resistance to hypoxia stress (Jia et al., 2008; Wu et al., 2018).

CONCLUSION

Zinc is known to play an important role as a metal component of enzymes or as a functional, structural or regulatory co-factor of a large number of enzymes. Foliar Zn application in the primary grain filling period increased grain Zn content. Zn is taken in the form of Zn^{2+} by the roots of the wheat predominantly. In wheat, zinc is responsible for several physiological activities like activation of enzymes, synthesis of proteins and nucleic acid and metabolism of carbohydrate. It was reported that under the heat stress if zinc is applied it enhance and improve the ratio of chlorophyll fluorescence in zinc inefficient genotype. Polyamines are synthesized by the precursor S-adenosyl methionine (SAM), which is also a precursor of ethylene synthesis. Plant polyamines occur in actively developing tissues and are synthesized under stressful conditions, including their cell division, root formation, fruit establishment and ripening, defense mechanisms and embryogenesis. Due to the stimulating effect of polyamines on yield, polyamines are considered primarily as a new class of growth substances and are common for their anti-deteriorating effects due to their antioxidant properties and membrane stabilization ability.

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