Effect of Biofertilizers (Fe and Zn) on the Growth of Agronomic Crops

[1]*Aftab Ahmad Sheikh, [2]Muhammad Hafeez Javed, [3]Muhammad Adnan Rafique, [4]Shahid Munir, [5]Muhammad Tahir Akbar, [6]Abdul Waheed, [7]Fareeha Akram, [8]Muhammad Asif, [9]Nadia Manzoor, [10]Irfan Ahmad Saleem, [11]Faraz Ahmad, [12]Saima Nazar, [13]Sammia Ghazanfar,
[1*]Soil and Water Testing Laboratory for Research, Gujranwala-52230, Punjab.
[2]Soil and Water Testing Laboratory Okara-56181, Punjab, Pakistan.
3Pesticide Quality Control Lab, Kala Shah Kaku-39350, Sheikhpura, Punjab.
[4]Pesticide Quality Control Laboratory Multan-60000, Punjab.
[5]Office of the Senior Scientist Soil Fertility (Field), Multan-60000, Punjab
[6]Soil and Water Testing Laboratory, Rawalpindi-46000, Punjab,Pakistan.
[7]Soil and Water Testing Laboratory, Nankana Sahib-39100, Punjab,Pakistan.
[8]Soil and Water Testing Laboratory, Bahawalnagar-62300, Punjab, Pakistan.
[9]Regional Agricultural Research Institute Bahawalpur-63100, Punjab Pakistan
[10]Soil and Water Testing Laboratory, Mandi Bahauddin-50400, Punjab, Pakistan.
[11]Soil and Water Testing Laboratory, Sargodha 40100, Punjab, Pakistan
[12]Soil Fertility Section, Gujranwala-52230, Punjab, Pakistan
[13]Department of Soil Science, The Islamia University Bhawalpur-63100, Pakistan.
***Correspondence Author**: aftabas@yahoo.com

Abstract
Individual malnutrition is a worldwide problem that mostly affects people whose diets (often of plant origin) are deficient in essential vitamins and minerals. Low levels of micronutrients in plants are associated to declining soil concentrations and/or low bioavailability, as well as the presence of abiotic stressors that disrupt plant growth and development. Agronomic biofortification of crops is a promising technique to increase the concentration of micronutrients in edible sections of crops without sacrificing production, and it is often regarded as the most cost-effective strategy for addressing hidden hunger around the world. The focus of the study is on the elements that influence the efficacy of biofortified crops (a type of application, form, and a dose of applied microelement, biofertilizers, and nano fertilizers). The accumulation of zinc, and iron in edible sections of plants, their impacts on metabolism, morphological, and yield parameters, and their impact on plants' defense mechanisms against abiotic stress such as salt, high/low temperature, heavy metals, and drought were also studied. Finally, future agronomic biofortification research directions are suggested.

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Introduction

It is well understood that (iron) Fe and (zinc) Zn are required for wheat growth and yield, and that they have a significant impact on photosynthesis, chlorophyll production, hormone biosynthesis, carbohydrates, enzyme activation, and the production and scavenging of reactive oxygen species (ROS) and osmoprotectants (Seyed Sharifi et al., 2020). The concentration of bioavailable Fe in naturally occurring hydroxides, oxyhydroxides, and oxides in the rhizosphere is exceedingly low

(Zandi, P et al. 2022). As a result, Fe insufficiency could be avoided by choosing microbial populations that help plants maintain their Fe status. Despite the widespread usage of Zn and Fe fertilisers, the effects of these fertilisers on crop production and quality are dependent on the forms and techniques of fertiliser administration (Mahmood et al2021). The right fertiliser is critical for maximum yield, which can be achieved through a variety of positive and environmentally friendly strategies such foliar treatment and nanopartic (Kolbert et al.2022). These methods increase soil fertility and crop output, as well as nutrient uptake and translocation, resulting in lower fertiliser usage (Rebi et al.2021a). Foliar fertilisation has the benefits of uniform distribution, low application rates, and rapid plant response to nutrients provided. Furthermore, nanoformulations of micronutrients could be applied foliarly for improved foliar uptake and concentration reduction (Niu et al.2021). Because it causes the progressive release of Zn and Fe across a wide pH range, nano Zn-Fe fertiliser can be employed as a rich supply of micronutrient for plants. At the nanoscale, most compounds' chemical and biological activity increase (Ondrasek et al.2022). The nanoparticles penetrate the cells and travel through plasmodesmata from one cell to the next. Following nano-zinc oxide spraying, various investigations revealed changes in physiological characteristics as well as enhanced plant output. Plant growth-promoting rhizobacteria (PGPR) are also utilised in addition to these strategies to improve plant development in normal and drought conditions (Ashry et al.2022). Plant growth and development can be aided by PGPR through both direct and indirect methods. Direct growth promotion occurs when the bacterium uptakes nutrients from the soil environment or provides beneficial compounds to the host plant synthesised by the bacterium (Rebi et al. 2022b). Indirect growth promotion occurs when the bacterium induces systemic resistance (preventing or reducing some of the harmful effects of plant pathogens), and direct growth promotion occurs when the bacterium uptakes nutrients from the soil environment or provides beneficial compounds to the host plant synthesised by the bacterium. Seed priming using PGPR increased wheat growth and biomass, and demonstrated excellent antioxidant enzyme activity against saline and water deficiency conditions, according to earlier findings. Under stress conditions, researchers discovered that bacteria inoculation increases sugars, proline, chlorophyll compounds, and the relative water content of triticale (Gamalero et al.2022). It is hypothesised that using nanofertilizers and biofertilizers together could boost wheat output by improving physiological and stress responses during drought stress. A greater understanding of wheat physiological responses and antioxidant status should aid programmes aimed at increasing grain yield in water-stressed environments. As a result, the goal of this study was to see how nano Zn and Fe, as well as bio-fertilizer, affected wheat physiology, antioxidative response, and yield.

Micronutrients

World health report recognized Fe, Zn and vitamin A deficiencies causing severe health issues throughout the world population (WHO, 2000). However, deficiency in world is not reported by WHO but here it is integrated, because it plays a significant function in bio-fortification approaches and in child growth. Purposes of supplementary micronutrient (minerals, Ca, Se and fluoride as well as vitamins D, C and B) are only to introduce their significance to world population but not discussed here are. Enhancement in bioavailability of iron, zinc, carotenoids, pro-vitamin A, iodine and Se in eatable part of numerous most important staple food crops and its genetic potential has been reviewed in recent times (Grusak, 2002; Graham, Welch & Bouis, 2001).

Above one 3rd worldwide population is infected from anemia; partly more than 50% of it caused by Fe deficiency. Iron is a redox-active portioning catalytic place of non-heme and heme proteins of Fe. Deficiency of iron negatively affects the learning capacity, cognitive physical growth, resistance against infection, off springs and production. Kids birth from anemia infected mothers have small iron storage that require more Fe concentration than they received from breast milk and suffer from reduced growth (WHO, 2001). It is reported that annually 800,000 deaths are caused by Fe (McLean et al. 2001).

Zinc (Zn) concerned with RNA and DNA creation and is a part of several enzymes containing Zn that are dangerous to cellular enlargement and differentiation. Whereas, low to moderate Zn deficiency is ordinary in all over the world population (Sandstead, 1995). Zinc deficiency attributes to impaired growth development, skeletal abnormalities, poor functioning in immune system, improved mortality and complex pregnancy results. Zn deficiency is directly linked to important reason of child death (by the harshness of diarrhoeal episodes) (WHO, 2004). World Health Organization and FAO recommended zinc fortification for body health (Allen et al. 2006). Zinc application approach for zinc bio-fortification is normally recommended to improve grain zinc contents and Zn bioavailability (Hussain et al. 2012a).

Vitamin A belongs from a C_{20} carotenoid group, which play a vital function in immune system, vision, epithelial cell growth, bone development, protection of the surface linings of the eyes, reproduction, embryonic improvement, and adult genes regulation. Night blindness is an early indication of vitamin A deficiency. Structural changes of the cornea and the conjunctive away appear and later swelling and disease results in permanent blindness. Depression of the immune system enhances the harshness of diarrhoea and measles. It is reported that about 127 million children are adversely influenced by vitamin A deficiency. (Jones et al. 2003).

Iodine is an important nutrient for human body functioning (Andersson, 2005) being concerned with production of thyroid hormones. For adults the recommended dietary allowance (RDA) is 150g iodine per day (Pearce, 2004). Hypothyroidism is called chronic iodine deficiency cause growth injury, cretinism, hearing loss and numerous kinds of brain destructions (Andersson, 2005). However, iodine shortage can be managed, but it is a health issue for about 35 % of the global population (Pearce, 2004; Winger, 2008). Iodized salt is used as iodine supplementation to reduce iodine deficiency (Delange and Lecomte, 2000).

Importance of Zinc and Iron in wheat

Development of human physical condition by raising the Fe and Zn concentration in cereal crops is a foremost world population challenge (Welch & Graham, 2004). According to Hotz & Brown, (2004) one-third global population is influenced by Zn deficiency, ranged between 4 to 73 % in various countries.

Deficiency of Zn in plants and soil is worldwide issues observed in numerous countries (Si Seilsepour, 2007). In developing countries cereals provide a chief tool of protein and minerals. For instance, in West Asian and Central Asian states, wheat gives about fifty percent of the calorie ingestion on daily basis (Cakmak, Tourn et al. 2004). According to Bybordi & Malakouti, (2003) wheat is not responsive to zinc deficit soil, but less responsive to iron dearth. When wheat is grown on Zn deprived soils, Wheat shows Zn deficiency in grain. On the base of a range and survey reports, the mean strength of Zn in wheat grain in different regions ranges 20 to 35 mg kg^{-1} (Seilsepour, 2007).

In most of the seeds Fe and Zn is placed in the aleurone layer and in embryo, whereas the very little amount of Zn contents is present in endosperm (Ozturk et al. 2006). The embryo and aleurone parts also have high concentration of protein. The parts, aleurone and embryo of wheat seed that are rich in Zn are detached during milling process that cause reduction in flour Zn concentrations. This difficulty becomes more complex when Fe transfers in protein storage vacuoles (PSVs) (Regvar et al. 2011), where it attaches to phytate by which its availability to human reduced.

According to Rashid and Fox, (1992) zinc deficiency is 3rd severe problem of crop nutrition after P and N deficiency. According to sillanapaa, (1990) almost 50 % samples of soils that were collected from 25 countries indicate Zn deficiency. This deficiency problem can be solved by using mineral fertilizers that has not become within the approach of farmer. In this view, expansion of crop varieties having ability to grow in nutrient deprived soils is significant tool for enhancing crop yield.

Therefore bio-fortification of grains in cereal crops with Zn and Fe is main concerning area of research (Bouis, 2003; Stein, 2007). Bio-fortification is a method to improve the nutritional value in foods of living beings those suffer from hidden hunger (Bouis, Hotz, McClafferty, Meenakshi & Pfeiffer, 2011).

Zinc and Iron application on food crops through foliar

Iron (Fe) application on soil is thought to have slight or no effect on iron contents of grains (Narwal, 2010). Thus, lot of the efforts has been done to recognize the effects of foliar application on Fe increase in grains. (Shukla & Warsi, 2000; Zeidan, 2010).

Foliar application indicated maximum raise of zinc contents in grain than soil application in both durum and bread wheat (Zhang, 2010).

Wisal, (1990) performed pot research and evaluate the application effect of Zn applied through foliar and soil application techniques on uptake of Zn and wheat yield. Grain yield and dry matter improved significantly by using these methods of Zn application. The higher concentration of total Zn uptake by grain and wheat straw was observed where Zn was applied by foliar method.

Soomro, (2000) reported the influence of boron and zinc fertilization on production of seed cotton. Results explained that both Zn and B both increase the seed cotton yield and its components. Rashid and Rafique, (2000) checked the response of cotton against fertilization. They choose 15 dissimilar places to perform their trail and they detected improved response of Zn on cotton. These experiments were performed in a field of farmer.

Deficiency and toxicity of grapevine nutrition cause reduced grape production and unstable vine growth. Mineral fertilization also plays significant role in fruit quality and yield. An experiment was performed in Slovenian wine growing region to examine the effects of soil or foliar fertilization containing iron and Mg on the contents of Fe, Zn, K and Mg in the grapevine's leaves. In duration of 2-years of evaluation (2008-09) with seven dissimilar treatments of fertilizers (including control) results indicated that fertilizers application of K decreased magnesium uptake nearly half as compared to controlled vines. On the other side, application of Mg with iron had similar effect on accumulation of Zn contents in the leaf and soil Zn uptake. Furthermore, foliar application of iron fertilizers improved Fe levels in blades. (Brataseve et al. 2013).

Application of Zn and Fe on soil

Microelements are important nutrients for plant development that are required in trace amount (Fageria, 2007). If these nutrients are not presented adequately, plants will experience physiological stresses cause incompetence of numerous metabolic functions and enzymatic systems. Various responses were evaluated regarding productivity and growth in crops species against micro elements deficiency (Fageria, 2009). Trace elements contents in various plant organs are associated with plant development stage, mobility and accessibility of micronutrient. These can be replaced from the root, stem and leaf into seeds (Waters & Sankaran, 2011). Micro elements captured by the roots and displaced from vascular systems to further plant parts. A significant variability can be observed in movable ability of trace elements in soil (Page & Feller, 2005). Fe, Zn and Mn are positive ions that need to be replaced from the soil solution to various organs of plant. Micronutrients ssupply into different organs of plant is influenced by genotypic attribute (Moraghan et al. 2002). Furthermore, this procedure is affected by situation of soil and plant (Paschke et al. 2005). There are associations between plant and soil that show antagonistic and synergistic effects. (Alloway, 2004; Ghasemi et al. 2003).

Zinc application on soil resulted in 60 to 250 percent and 20 to 90 percent improvement in grain zinc contents in durum wheat (*Triticum durum* L.) and bread wheat (*Triticum aestivum* L.) respectively (Stomph, 2011).

Small concentration has been given to evaluate the effect of long-term fertilization on barley grain production in non-contaminated soil. In 2010, they observed contents of nutrients in grain and yield of spring barley in three treatments, control (unfertilized), in application of synthetic fertilizers and in combinations of farmyard manure with synthetic fertilizer. The results indicated that in the control treatment and in combination of farmyard manure with synthetic fertilizers treatment, the grain yield ranged from 4.03 to 9.74 ton per ha. There was an encouraging effect of fertilizer application on contents of N, P and K whereas, no effect on contents of Ca and Mg. In spite of Fe, contents of micro elements (zinc and copper) and danger elements (Ar, Cd, Cr, Ni, Mn & Pb) were not considerably affected by the fertilizer treatments. Long-term use of inorganic and organic fertilizers with suitable rates does not represent any hazard for infectivity of barley grain by danger elements on metal non-contaminated and mineral containing agricultural soils (Hejcman et al. 2013).

Zinc-Iron associations and zinc over supply were evaluated in corn (Zea mays L. var. Barbecue hybrid) that was grown by hydroponic technique. Root and shoot fresh weights, improvement of iron greatly but not absolutely and normal growth is greatly reduced by Zn toxicity. After the analyses of leaf and roots, results revealed that Control plants were healthy and green and indicated significant lateral root growth. But with Fe held at 1.4 mg/l, when Zn increased, toxic symptoms were appeared: reduced plant height, stunted lateral root growth, and chlorosis in new growth. Increasing Fe constantly, Zn increased to lessen the chlorosis but had only a minor effect. Results also revealed that Zn/Fe ratios of shoot and root enhanced with improving Zn nutrient and decreased with improving Fe nutrient. Considerable positive association appeared between root zinc and Zn nutrient, leaf Zn and nutrient zinc, and leaf zinc and root Zn and also between root iron and Fe nutrient, leaf Fe and iron nutrient and leaf Fe and root Fe. Iron and Zn concentrations recommended that Zn may hamper with the uptake and translocation of iron; however, Zn over supply was not related with a deficiency of leaf Fe content. The chlorosis in plants with Zn toxicity is not related with leaf that is deficient in Fe contents. Though, this chlorosis occurs due to increased iron nutrient. Zinc and iron nutrients do interrelate at a few sites. (Rosen, Pike & Golden, 1977).

In main tomato growing sites of Sindh an experiment was performed to judge the status of soil micronutrient and related tissues of plant. Multiple plant and soil samples were taken from 32 foremost growing sites of Taluka Badin to analyze iron (Fe), copper (Cu), manganese (Mn), boron (B) and zinc (Zn) with preferred physico-chemical characteristics of soils. Most of the soils (81 %) had clayey texture whereas sandy and silty clay texture were (13 %) and (6 %) respectively. Data of EC indicated that 80 percent were non-saline soils and 20 percent were slightly saline soils. The soils poor in O.M and alkaline in nature have high concentrations of extractable Cu, Fe and Mn were sufficient in all soils. While extractable zinc in soil and B in hot-water soluble values varied in a various way. Sixty six percent soils were low, twenty eight percent marginal and six percent were sufficient in soil Zn. Ninety one percent samples were low and nine percent were sufficient regarding B. The results of plant analysis indicated that 19 % samples were high in copper and 81 % samples were sufficient in Cu, all samples were high in iron. While, ninety four percent samples were sufficient with Manganese samples and 6 % samples were low. Zinc analysis of plant revealed that 53 % samples were high and 25 % were low in zinc supply. The association of plant and soil nutrition status was greatly significant. It is accomplished that application of micronutrients fertilizer with organic manures may be integrated with fertilization program. (Memon et al. 2012).

Zinc and Iron toxicity in plants

Zinc toxicity is controlled by pH by controlling the contents of Zn in solution. Whitehead, (1987) elevated that the contents of zinc cause toxicity in plants (Daviscarter & Shuman, 1993). The common symptoms of zinc toxicity are chlorosis, dead leaf tips, stunting of shoot, rolling of young leaves and curling of leaves. Zinc overload have effects on germination, root growth, reproductive growth, physiology and morphology of plant. Zinc is an important nutrient for plant development, while high concentrations revealed toxicity and growth inhibition.

Baker, (1978) documented that the seeds of Silene maritime were germinated fastly on solution of calcium nitrate with dissimilar concentrations of Zn.

Iron (Fe) as an important constituent for all plants which pays vital biological contributions in the chlorophyll biosynthesis, photosynthesis, chloroplast development. Iron (Fe) is a foremost ingredient of the cell redox systems like iron, sulfur (S), proteins including superoxide disumutase (SOD) and heme proteins counting leg hemoglobin, peroxidase, catalase and cytochromes (Marschner, 1995). However, the majority of mineral soils are loaded with iron. The symptoms of Fe toxicity in leaf tissues appears under flooded situation (Becker & Asch, 2005). The iron toxicity in plants appear due to elevated Fe_2 uptake by roots and its distribution to leaves. The free radical created due to high Fe_2 that destroy cellular arrangement permanently and damage DNA, proteins and membranes. Reduction of plant photosynthesis causes Fe toxicity in canola, tobacco and in soya bean and the increase in ascorbate peroxidise activity and catalase.

Audu and Lawal, (2006) conducted an experiment to determine the concentrations (mg/Kg) of Zn, Co, Cu, Cr, Fe, Mn, Ni and Pb in seven separate vegetables which were taken from irrigation gardens of sharada, Jakara, kwakwachi in the Kano metropolis with the help of Atomic Absorption Spectrophotometer (AAS). Samples were taken during rainy and dry seasons. The results revealed the relative abundance of metals in vegetables in following order Fe > Zn >Mn> Cu > Ni >Pb> Co > Cr. The average levels of metals observed ranging from 0.34 mg kg^{-1} Cr to 27.35 mg kg^{-1} Fe. Decreased metal levels ranged from 8.25 % Fe in onion to 45.19 % Ni in Okra were reported in rainy season samples over dry season.

In water flooded soils, though, iron availability enhances and can attain toxicity level. Rice is an imperative food crop throughout the world and have Fe excess or shortage, relying on the growth environment. Experiments were performed to the investigate mechanisms concerned with response to iron shortage and resistance to Fe surplus with rice cultivars BR-IRGA 409 (susceptible to Fe toxicity) and EPAGRI 108 (resistant to Fe toxicity) grown in culture solutions. Results indicated lower Fe concentrations in E108 plants than I409 plants when exposed to excess Fe. PlantsE108 appear to make use of the avoidance mechanism in the resistance to Fe toxic plants whereas I409 appear to be affected directly by Fe toxicity. Furthermore, resistant to iron toxicity, E108 plants appear to be more capable in suggesting iron deficiency responses (Silveira et al. 2007).

Metal susceptible plants when exposed to metals, show many constraints in getting the reproductive stage. plant species growing on soils having high concentrations of heavy metal indicated concentrations of metal in trace amount. The expression "heavy metals" means that any metallic constituent that is poisonous or toxic even at little concentration and has high density (Lenntech , 2004). "Heavy metals" is a broad communal term, which used for the set of metals and metalloids having atomic density more than 4 g/cm^3, or five times, greater than water (Hawkes, 1997). Heavy metals comprise of iron (Fe), lead (Pb), cadmium (Cd), nickel (Ni), chromium (Cr), cobalt (Co), zinc (Zn), arsenic (As), platinum (pt) and silver (Ag) elements. (Farlex Incorporated, 2005).

Few heavy metals (Fe, Cu and Zn) are necessary for animals and plants (Wintz et al. 2002). The heavy metals availability in soil varies, and metals for example Co, Ni , Fe, Mn, Zn, Mo and Cu are fundamental microelements whose excess accumulation to the plant represents toxic effects (Monni et al. 2000). Because these elements are present in trace amount in environment so they are also called as trace elements.

Indian village (Mahal gaon) is the main dealer of vegetables in Nagpur market. Majority of the formers of this village are busy in vegetable farming. Each and every farm of this area is irrigated by highly polluted water of the Nag River that contains huge number of heavy metals. The objective of this study was to check the accumulation of heavy metals (Pb, Mn, Fe, Ni, Cu and Zn) in Soil, Water and Vegetables irrigated by water of Nag pur River and to assess the amount of accumulation of the heavy metals by the various vegetables. In this trail five farms were chosen in the Mahal gaon area. Every farm was located near the reservoir of Nag River. The samples of soil, water and vegetables were taken according to grab method. The number of heavy metals (Cu, Mn, Fe, Zn, Ni, Pb) were detected with the help of Atomic Absorption Spectrophotometer (AAS). The results indicated that the Zn and Fe contents in the soil samples were very high compared to the FAO/WHO highest allowed limits whereas the Mn and Cu contents were faintly above the permissible limits. The amount of nickel and lead were lower than the finding limits in soil. In water the contents of Iron and zinc were maximum while concentration of Ni and Pb were minimum. In case of vegetables, the contents of metals were higher than the allowed limits FAO/WHO. Transfer rate in the soil-plant of heavy metals indicates the following sequence: TFZn>TFFe>TFCu> TFNi>TFMn>TFPb. **(**Mahakalkar et al. 2013)**.**

The concentrations of heavy metals (Iron (Fe), Lead (Pb), Zinc (Zn), Copper (Cu) and Cadmium), were evaluated in four samples of different vegetables by means of atomic absorption spectrometer. The average values of heavy metals ranged between 0.071 mg kg^{-1} Pb to 0.632 mg kg^{-1} Cu. The order of concentration of heavy metals in vegetables is following copper (0.483 mg kg^{-1}) > Zinc (0.268 mg kg^{-1})> iron (0.260 mg kg^{-1}) > lead (0.095 mg kg^{-1}). The concentrations of these heavy metals were under the FAO/WHO suggested limits for vegetables. Small contents of lead and lack of cadmium in samples of all vegetables were indicated that these plants donate low toxic effects of heavy metals. The results indicated these vegetables as the central sources of fundamental elements (Shuaibu et al. 2013).

Zinc resistant varieties of Silene vulgaris were stimulated by improved levels of zinc, not only in seed production but also in vegetative growth (WHO, 1998). Zinc however a necessary nutrient for plant growth and development, indicated toxicity symptoms at elevated concentrations (Baker, 1978). Zinc toxicity was noticeable in root structure mainly in root blunt, and caused control on both cell elongation and cell division. Pearson and Rengel, (1995) reported that zinc concentration in roots decreased with age of plant. Sresty and Madhava Rao, (1999) concluded on the base of transmission electron microscopy (T.E.M) that radicle elongation was negatively affected more than plumule extensions.

Zinc and Iron uptake and transport

The root-soil boundary is the initial and most significant obstacle which affects Zn uptake (Welch & Graham, 2002). The Zn accessibility in the rhizosphere must be enlarged to enhance uptake of Zn by roots (Welch, 1995), which can be achieved by increasing discharge rates of H^+ from root cells. Zinc transportation in plants occurs via both the phloem and xylem.

It is generally understood that most Zn is transferred simplistically from root to the xylem, (Zelko & Lux, 2007). Zinc can be taken up from root cell membrane in the form of Zn-phytosiderophore complex or in the form of Zn^{2+}. Aplenty of proteins is enclosed by cytoplasm of plant cell that attach Zn^{2+} (Broadley, 2007).

Iron (Fe) is the 4th most plentiful constituent in the earth. The iron concentration in the soil is ten thousand times larger than plant life grown in soil but up till now iron deficiency is ordinary in plants. This irregularity is caused by low availability of Fe particularly at high soil pH in the existence of oxygen. Iron in the soil is only solubilized by reducing soil pH with the help of product of ferric iron [Fe (III)] and/or by reduced form of Fe (III) (ferrous iron Fe (II)). The strategies used by plant roots to access iron exploit each of these chemical options but the mechanisms vary between species in such a way as to divide the plant kingdom is divided into two categories (Strategy I and Strategy II plants) based on the mechanism occupied by plant roots for iron uptake. The 1st group is the dicotyledonous plants together with the non-gramineous and 2nd group includes Gramineae (Marschner, 1995). In Strategy I plants mechanism, soluble reductants and Fe binding ligands excreted which are usually phenols. All of these changes are planned to solubilize iron by each of the mechanism described. Strategy II plants release non-protein amino acids called Phyto siderophores (PS). The latter expression suggested that (A.A) amino acids have ability to chelate not only Fe but also most of the transition metals recently (Romheld, 1987).

The system of iron uptake into leaf tissues from the xylem vessels (xylem unloading to simplest and re-absorption to apoplast) are not so apparent. Though, it is assumed that Strategy I uptake plays a significant function when Fe transport across leaf cell membrane (Dinneny et al. 2008). Iron transportation via phloem is also must. Iron transportation from mature to younger leaves also occurs through phloem transportation. The phloem sap pH is >7, as a result, to remain soluble Fe requires to bound with chelators (Suzuki, Yamaguchi, Nakanishi & Nishizawa, 2000).

Wheat germplasm tolerance to zinc shortage has inverse relationship with distribution and uptake of iron to shoots. In this study they evaluated up take capacity and transportation of Fe by two durum (*T. turgidum* L.) wheat and eight breads (*Triticumaestivum* L.) Genotype under either zinc or iron deficient soils. Genotypes of bread wheat Aroona, Stilleto and Excalibur appeared as tolerant against to iron and Zn deficiency, whereas durum wheat appeared as less tolerant against deficiency. Roots of bread wheat released more phytosiderophores as compared with durum wheat genotypes. Higher concentrations of phytosiderophores were released by roots grown under zinc and iron deficiency. A comparatively poor association prevailed between the Fe uptake velocity and shoot development under iron deficiency. Zinc shortage lowers the Fe transport velocity to shoots in all genotypes at premature levels, whereas higher Zn deficiency showed reverse effect. It is accomplished that higher tolerance against zinc shortage among wheat genotypes is linked with the better release of phytosiderophores (Rengel & Römheld, 2000).

Conclusion

The use of mineral and organic fertilisers to agronomically biofortify staple and non-staple crops with Zn, Se, and Fe offers tremendous potential for combating hidden hunger around the world. The review focuses on the state-of-the-art use of Zn, Se, and Fe fertilisers, covering fertiliser selection (including nanofertilizers and biofertilizers), type and dose of applied micronutrients, and micronutrient uptake by selected crops. Aside from providing insight into the usage of Zn, Se, and Fe in boosting the nutritional value of crops, the paper also discusses the beneficial effects of micronutrients in reducing the damage caused by abiotic stress.

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