

# Impact of salinity and zinc application on growth, physiological and yield traits in wheat

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**Globally salinity impairs the productivity potential of agricultural land. Apart from salinity, there are a number of factors responsible for the stagnation of wheat productivity. This problem is becoming acute day by day due to improper management of natural resources. Salinity has repressive effects on physiological characteristics of wheat. Soil salinity affects plant growth by creating water and ionic imbalance in the plant due to the presence of toxic ions. Salt-affected plants exhibit stunted growth and have darker leaf colour. Nutrient deficiency is another yield-limiting factor and this problem is aggravating gradually due to intensive cultivation, imbalanced and injudicious usage of fertilizers. The widespread deficiency of nitrogen and phosphorus is followed by Zn deficiency. Zinc is an important component of proteins and acts as a structural, functional or regulatory cofactor of a number of enzymes. Moreover, it plays a significant role in plant metabolism. Generally, the presence of excess salt decreases photosynthesis, total carbohydrate, fatty acid and protein, therefore, zinc has the tendency to offset the negative effects of salinity on plant growth.**

**Keywords:** Growth and yield, salinity, wheat, zinc.

In recent decades, cultivated areas have been badly influenced by ecological stresses such as salinity and drought in various parts of the globe, which suppress crop growth and productivity<sup>1</sup>. Soil salinization is a key factor leading to the loss of productivity of arable soils. Though hard to calculate precisely, the area under salinized soils is increasing, and this phenomenon is exceptionally extreme in irrigated areas. It was calculated that around 20% (45 million ha) of irrigated land, producing one-third of the world's food, is salt-affected<sup>2</sup>. Saline soil is formed when chlorides and sulphates of sodium, calcium, magnesium and potassium are copious in the soil. The USDA Salinity Laboratory describes saline soil as having an electrical conductivity of the saturation extract ( $EC_e$ ) of  $4 \text{ dS m}^{-1}$  or more. Apart from  $EC_e$ , pH and ESP (exchangeable sodium percentage) are also some of the quantitative parameters to define saline soil. It has pH value  $< 8.5$ , exchangeable sodium percentage (ESP)  $< 15$  and sodium absorption ratio (SAR)  $< 10$ . Salt accretion in the root zone causes development of osmotic stress and disturbs cell ion homeostasis by inducing both the inhibition in

the uptake of essential elements like  $K^+$ ,  $Ca^{2+}$  and  $NO_3^-$  and the accumulation of  $Na^+$  and  $Cl^-$  ions<sup>3</sup>. It is anticipated that these ecological stresses will turn more extreme and frequent in time to come. On the contrary, the world population is presumed to reach about 10 billion by 2050, which will experience grave food shortages<sup>4</sup>. Thus, the development of schemes to alleviate the adverse effects of ecological stresses have received significant attention. Salinity is one of the severe agrarian and environmental issues in arid and semi-arid areas which detrimentally affect crop growth and agricultural productivity<sup>5-7</sup>, thereby affecting 19.5% of irrigated and 2.1% of dry land agriculture at global scale<sup>8</sup>. Despite the fact that soil salinity occurred prior to the dawn of agriculture, the salinity problem in soils is currently increasing at an annual rate of 10% (ref. 2). Researchers have figured that more than 50% of the earth's cultivable land could be salinized by 2050 (refs 9-11). The total area of salt-affected soils across the globe is 932 m ha, of which 351 and 581 m ha is saline and sodic respectively<sup>12</sup>. In India total salt affected area is 6.74 m ha out of which 3.79 and 2.95 m ha are of sodic and saline soils respectively, whereas 0.49 m ha is the area affected by saline soil in Haryana. The maximum area under salt-affected soils is in Gujarat (2.22 m ha) followed by Uttar Pradesh (1.37 m ha).

Salinity is one of the most crucial abiotic stresses, which inhibits crop production in arid and semi-arid areas, as those contain adequate salt in the root zone to alter the growth of crops. Besides, low precipitation is inadequate for leaching these salts below root zone levels<sup>13</sup>. Excessive soluble salts in the root zone inhibit plant roots from withdrawing water from neighbouring soil, practically reducing the plant available water<sup>14</sup>. As a result, soil salinity has the capability to alter plant growth through higher concentrations of toxic ions present in the soil<sup>15</sup>. Specific ion toxicities are caused by the accumulation of sodium, chloride and boron in the tissue of transpiring leaves to damaging levels. Accrual of harmful ions might hinder photosynthesis and protein synthesis; inactivate enzymes, and injure chloroplasts and other organelles<sup>16</sup>. These effects are more critical in older leaves, as they have been transpiring the longest, so they accrue more ions<sup>17</sup>. The most influencing ions of saline soils are  $Na^+$  and  $Cl^-$  which affect the cell membrane by interaction, competition and selectable ion penetration and disorder

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on the absorption of macro and micro elements<sup>18</sup>. Salts damage cells of plants and inhibit their growth. The damage is because of different types of oxygen activation radicals that are toxic and activators for their cells<sup>19</sup>. The distribution of plants, their survival and productivity are distinctly influenced by salinity<sup>20,21</sup>.

Salt stress influences plant physiology of the whole plant besides at the cellular level, through osmotic and ionic stress which creates a physiological drought or osmotic stress by disturbing the water relations of the plant<sup>22</sup>. Generally, the cultivated plants are sensitive to salt-stress, in which sodium chloride (NaCl) causes a diminution in carbohydrates that are required for cell growth. Carbohydrates are synthesized largely through the process of photosynthesis and photosynthetic rates are generally lower in plants exposed to salinity and particularly to NaCl<sup>20,23</sup> and this would cause a restriction in water availability and imbalance in nutrient uptake by plants with inhibition in seed germination owing to ionic disturbance, osmotic and toxic effects. Ion exclusion, ion sequestration, osmotic regulation and membrane transport system adjustment to saline environments are principal strategies that may confer salt tolerance to plants<sup>24</sup>. Alloway<sup>25</sup> observed that zinc is a trace element required in small but critical concentrations and if the quantity available is not sufficient, plants will undergo physiological stress caused by the dysfunction of various enzyme systems and other metabolic functions in which Zn plays a part. Maischner<sup>26</sup> suggested that zinc is an indispensable constituent of over 300 enzymes. Zinc is known to have a crucial function either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a multitude of enzymes. Zinc is a basic component of a number of enzymes, i.e. dehydrogenase, isomerases, aldolase, proteinase, peptidase and phosphohydrolase<sup>27</sup>. A meagre amount of nutrients, especially Zn applied by foliar spray, enhances the yield of crop significantly<sup>28</sup>. Zinc fertilizer alleviates the adverse effects on physiological and biochemical parameters in sensitive and tolerant varieties of wheat genotypes in the saline soil environment. Soil salinity adversely affected the relative water content (RWC), transpiration rate, protein, carbohydrate and starch content but diffusive resistance increased significantly in the wheat genotypes at tillering and ear emergence stage<sup>29</sup>. Wheat is the most widely cultivated food crop of the world. In India, wheat is the second most staple food crop. In the light of the role of zinc application and salinity on growth and nutrient content in wheat, an attempt has been made to review the pertinent literature under the following headings.

### **Effect of salinity and zinc application on crop growth**

Abou-Hadid<sup>30</sup> revealed that crop reduction owing to salinity is, by and large, linked to the increase in osmotic

potential of the root-zone soil solution which results in certain physiological changes and a considerable decrease in productivity. Generally, wheat is classified to be moderately tolerant to salinity. Hasegawa *et al.*<sup>31</sup> demonstrated that the harmful effects of salinity on plant growth are coupled with: (1) low-water potential of the root medium which triggers water deficit within the plant; (2) toxic effects primarily of Na and Cl ions and (3) nutritional imbalance produced by decreased nutrient uptake and transport to the shoot. Munns<sup>32</sup> observed that soil salinity influenced plant growth by creating water imbalance in the plant and ionic imbalance due to the presence of toxic ions. Salt-affected plants exhibit stunted growth and have darker leaf colour. Higher carbohydrate and starch content in the salt-tolerant varieties KRL 19 and NW 1012 is probably due to better mobilization efficiency of carbohydrate and starch as a result of salinity<sup>33</sup>. Khoshgoftarmansh *et al.*<sup>34</sup> suggested that enhanced salinity in the soil solution, particularly increased concentrations of Na<sup>+</sup> and Cl<sup>-</sup> ions, considerably influences solubility, i.e. mobility of potentially toxic trace elements which are easily available to crop plant and negatively influence the growth and yield of a crop.

The deleterious effect of salt stress on plant growth mainly involves ion toxicity, osmotic stress and mineral deficiency<sup>20</sup> which suppress the plant growth and alter the several physiological processes including photosynthesis, transpiration rate, chlorophyll status and relative leaf water content (RLWC%)<sup>35,36</sup>. The increasing level of salinity up to 15.7 dS m<sup>-1</sup> augmented the uptake of sodium and chloride ions. The increased concentration of Na and Ca ions at the high salinity level ensued in the reduction of growth of the plant<sup>37</sup>. Soil properties and crop growth were adversely affected by salinity<sup>38</sup>. Munns *et al.*<sup>39</sup> observed that field conditions differ from location to location for soil salinity, physical and chemical soil characteristics. They also differ from season to season for temperature and drought, especially in dry-land agriculture, and directly influence the accrual of salts around the roots.

Mirvat *et al.*<sup>40</sup> reported that metabolism defect in plant cells is linked to zinc and phosphorus imbalance, therefore, by enhancing the concentration of phosphorus, zinc tasks are impaired at specific positions in the cells. Shoot growth is more affected than root growth. Harris *et al.*<sup>41</sup> reported an increase in wheat germination, emergence and seedling growth by increasing the application of Zn. The fact that foliar spray of Zn and Mn augmented values of germination parameters suggests that seeds with sufficient Zn and Mn supply can germinate and produce seedlings with improved ability to grow and endure any hostile ecological conditions. Hendawy *et al.*<sup>42</sup> showed that increasing soil salinity progressively decreased the vegetative growth characters, i.e. plant height, number of branches, fresh and dry weight of the same plants. The highest level of soil salinity (2500 ppm) caused the highest effect on vegetative growth characters. Moreover, the

increasing level of soil salinity up to 3000 ppm resulted in the complete death of the plant either treated or non-treated with zinc. Minakshi *et al.*<sup>43</sup> reported that almost 11% (39,369 ha) of the total geographical area of district Patiala (Punjab) was deficient in zinc; only 4% and 5% of the area was deficient in manganese and iron, respectively, which adversely affects the growth as well as yield of the plant. Aktas *et al.*<sup>44</sup> reported that Zn deficiency in soil significantly reduced the shoot growth, especially under the highest salt treatment. Increase in the zinc application from 2 to 10 mg kg<sup>-1</sup> soil decreased the shoot concentration of Na<sup>+</sup> and elevated the K<sup>+</sup> concentration. As a result, K/Na ratios of the plant were highest under the highest Zn application conditions. By affecting structural integrity and controlling the permeability of root cell membranes, sufficient Zn nutrition reduced excess uptake of the Na<sup>+</sup> by root in the saline conditions. It also indicates the protective role of high Zn supply against salt stress.

Simoglou and Dordas<sup>45</sup> noticed a significant variation in plant height of durum wheat (*Triticum turgidum* L. subsp. durum Desf.) by the foliar application of Zn and other micronutrients. Plant height was increased by 2 cm due to foliar application of Zn than in control. Goswami<sup>46</sup> reported an increase in grain and straw yield in addition to harvest index because of Zn fertilization which might be due to the fact that Zn plays a crucial role in the biosynthesis of indole acetic acid and the initiation of primordia for reproductive parts, on account of beneficial effect of zinc on metabolic reactions inside the plants. At the EC<sub>e</sub> 6 dS m<sup>-1</sup>, the growth of wheat at the boot stage decreased under both salinity levels of Cl<sup>-</sup> and SO<sub>4</sub><sup>2-</sup> irrespective of P level in the soil. At EC<sub>e</sub> 6 and 8 dS m<sup>-1</sup>, the growth of wheat under SO<sub>4</sub><sup>2-</sup> salinity was better than Cl<sup>-</sup> salinity particularly at 60 and 90 mg P kg<sup>-1</sup> soil<sup>47</sup>. Evelin *et al.*<sup>48</sup> concluded that higher concentrations of soluble salt in the soils of arid and semi-arid areas negatively influence the yield of crops and all major living processes like photosynthesis, protein and lipid metabolism are also affected by excessive salts in the soil. Kamrani and Ardalan<sup>49</sup> reported that the simple effect of cultivar on plant height showed that the mean height of Atrak cultivar was 58.1 cm and for Ghods cultivar was 50.9 cm. Increased level of applied Zn led to the increase in the mean height of two cultivars enhanced compared to the control, such as, in 10 mg kg<sup>-1</sup>, 20 mg kg<sup>-1</sup> and spray solution treatments the plant height was about 3.19, 5.07 and 1.31% more than control treatment respectively. Also, with increasing salinity levels, the plant height decreased.

Radi *et al.*<sup>50</sup> reported that the adverse effects of salinity stress were distinctly seen in wheat and bean cultivars treated with 160 mM NaCl. Rahman *et al.*<sup>51</sup> suggested that the foliar-applied nutrients improve more vegetative and yield components of wheat as compared to soil-applied nutrients. Moreover, it is very useful when roots are incapable of absorbing nutrients from the soil because of interference of several edaphic factors, for instance, low

soil temperature, lack of soil moisture and loss of nutrients owing to leaching. Therefore, foliar application can be viewed as a valuable practice for production of wheat. Foliar feeding of mineral nutrients at tillering, jointing, booting and various stages of the wheat crop has resulted in effective usage of nutrients and increase in yield.

### Effect of salinity and zinc application on physiological traits

Chougui *et al.*<sup>52</sup> observed that the least photosynthetic ability under salt stress conditions was because of suppression of chlorophyll synthesis or decrease in the absorption of minerals needed for chlorophyll biosynthesis. Kaya *et al.*<sup>53</sup> reported that micronutrients, for instance, Zn and Mn, have a structural function in chlorophyll. These nutrients can be easily sprayed on the leaf. Therefore chlorophyll concentration of leaves can be enhanced by micronutrient foliar application, which successively, increases plant height and yield. Moreover, zinc increased plant height by increasing internode distances, thereby playing a crucial role in biomass production. With the addition of NaCl, the net photosynthetic rate ( $P_N$ ), stomatal conductance ( $g_s$ ) and transpiration ( $E$ ) were reduced. Salinity increased leaf to the air temperature gradient ( $\Delta T$ ) in both genotypes of wheat, i.e. salt-tolerant (K-65) and salt sensitive (HD-2329). NaCl increases the activity of the superoxide dismutase (SOD) and peroxidase (POX); the increase in an increment is higher in salt-tolerant variety of wheat<sup>54</sup>. Muranaka *et al.*<sup>55</sup> observed that under salt (NaCl) stress, the rate of photosynthesis in wheat plants reduced in two stages. In the first stage, the photosynthetic reduction was sluggish without any apparent photochemical changes. Though, in the second stage, the photosynthetic decline was rapid and coupled with degeneration in the energy conversion efficiency in PSII. These researchers suggested that the salt-induced osmotic effect may induce a steady decline in photosynthesis owing to stomata closure under saline regimes. Nevertheless, an uptake and accrual of excessive amounts of Na<sup>+</sup> may at once affect the electron transport and cause a noticeable reduction in photosynthetic ability affecting the chlorophyll content. Hao *et al.*<sup>56</sup> observed that plants with zinc application have enhanced photosynthetic rate owing to the synthesis of chloroplast, increased synthesis of chlorophyll, oxidation of water at PS-II, and predominated activities of Calvin cycle enzymes, in addition to increased absorption of CO<sub>2</sub> as a result of stomatal opening and increased nutrient uptake. Alpaslan *et al.*<sup>57</sup> suggested that zinc has controlled mechanism or a regulatory role on the Na<sup>+</sup> and Cl<sup>-</sup> uptake and translocation rate. They also concluded that in the salt-affected soils, zinc application could abate possible Na<sup>+</sup> and Cl<sup>-</sup> injury in the plant. Salinity-induced reductions in P concentrations in plant tissues were often reported in research conducted in soil conditions.

Chen *et al.*<sup>58</sup> reported that zinc deficiency caused a drastic reduction in chlorophyll content in addition to severe damage to the fine structure of the chloroplast. The total chlorophyll content and other growth parameters such as plant height, plant fresh and dry weight and leaf area as well as N, P and K content were decreased as the salinity level increased and salinity effect can be reduced by zinc application and gave positive effect on plant growth parameters<sup>59,60</sup>. Cakmak<sup>61</sup> demonstrated from his study that foliar nutrition is an alternative when nutrient deficiencies cannot be corrected by the application of nutrients to the soil. Zinc also plays a significant role in the production of biomass. Moreover, zinc may be required for chlorophyll synthesis, pollen function, fertilization and germination. Salt stress decreases the chlorophyll content; however, the degree of reduction depends on salt tolerance of that plant. By and large, it is known that in salt-tolerant crops such as wheat, chlorophyll content increases, while on the contrary, it decreases in salt-sensitive species or crops under saline regimes or conditions<sup>62</sup>. Saeidnejad *et al.*<sup>63</sup> ascertained that salinity causes a significant reduction in chlorophyll *a* and *b* content. However, the activity of catalase (CAT), superoxide dismutase (SOD) and glutathione reductase (GR) increased as the salinity level was enhanced. Addition of zinc alleviated the significant enhancement of Na<sup>+</sup> concentration caused due to salinity.

Rani *et al.*<sup>64</sup> reported that under salinity there was a considerable decrease in dry weight of roots and micronutrient (Zn, Cu, Fe and Mn) uptake. The adverse effect of saline environment was ameliorated by Zn applications and for that optimum dose of Zn application in both types of salinity was 15 mg kg<sup>-1</sup> soil. Moreover, root dry weight and micronutrient uptake (Zn, Cu, Fe and Mn) have a negative interaction with increasing salinity and positive interaction with the increasing application of Zn. Bagayoko *et al.*<sup>65</sup> demonstrated an important method for enhancing P uptake which involves taking advantage of the symbiosis between the mycorrhiza and roots and, the former of which increases both the growth and resistance of plants exposed to drought, and also the uptake of P, Zn, Cu, Mn and Fe. Wheat with different levels of zinc influences the concentration of micronutrients (Zn, Cu, Fe and Mn) in several parts of the plant and it was also observed that the zinc content in various parts of wheat increased with increased levels of zinc application<sup>66</sup>. El-Fouly *et al.*<sup>67</sup> observed that foliar spraying of micronutrients may somewhat counteract the negative effect of NaCl on nutrient uptake by improving root growth and preventing disorders and as a result, caused an increase in the uptake of nutrients by the roots. Hu and Schmidhalter<sup>68</sup> reported that salinity stress also induces ion deficiency or imbalance owing to the competition of nutrients, for example K<sup>+</sup>, Ca<sup>2+</sup> and NO<sub>3</sub><sup>-</sup> with the toxic ions Na<sup>+</sup> and Cl<sup>-</sup>. The higher K<sup>+</sup>:Na<sup>+</sup> will also improve the resistance of plant to salinity. Calcium is a key signal

messenger for regulating plant resistance to salinity, the competition between Cl<sup>-</sup> and NO<sub>3</sub><sup>-</sup> under saline conditions means that the form of N plays a crucial role in deciding the growth of salinized plants.

Tabatabaei<sup>69</sup> observed that under saline conditions nutrient absorption is constrained by lack of nutrients and low water potential in the rooting medium. The results are in conformity with those reported by Murat *et al.*<sup>70</sup> who stated that application of NaCl caused a reduction in N, K, Zn and other micronutrient concentrations. Such an effect may be ascribed to the effect of salinity on nutrient absorption. Abd-El and Hady<sup>71</sup> examined the effect of zinc application on growth and nutrient uptake of barley irrigated with saline water and stated that Zn content of the fresh and dry weight enhanced with increasing Zn rate at various salinity levels as compared to control and the amount of nutrient elements significantly decreased by increasing salinity. Chang *et al.*<sup>72</sup> demonstrated that zinc mobility and uptake in soil is dependent on various factors, for instance soil acidity, zinc total value in the soil, organic matter, soil type and phosphorus levels in the soil. The most important factor which affects zinc usability is the soil pH. The yield of wheat increased from 3.40 to 4.35 t ha<sup>-1</sup> and Zn uptake increased from 142 to 256 g ha<sup>-1</sup> with long-term application of crop residues together with Zn by using appropriate rates, methods (soil) and sources (such as ZnSO<sub>4</sub>). Although there are several sources of Zn, the most common source of Zn remains ZnSO<sub>4</sub> (ref. 73). Saeidnejad *et al.*<sup>63</sup> reported that potassium content was increased by Zn treatments. A considerable increase was noticed in leaf Zn concentration as the applied level of Zn was increased. By and large, the results suggest some positive and negative interactions of salinity and Zn application, which could be useful in the management of saline soil and water.

### Effect of salinity and zinc application on crop yield attributes

Tuna *et al.*<sup>74</sup> suggested that shoot and root growth inhibition is a common response to salinity. Plant growth is one of the most crucial agricultural indices of salt stress tolerance as suggested by certain studies. The dry matter yield of root and shoot systems of the crop showed a noticeable decrease as salinity levels increased. Salama *et al.*<sup>75</sup> observed that with every increase in saline water levels of 2000 ppm the negative effect on total yield is assigned to the adverse effect of salinity on leaf area, total chlorophyll content, NPK content in leaves and fruit setting which may consequently lead to reduced total yield. Morschedi and Farahbakhsh<sup>76</sup> observed that yield components, grain yield and protein content of the two genotypes (Line no. 4 and Backcrossroshan) increased linearly as the levels of K × Zn interaction treatments increased. Line no. 4 produced 1000-grain weight, the weight of grains per ear and grain yield greater than Backcrossroshan

by 17, 30 and 23% respectively. Moreover, a significant relationship between grain weight per ear and grain yield was observed. As a result, line no. 4 is more productive under salinity and alkalinity of soil and water.

Micronutrient application significantly affected plant height, number of spikes per plant, number of grains per spike, 1000-grain weight, grain yield, biological yield and harvest index. Application of micronutritious elements especially manganese, zinc and iron alone or in a combination of manganese and iron significantly increased yield and yield components. Therefore, it can be concluded that micronutrient application had a positive effect on wheat growth and yield<sup>77</sup>. As the application of Zn increases, the concentration of Zn in the shoots and grains increases significantly. Grain protein was decreased by salinity, while the utilization of grain protein enhanced and finally improved the growth and yield of wheat by decreasing the effects of salinity, therefore the addition of Zn helped in reducing the unfavourable effects of increased salinity tolerance of wheat to salinity<sup>78</sup>. Keram *et al.*<sup>79</sup> observed that the treatment with 10 kg Zn ha<sup>-1</sup> was statistically at par to 20 kg Zn ha<sup>-1</sup> in grain (4.62 t ha<sup>-1</sup>) and straw (5.42 t ha<sup>-1</sup>) yield and harvest index (46.07%). The lowest grain (3.88 t ha<sup>-1</sup>) and straw (4.76 t ha<sup>-1</sup>) yield in addition to harvest index (44.97%) was registered in control. The treatments consisting 1.25, 2.50 and 5 kg Zn ha<sup>-1</sup> were at par with control in grain and straw, correspondingly, whereas the harvest index was inferior and nonsignificant with all the treatments.

Khoshgoftar *et al.*<sup>80</sup> observed that growth and yield of wheat plants significantly decreased with increasing NaCl rate and Zn application increased dry weight yield at different levels of salinity. Application of Zn fertilizer somewhat counteracted the negative effects of salinity on plant growth. Amador *et al.*<sup>81</sup> found that biomass declined more severely at 170 mM NaCl compared to 85 mM NaCl in all groups of cowpea genotypes and diminished as salinity increased. Ali *et al.*<sup>82</sup> concluded from the experiment that solutions of zinc, boron and zinc plus boron were used as a foliar spray, each applied at tillering, jointing and boot stage. A significant increase was noticed in the number of spikes per metre square, grains per spike, thousand-grain weight, biological yield and grain yield for foliar application of zinc and boron in comparison to both control treatments. In India, 10% yield loss is reported due to the omission of Zn fertilization<sup>83</sup>. Khan *et al.*<sup>84</sup> accomplished a field experiment to test the response of wheat to market available micronutrient application 'Shelter' (zinc = 2%, iron = 1%, manganese = 2%, copper = 1%, boron = 1%). Shelter treatment significantly increased the number of grains per spike, 1000 grain weight, straw yield, grain yield, biological yield and harvest index at various growth stages of wheat. Lastly, the commercially available foliar application may be beneficial to improve the growth as well as yield of wheat. Yassen *et al.*<sup>85</sup> executed experiments to

study the response of wheat, its yield, and growth to foliar spraying with (1%) urea and different applications of micronutrients (Fe, Zn and Mn). The results showed that foliar spray of 1% urea gave significantly higher 1000-grain weight whereas the interaction effect of micronutrients spraying and 1% urea revealed affirmative results on all the attributes and showed a significant increase in grain and straw yields.

Lu *et al.*<sup>86</sup> observed that the joint application of P and Zn enhanced the diethyltriaminepenta acetic acid-Zn and loose organic matter bound Zn; however, the increase becomes smaller as the P fertilizer application rate increased. The addition of Zn fertilizer to Zn-deficient soils can increase or improve the nutritional attributes of wheat grain, grain Zn concentration and biodiversity. Bameri *et al.*<sup>77</sup> showed in his experiment that micronutrient application significantly affected plant height, number of grains per plant, number of grains per spike, weight of 1000-grains, grain yield, biological yield and harvest index. Srinivasarao and Rani<sup>87</sup> observed that the foliar application of Zn is the significant preventive measure of Zn deficiency symptoms in crops and has a substantial effect on yield and quality of production. Soil and foliar application in conjunction with organic manure (FYM, incorporation of green leaf manuring, composts, tank silt, etc.) are efficient in ameliorating Zn deficiency disorders. Screening of cultivars of most of the crop species for Zn efficient strains decreases the necessity for Zn fertilizers.

## Conclusion

Salinity is a major abiotic stress that reduces and endangers agricultural productivity in various parts of the globe. Salinity has inhibitory effects on physiological aspects of wheat which impair the growth and yield of the crop. Zinc application can increase both quantitative and qualitative traits of wheat when applied properly. Also, zinc application reduces the negative effect of salinity on crop growth and yield. From the literature, it is evident that combination of salinity and Zn caused a broad range of physiological response in wheat plants, which alleviate the detrimental effects of stress and these outcomes might be regarded as a nutrient management tool, particularly for plants under salinity stress.

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