Toxic Elements and Cereal Crops

Effects and Strategies to Combat the Toxicities

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***Abstract*— the toxic element stress is one of the major abiotic stresses reducing crop production and yield in many parts of the world. Abiotic stresses such as element toxicity, drought, high temperature and salinity are the main constraints that decline the crop production in Asia and Africa. Among the toxic elements, iron (Fe), aluminum (Al), copper (Cu), cobalt (Co), chromium, nickel (Ni), cadmium (Cd), and arsenic (As) known for their toxicity to plants if present in high concentrations. These elements have deleterious effects on crop growth and reduce productivity. Toxicity limits the root elongation that leads to inhibition of nutrient and water uptake; reduce leaf area, necrosis wilting and even plant death. Seed germination is more sensitive to toxicity than other growth stages. Toxicity hinders the plumule and radical growth in crops. The current work is reviewing to provide effective information on the toxicities of different toxic elements in food crops and plant growth and to understand the mechanisms that would help the plants to overcome the toxicity**

Keywords—crop; soil contamination; stress toxicity; seed germination; tolerance strategies;

I. INTRODUCTION

Toxic elements (metal and metalloids) are a term that described the metals or metalloids. These elements are non-degradable having density more than 5g/cm^3 and remain in the environment forever. Most of agricultural soils of the world are contaminated with toxicities of elements such as Aluminum (Al), Cadmium (Cd), Arsenic (As), Lead (Pb), Ferrous (Fe), and Nickel (Ni), and Copper (Cu) [1]. Urbanization and industrialization processes are increasing rapidly and becoming the causes of pollutants in our natural resources.

Toxic elements pollution in soil are the great worrying concern in the world [2] (Table 1.). Soils have toxic elements in traces, as essential elements required by plants, but an excessive concentration of certain metals is reported to be harmful to plants and ultimately in animals and humans [3-5]. The accumulation of toxic elements are very from soil to soil and plants to plants [2]. Differences in solubility, absorbability, transport and chemical reactivity in toxic metals lead to specific differences in toxicity [6].

TABLE I. FEW WORLD'S SOIL TOXIC ELEMENTS

Regions / Area	Some Toxic element soil pollution	References
Hong Kong	As, Cu, Cd, Pb, Zn	[7]
	Cr, Co, Ni, Cu, Zn, Cd, Pb	[8]
China	Cd, Hg, As, Pb, Cr	[9]
Central China	Ag, Cr, Cu, Mn, Pb, Zn	[10]
South China	Cu, Zn, Pb, Cd	[11]
Beijing, China	Cu, Pb, Zn	[12]
Shanghai, China	Pb, Zn, Cu, Cr, Cd, Ni	[13]
Northern Bangladesh	Ti, Mn, Zn, Pb, As, Fe, Rb, Sr, Nb, Zr	[14]
India	As, Ba, Co, Cr, Cu, Ni, Mo, Pb, Sr, V, Zn	[15]
Delhi	Cu, Zn, Pb, Cd	[16]
Selangor, Malaysia	Mn, Cu, Cr, Ni, Zn, Pb, Co	[17]
Perak, Malaysia	Pb, Cd, Cu, Zn, Fe, Mn, Ni	[18]
Peninsular Malaysia	Fe, Mn, Zn, Pb, Cu, Cd	[19]
Australia	Cd, Cu, Pb, Zn	[20]
Korea	Cd, Cu, Pb, Zn	[21]
Jordan	Cu, Cd, Pb, Zn	[22]
Istanbul, Turkey	Pb, Cu, Mn, Zn, Cd, Ni	[23]
France	Cr, Co, Ni, Cu, Zn, Cd, Pb, Sc	[24]
Sweden	Cd, Pb, Hg, Cu, Zn	[25]
Spain	Zn, Cu, Pb, As	[26]
Zimbabwe	Cu, Zn, Cr, Ni, Cd, Pb	[27]

Continue…

European Mediterranean	Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn	[28]
England	Zn, Cu, Ni, Pb, Cd, Cr, As, Hg	[29]
Norway	Cu, Zn, As, Se, Cd, Sb, Pb	[30]
Greece	Pb, Cu, Zn, Ni, Cr, Cd, As, Hg	[31]

II. Sources of Toxic Elements Contamination

The excessive concentration of toxic metals (metalloids) in soils is the result of several anthropogenic activities which are not only pollute the soil ecosystem, but also toxic to other living organisms [32, 33]. Although, the anthropogenic activities are the fourth major factor for toxic element pollution. The major primary sources are industries, mines, power plants. Emissions of toxicities to the atmosphere are by the road transport and combustion byproducts [34]. Emission of toxic elements to the environment is seriously affecting human health [35]. Other sources of contamination are affecting predominantly agricultural soils include inputs such as fertilizers, pesticides, sewage sludge, organic manures and composts [27, 36]. The concentration of these toxic elements different in different countries or regions in the world, but the highest value toxic elements have observed in agricultural soil. For example, Cd shows a wide range of minimum value 0.13-1.1mg/kg but the highest value encountered in agricultural soil *i.e.* 41mg/kg [37].

The major reasons for toxic metals (loids) contamination in urban and agricultural soil are mining, manufacturing and the use of synthetic products. Potentially heavy metal toxicity has found in old land filled sites, Old orchards have Arsenic as an active ingredient due to excessive use of insecticides in the past and industrial sites where the chemicals have been dumped [38]. Anthropogenic activities specially mining and smelting and agricultural activities have polluted the major area of the world such as England [29], Japan, Indonesia, and China [39] mostly by toxic elements such as Cd, Zn, Pb, Ni, and Cu.

III. Causes of Toxic Elements Mobility

The toxicities of toxic elements to seed germination, seedling development and growth are well-known influences by other environmental conditions, such as availability of other nutrients and soil pH [40]. The mobility of toxic metals in soil and water has influenced by their chemical and physical properties. Some anions such as carbonate, sulfide and phosphate influence the potential of soil to fix the toxic metals (loids) chemically. Soil pH has great impact on the mobility of toxic metals (loids). In fact, in acidic condition the metal cations are more mobile [41]. In an acidic environment, excess of hydrogen ion (H^+) in the soil have attracted by the negative charge of clay particles and organic substances and leaving no space for soluble toxic metal (loid) ions. Consequently, soluble available toxic metal (loid) ions are uptake by plant roots [42].

TABLE II. Toxic elements concentration increases in low pH of soil.

Soil pH	Toxic elements (µg/g)				
	Fe	Cu	Cd	Zn	Mn
4.3	106	4.1	14.5	398	97.2
5.3	76.4	3.5	13.3	332	52.7
6.0	35.0	3.0	13.0	287	26.7
6.7	21.6	2.9	12.3	249	21.8
7.2	15.8	2.4	11.0	218	8.90

Source: EL-Kherbawy, Angle, Heggo and Chaney (1989).

Soil pH has increased or decreased the toxic metals (loids) availability to plants. On 7.2, the concentration of Fe, Cu, Cd, Zn, and Mn were 15.8, 2.4, 110, 218, and 8.90. Whereas at 4.3 soil pH the concentration of these metals were 106, 4.1, 14.5, 398, and 97.2. The concentration of Fe, Al and Mn are more dependent on soil pH than other toxic elements. [43] studies Al^{+3} concentrations in different pH level. They showed rice field trial results that at 3.7 pH Al^{+3} concentrations were 873uM which became so high when pH decreased from 3-4. However the critical pH of the rice plant is 6 [44].

The cation-exchange capacity of the soil also influences the metal (loid) uptake and increase in cation-exchange capacity of the soil; increases root cation-exchange capacity. By this mechanism, roots are able to compete with the soil on the element adsorption and high root cation-exchange capacity promotes metal (loid) uptake. Other metals (loid) could affect the uptake of one metal by competition at the uptake sites. A bundle of research evidences is available on this subject with numerous results and discussions. For example, one of these evidence explored that adsorption of Cd by the roots was reduced in the presence of other cations increasing valency or ionic radii. The Zn content in bush beans decreased with the increasing uptake of Cd, Pb, and Cu [45].

The addition of nutrients also affects the metal (loid) uptake, since other cations in the medium can compete with the metal. Thus, the uptake of the studied metal (loid) decreases with decreasing metal or a nutrient ratio [46]. The nutrients also influence the growth and thereby affect the metal uptake and accumulation. One nutrient influencing the metal uptake is calcium. In the case of the sugar beet, there was no effect on the Cd uptake in roots by Ca while Cd uptake increased in birch, but decreased in *Salix* and pea in the presence of Ca [47]. Anions may also influence the metal (loids) uptake. Since a metal has taken up in ionic form, the strength of affinity to a certain anion affects the metal uptake.

External factors such as temperature and light, not only influence growth, but also affect metal uptake. Heavy metal uptake had shown to increase with increasing light. Enhanced temperature increased the uptake of Cd in *Solanum nigrum* [48] and *Lolium* *perenne* [49]. However, a recent study devoted on the Cd uptake in Scots pine for 18 days in a nutrient medium shows that there is no direct effect of temperature and light on metal uptake; however, the effect of increased light and temperature was rather through increased growth. Increased biomass production enhances the uptake of elements; conversely, the accumulation in the tissue will diminished due to dilution caused by biomass increase and the uptake rate is lower than the rate of biomass production [49].

IV. EFFECTS OF TOXIC ELEMENTS ON CEREALS

The presence of toxic metals (loids) in irrigation water or in soil at an elevated level could hamper normal growth and development of plants. The toxicities of metals (loids) in contaminated soils and water are raised as a critical threat to agriculture productivity [5, 50]. Plants develop toxicity symptoms while they are exposed to excess either in soil or in solution culture (Table 3).

Germination and seedling stages are the most critical stages in the plant life cycle. Crops like rice and cotton germinating seeds and seedlings were easily diseased and inhibited due toxicities of metals (loids) in a hydroponics exposure [51]. The toxic effects of toxic metals (loids) decreased the seed germination in *Arabidosis*, was reported in ordered as Hg>Cd>Pb>Cu [52]. Cd, Pd, and Cr are higher concentrations in wheat than mustard and create health problems [53].

TABLE III. EFFECTS OF TOXIC ELEMENTS TOXICITY ON CROPS.

Toxic metals (loids)	**Crops**	**Effects on Physiological and biochemical mechanisms on seed germination and early seedlings**	**References**
Cd	Rice (*Oryza sativa*)	• Inhibition of growth rate, photosynthesis and distribution of nutrient transport. • Inhibition of DNase and RNase activities	[54-56]
	Barely (*Hordeum vulgate*)	• Chromosomes fragmentation and aberration take place	[57]
	Maize (*Zea aze*)	• Inhibition of absorption of Fe, Mn, Cu, Zn, Ca and Mg.	[58]
Cd	Wheat (*Triticum astivum*)	• Inhibition or reduction in seed germination, decreased shoot and root length. Low uptake of nutrient contents.	[5]
Fe	Rice (*Oryza sativa*)	• Excessive Fe^{2+} by roots, damage cell membrane, bronzing of leaves and reduction in yield.	[59]
	Wheat (*Triticum astivum*)	• Leave chlorsis and stunted growth.	
As	Rice (*Oryza sativa*)	• Deposited in grains as enter by the high affinity phosphate uptake system.	[60]
	Wheat (*Triticum astivum*)	• Reductions in seed germination root and shoot length.	[33]
	Maize	• As concentration accumulated in leaves, stems, bracts and kernels	[61]
Ni	Rice (*Oryza sativa*)	• Inhibition of seed germination and root growth. Reduction in ribonuclease and protease.	[62]
	Wheat (*Triticum astivum*)	• Inhibition of cell division. • Inhibite the peroxidase activities.	[63]

	Rye grass (*Lolium perenne*)	• Reduction in shoot growth, preventing the plant from nutrition uptake	[64]
Al	Wheat (*Triticum sativum*)	• Rapid reduction of ATPase enzyme. • Cause oxidative stress due to the deposition of reactive oxygen radicals.	[65, 66]
	Rice (*Oryza sativa*)		

In Table 3 above, scattered literature is utilized to focus on the effects of poisons or toxicities of toxic elements Al, Fe, Cd, and As on seed germination. Early seedling of crops is the important major problem in crop soils; early seedling mechanisms tolerance to the toxicities of toxic metals (loids) and ongoing progress for the development to tolerant crop varieties are also focusing in this paper.

V. Toxicities of Heavy Metals: Effiects on Germination and Growth

A. Ferrous (Fe) Toxicity

Fe toxicity is one of most important constraint in acid soil, along with Zn deficiencies that Fe and Zn are soluble ions in low pH damage the root system and reduce the growth of crops. Under aerobic conditions, the iron ion reduced in to iron ion, which is soluble in water and readily absorb by crop [67]. Iron toxicity is a very complex disorder; it reduces the uptake of Mg, Ca, K, and P by crop plant [68]. As leaves accumulate high amounts of Fe, it increases the production of radicals, which causes the irreversible damage of cell structural components and consequently oxidized poly phenols accumulated [69], this process causes bronzing of leave in crop plants. Commonly the bronzing has lost 15% to 30% crop production and if toxicity becomes more severs then total production failure of crop can be taken [70]. Seed germination is one of the most sensitive phases to stress, particularly to toxic element's toxicity due to the absence of defense mechanisms [71, 72]. It has well known that germination of seeds has disrupted in the presence of toxic element stresses [73]. Iron in emerging seed is mainly found in embryo and endospermic alurone layer in species of Poaceae family and Solanaceae. The high concentration of iron creates oxidative stress that adversely effects on the germination rate and subsequently killed the seed [71]. At 10-0mg/L of iron concentration rice plant (*Oryza sativa*) showed growth, but at the 250-500mg/L growth was inhibited [74]. Xiaoli Liu in [71] investigated the influence of iron on seed germination and seedling growth in wheat. In 500uM reduction in seed germination and at 300uM seedling growth inhibition, were observed. Seed germination and early seedling of were influenced by increased concentration of FeCl3. When seeds were exposed to 100uM and 300uM significant seed germination was observed. However, at 500uM significant reduction was found in germination rate. Fe significantly reduced the growth of shoot and root. The length of root reduced more than shoot.

B. Aluminum (Al) Toxicity

Al^{+3} is reported to be toxic to most of the plant species affecting cell structure and disrupt the inter molecule like enzyme, RNA, DNA, thus inhibiting seed germination and growth of many crop plants [63, 75]. Al^{+3} is cation so can easily interact with cell wall, cell membrane through cation transporter and disrupt their functioning. Seeds are directly exposed to toxic element contaminants in soil and causing severe damage in production. Aluminum toxicity has damaged the ability of seeding to become established [76]. Shoot and root of seedling growth both inhibited in excess amounts of Al [75]. When roots expose to high Al^{+3} in the soil just 2 hours, root elongation has been stopped and change into fragile and the thick root system subsequently plant collapse due to insufficient uptake of water and nutrition from the soil [77]. Al is a toxic metal to maize plant and usually available to roots in the low pH of soil [78]. Cultivation of some crops like rice, soil is required to be flooded to grow, which increases the pH of soil and water [79, 80]. Consequently, the crop plants were not only subjected to Al^{+3} toxicity, but also H^{+} constrain. The combined effects can cause lower growth and reduced yield [43]. The root growth of rice was affected by low pH and high concentration of Al^{+3} [44]. It is reported that mitotic activity was decreased as wheat [81], maize [82] and barley root tips were exposed to Al^{+3} toxic [83]. Al^{+3} inhibit root growth within very short time, whereas, slow the cell division process, e.g. in Al sensitive maize root growth inhibited in 30min [84]. A researcher in [85] discussed the effect of Al^{+3} concentrations on seed germination and seedling development of Wheat varieties (*Triticum aestivum* L.) and found that at 500ppm Al^{+3} inhibited the seed germination and its seedling growth. High concentration of Al^{+3} inhibited water uptake, growth and yield in Soybean [86]. In fact, Al^{+3} toxicity influenced root elongation more than shoot, which was delayed response of Al^{+3} toxicity [87].

C. Arsenic (As) Toxicity

Arsenic is a toxic metalloid present in soil, water and air. There are many arsenic polluted areas in the world, e.g. Bangladesh, Chile and China, causing a widespread contamination in soil and ground drinking water [35]. As can be found in arsenate, As (V) or arsenite, As (III), increased concentration of As in soil causing high As toxic in crop grains [88]. As has been reported as strongly affect the physiology and morphology of seeds and seedlings. The accumulation of As in plants severely affects the metabolic processes and inhibits the growth and development of cereal crops [89]. It inhibits the seed germination [90], decreased shoot root growth [91, 92], reduction in leaf blade, leaf necrosis [93], lower grain production [89], low chlorophyll content causing alteration in chloroplast [52] and abnormal uptake of essential elements such as phosphorous [94]. In the experiment with rice, this author observed that under low phosphorous condition high plaque formation occurs with As accumulation in rice root. Arsenic is potentially toxic for cell as it is the substitute for phosphorous because As (V) easily enter in to cell through Pi transport system [95]. At 1mg/L As concentration, the seed germination of crop varieties has decreased significantly, so contaminated irrigated water in the field may have an adverse effect on seed germination [71]. The available store food for all seeds is starch and it is reported that in germinating seed starch is degraded due to down regulation of α- amylase and β-amylase activity by higher arsenic concentrations [96]. In [71], researchers investigated the toxicity of Arsenate and Arsenite on germination and seedling growth and amylolytic activity of Wheat (*Triticum aestivum*). Seed germination, root and shoot length of Wheat significantly reduced by increases in Arsenate and Arsenite, while Arsenite is more toxic than Arsenate. As concentration in rice tissues retained in order of abundance were grain, leave, shoot and root [97] whereas the translocation of As concentration in maize tissues were root>stem>grain [98].

D. Cadmium (Cd) Toxicity

Cadmium compounds are widely used in several products, *e.g.* colour pigment, rechargeable nickel cadmium batteries. It is also present as a toxic contaminant in phosphate fertilizers. The product of cadmium is hardly recycled and usually dumped with household waste and cause the pollution in the environment [35]. Cd have considered as most hazardous toxic elements in current environment [99]. Cd toxicity have reported to cause delay in germination and embryo growth [100]. It increases the ratio of soluble sugar, glucose, fructose and amino acid in cotyledons/embryo [101] that cause the low nutrition and accumulation of lipid per oxidation product in seeds [100].

Fig. 1. *Effects of Cd toxicity on seed germination*

Ahsan *et al.* in (2007) studied the toxic effect of Cd on rice seed at 0.2–1mM concentrations. For treatment of 0.4 to 1mM Cd toxicity extremely has reduced shoot and root growth (Fig 1.) while root growth has inhibited even at lower Cd concentrations than shoot. Seed is influenced by excess amounts of Cd and their toxicity inhibits the seed from water uptake [62]. Cd is very mobile toxic elements in soil, water and therefore is easily taken up by plants. Severe effect on rate of seed germination and seedling growth has been reported in plants like *Parkinsonia aculeata* and *Pennisetum americanum* [102]. Excess amount of Cd in the soil affects the productivity, injuries symptoms, like chlorosis, browning tips of the roots, growth inhibition and eventually death of crop plants [103, 104]. It interrupts the uptake and transport of many essential minerals like calcium, magnesium, phosphorous and potassium by plants [105]. [52] investigated on the Cd toxicity on seed germination of *Arabidosis thaliana*, they reported that the tissues, which cover embryo, play important role in the penetration of toxic metals (loids) into seed. Cd toxicity affects the regulation of guard cells, translocated by cell through calcium channel [106]. Seed germination is sensitive to heavy metal toxicity because of the lack of defense mechanisms [72]. It is well documented that Cd effect the seed germination in rice [107]. In barely during seed germination, root growth was inhibited primarily than shoot or coleoptiles growth. On Cd, contaminated soil seed germination is inhibited by the inhibition of water uptake and other physiological processes are inhibited by oxidative stress of toxicity [108].

VI. Strategies to Combat the Toxicities of Heavy Metals

Some plants show sensitivity when they are exposed to high concentration of heavy metals and they adopted some strategies to cope with toxicities of heavy metals. Many studies have been done to identify the genetic and biochemical mechanisms helping plants to overcome with toxicities of heavy metals. The molecular mechanisms of plants play very crucial to exclude, detoxify or compartmentalize the heavy metal toxicity for the protection of plant in a contaminant environment [109]. Plants mechanisms for different individual aspects have been reviewed such as:

A. Inhibits the Heavy Metals up Take and Reduces the Concentration of Heavy Metals in Plants

Plants prevent the heavy metal entrance from the soil into the cell. Plant cell wall or specific root exudates are the first line of defense against toxic metals (loid) toxicity [110]. Root exudates are low molecular weight compounds like amino acid, organic acid, phenolics and sugar and high molecular weight compounds such as proteins and polysaccharides [111]. Root exudates play a very important role in the reduction of toxic metals (loids) toxicity either by chelating the metals directly or by the acidification of the rhizosphere [112]. The chelation mechanisms of some crops can inactivate the toxic metal (loid) cations.

In rice defense mechanism [43], this researcher investigated the defense mechanism against Al toxicity in rice plant and reported that when rice roots were subjected to Al toxicity. It was attracted to negatively charged cell walls of the roots. When the Al got to the cell walls the roots started to release oxalic, citric, and malic acids. Concentration of organic acids increased with high concentration of Al on the cell walls. These acids have chelated Al and turns into an inactive form. Metals transporter genes, Phytochelaten synthase and antioxidative system in plants have high contribution in metal tolerance such as Cd [113]. Root can inhibit or enhance the metal uptake and regulate metals tolerance and accumulation of plants by the root exudates. For example, two barely varieties Sahara and Clipper. Sahara accumulates more toxic elements, particularly Zn than Clipper due to higher exudation of organic acid and amino acid [114].

Toxic metals (loids) enter into plant cell through several mechanisms by metal homeostasis by the passive transport through channel protein or by active transport through the carrier proteins are called as metal transporter mechanisms [6]. The carrier transporter proteins have different affinity for heavy metals and at some level can discriminate the essential and nonessential elements at the plasma membrane. The Plasma membrane is considered as a primary living structure of cell that is damaged by high concentration of heavy metal toxicity. The function of plasma membrane is inhibited or affected by increased concentration of Toxic metals (loids). [115] and [116] have observed the effects of Cd treatments in the permeability and reduction of ATPase activities of plasma membrane in wheat roots. Similarly, Cu and Cd treatments have hampered the lipid composition of the membrane [115-117]. The high concentration of heavy metal toxicity has caused the increased leakage from cells. For instance, it was studied that the critical cause of Cu toxicity in wheat (*Triticum sativum*), *Silene vulgaris* was the cell membrane damage as monitored by ion leakage [116, 118]. Therefore, tolerance of plasma membrane is the protection of membrane integrity against toxic elements toxicity impairment, which is increased leakage of ions or solutes from the cells [119, 120]. Against these impairment plasma membranes are metal specific, to protect from oxidation and leakage [121, 122].

Another way of preventing toxic metals is homeostasis. Most essential and non-essential metals are divalent cations (Fe^{2+}, Cd^{2+}, Zn^{2+}). Studies on exclusion of ions are very few in numbers. However, for reduced toxic metal (loid) uptake as an adopted tolerance mechanism has been investigated in wild grasses in relation to arsenic toxicity [60]. In wild grass *Holcus lanatu*s roots arsenate enter into plants by phosphate co-transporters, but in polymorphic population (arsenic tolerant genotype) of *Holcus lanatus* arsenic uptake was much lower than the intolerant genotype and also showed a lower affinity uptake system because of suppression of arsenate uptake system high affinity along with synthsis of phytocheltons (PCs) [123].

Plant plasma membrane and tocoplasts contain different kinds of transporter proteins that contribute in metal uptake and homeostasis. These tranporters maintain the physiologial concentration of heavy metals and give response against toxic metals (loid) stresses [110]. From these transporters toxic element transporters are the NRAMP, the CDF, P1B-ATPase [124] and ZIP family [125]. Although there is very little evidence on cellular location, biological function and metal specificity of these transporters in plants [6]. However, in *Saccharomyces cerevisiae* these transporters were identified [110].

B. Accumulation of Heavy Metals in Epidermis Trichomes of Leave

The hairs on the epidermal layer of leaf surface, called trichomes. These trichomes accumulate heavy metals and stop transduction to protect the mesophyll cells. High concentration of Ni has been found in *Alyssum lesbiacum* leaves trichomes than other aerial parts of the plant [91]. A researcher [126] has reported the over gene expression in the metallothionein protein formation in trichomes and suggested that trichomes contain special sites for detoxification and accumulation of toxic metal (loid) ions. For instance, increased numbers in trichomes were studied in tobacco plants when exposed to Cd toxicity. However, the role of metallothionin in cereal crops for toxic metal (loid) tolerance is almost unknown [127].

a) Antioxidant Enzyme: Increase the antioxidant enzyme activities to reduce the free radicals usually under toxicities plants produces many free radicals that damage tissues severely. Upon the increase concentration of toxic metals (loids) in plants, one of major consequence is the production of reactive oxygen species (ROS). These ROS damages the plant tissues severely, signal transduction and inhibit the antioxidant enzyme activities [128]. When toxic metals (loids) enter into crop plants, complicated signal transduction of plants are activated that senses the heavy metals, in return stress related protein is released to overcome the toxicity stress [129]. Barely plant releases salicylic acid (SA) in response to Cd toxicity stress to protect the root from lipid peroxidation produced by Cd [130]. Crop plants, e.g. barely releases the high level of H_2O_2 in response to heavy metals [131, 132]. In fact H_2O_2 production act as signaling molecule against toxic elements toxicity stress [22]. Increased concentration of H_2O_2 changes the redux status of the cell. Consequently, cell releases antioxidant enzymes and activate antioxidant enzyme mechanisms [110].

b) Detoxification Mechanism: Some plants produce different proteins against toxic metal (loid) toxicities to resist the plants from toxicities stress [133]. Plants produce glutathione and cysteine low molecular weight proteins which have affinity for toxic metals [134] and critical for detoxification of toxic metals (loids) via synthesis of phytochelaton [135]. Cd resistant genes CDR3 has been identified in Arbidosis plants and responsible for toxic elements resistance mechanism, seed growth and development by increasing the GSH concentration [136].

c) Chemical Strategies: Chemical reactions such as oxidation, reduction and neutralization can be used to decrease the toxic metal mobility in soil. Oxidizing agents, including hypo chloride, chlorine gas, potassium permanganate and hydrogen peroxide are available that change the metal (loid) oxidation state. Similarly the reducing agents like ferrous sulfide, alkali metals Na and K, sulfides are present, which changes the toxic metal status through accepting one electron by reduction. Changing of metal state through oxidation or reduction process can solubalize or detoxify the toxic metals in soil [137].

Chelating agents have ability to extract the toxic metals (loid) from contaminated soils. Common chelating agents are nitriloacetic acid (NTA), diethylenetriamine pentaacetic acid (DTPA) S,S-ethylene-diaminedisuccinic acid (EDDS) and ethylenediamine tetraacetic acid (EDTA) can form strong metal complexes and are very effective in removing toxic metals (loids) from contaminated soils [138, 139]. This researcher reported that Cd was easiest toxic elements to extract from the soil than lead and chromium (Cr) and suggested that Chelating agents and acids are more effective in the removal of heavy metals than other compounds and less harmful to soil environment [140]. Similarly, organic acids like citric acid, tartarate and oxalate were found effective to remove the Cd Cu, Zn, and Pb from soil in a wide range of pH [141]. Saya and his colleagues tested the organic acid for polluted soil remediation. At pH 2.3 to 7.5 Citrate removed the Cd, Cu, Pb and Zn about 80% to 99.9% within 24 hours; whereas, tartarate extracted 84% to 99.9% of four heavy metals at pH2.1 to pH6.5 within 24 hours.

d) Management Practices: Soil and Crop management practices can help to inhibit the toxic element contaminants u take by plants [142]. Several practices are used to immobilize the toxic metals (loids) in the soil and reduce their toxic effect from heavy metals [38].

1) Cations are changed in to hydrous oxides sharply in to increased pH, while metals ions are more soluble and available to plants in to low pH [137]. Increasing pH of soil makes a very low availability of toxic metal (loid) ions to plants [38].

2) Soil washing is generally a waste minimizing or volume reduction treatment mechanism. Similarly, soil drainage is process to increase the soil aeration, which oxidize the toxic cations and transfer them in to less soluble form [143]. Some toxic metals (loid) like chromium become more available when it is in oxidize condition, in this condition organic matter help to reduce chromium in to less available form [38].

3) Applying heavy phosphate in soil also help in reducing availability of soluble cations. However, high phosphate has adverse effect on arsenic as anions and soil water [137].

e) Genetic Improvement: Plants have tolerance mechanisms against abiotic stresses such as toxic elements toxicity. Different regulatory processes are involved that activate the gene expressions responsible for tolerance mechanisms [144]. Several regulatory pathways have identified in cereal crops for tolerance [145]. It is reported that the gene expression for stress tolerance may not only depend on stress, but also depend on plant growth stages *i.e.* germination, early seedling stage and mature stage. Therefore, different genes play a role in prevention of damage through stress during different stages of plant growth. Consequently molecular markers linked to QTL for marker assisted selection of stress tolerant genotype could not be identified still now and it is very necessary to identify the QTL or genes for stress (heavy metals tolerance in more than one growth stage [146].

A researcher [72] found many QTLs for ferrous toxicity tolerance. $F_{2:3}$ Population was derived from Japonica and Indica rice. Five QTLs with the largest one on chromosomes 1 for Aluminum tolerance has been detected by [77]. He also identified ten QTLs on chromosome 9 in double haploid population for aluminum tolerance at seedling stage. In rice heavy metals appeared to be at very high levels within its grain [147]. As, Cd, Pb, and Hg have been reported as having toxic effect on plant growth. The molecular linkage approach has been used for identification of content of various cationic minerals within a seed [148]. Some work has been reported on QTLs analysis linked in rice with accumulation of minerals like phosphorous uptake [149], accumulation and concentration of Cd and As in roots grains and leaves [150]. This work [150] found high Arsenic concentration in rice seedling and observed QTLs for arsenic concentration in roots that were in position with QTLs regulating concentration of phosphorous in roots on chromosomes 12. In maize As accumulations observed to be more complex, [61] have found 11 QTLs for As accumulation in different tissues of maize in which only two were on the same chromosomal region and concluded that distribution and accumulation of As are controlled by different genetic mechanisms.

VII. Conclusion

Accumulation of toxic elements in soil, air and water is causing serious hazards for plants and human health. The crop plants are severly damaged from htoxic elements (metals and metalloids). It reduces the yield, inhibits seed germination and growth, and impairs plant biochemical and physiological activities. The mobility and effect of heavy metal toxicity depend on soil pH, organic substances, fertilizers, pesticides and plant species [151].

Even though plants have defense mechanisms to compete with toxicities of toxic elements like reduce the uptake of metal (loid) ions, GSH synthesis, activation of antioxidant, expression of genes [72, 152] development of enzymes and nucleic acid to detoxify the metal (loid) toxicity. A plant tolerance mechanism needs to be studied more to prevent the plants from toxic effect. Meanwhile mechanisms by which germinating seed overcomes the constraints of toxic elements are still largely unknown. Because in past cultivation method of some crops were old conventional method [153], whereas there are many methods now for cultivation, which require low labour and inputs [154]. Genomic protection of flora from environmental pollution is the key of conservations for plants [155]. Research on plant tolerance mechanisms at different growth phases and alteration in genetic are the need of recent age. In addition, the new tolerant varieties on bases of defense mechanism knowledge and molecular studies can be developed to combat with food security in the world. The future aspect of this paper will be to understand the effects of metaloxic elements on seed germination and early seedling. Knowing the strategies to combat with stress constrains advances in molecular technology for development of new varieties will help in better agriculture production even from the toxic element contaminated soil.

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