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Beneficial Elements in Plant Life Under A Changing Environment

Misbah Naz[1], Muhammad Ammar Raza[2], Muhammad Adnan Bodlah[3], Sarah Bouzroud[4], Muhammad Imran Ghani[5], Muhammad Riaz[6], Tariq Shah[7], Akmal Zubair[8], Imran Bodlah[9], and Xiaorong Fan[1, 10]

[1] State Key Laboratory of Crop Genetics and Germplasm Enhancement, Nanjing Agricultural University, Nanjing, China
[2] College of Food Science and Biotechnology, Key Laboratory of Fruits and Vegetables Postharvest and Processing Technology Research of Zhejiang Province, Zhejiang Gongshang University, Hangzhou, China
[3] Fareed Biodiversity Conservation Centre, Department of Agricultural Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan
[4] Laboratoire de Biotechnologie et Physiologie Végétales, Centre de Biotechnologie Végétale et Microbienne Biodiversité et Environnement, Faculté des Sciences, Université Mohammed V de Rabat, Rabat, Morocco
[5] College of Natural Resource and Environment, Northwest A&F University, Yangling, Shaanxi, China
[6] School of Agriculture and Biology, Shanghai Jiao Tong University, Minhang, Shanghai, China
[7] Department of Agronomy, Faculty of Crop Production Sciences, University of Agriculture Peshawar, Peshawar, Pakistan
[8] Biochemistry Department, Quaid–i-Azam University Islamabad, Islamabad, Pakistan
[9] Department of Entomology, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan
[10] Key Laboratory of Plant Nutrition and Fertilization in Lower-Middle Reaches of the Yangtze River, Ministry of Agriculture, Nanjing Agricultural University, Nanjing, China

Introduction

The presence of many essential element nutrients affects plant growth and yield (Elser 2012). The availability of a single element, rather than the availability of all nutrients, limits plant absorption of all nutrients (Kirkby 2012). The scarcity of fertile land is a major concern as the world's population grows day by day (Niste et al. 2014). As a result, increasing food production and using fewer appropriate soils, and those with high salinity, poor nutrient availability, limited water holding capacity, and partially contaminated sites, would become critical. Plants suffer as a result of poor soil quality, leading to reduced food production (Niste et al. 2014). To improve this situation, the valuable elements are not considered important for all crops, but they may be critical for specific plant taxa. In the case of certain trace elements, distinguishing between useful and vital is often difficult (Pilon-Smits et al. 2009). Plants benefit from elements such as aluminium (Al), cobalt (Co), sodium (Na), silicon (Si), and selenium (Se). These elements are not needed for all plants, but they can enhance plant growth and yield (Kaur et al. 2016). At low levels, beneficial elements are said to improve resistance to abiotic stresses (drought, salinity, high

Beneficial Chemical Elements of Plants: Recent Developments and Future Prospects, First Edition. Edited by Sangeeta Pandey, Durgesh Kumar Tripathi, Vijay Pratap Singh, Shivesh Sharma, and Devendra Kumar Chauhan.

temperature, cold, UV stress, and nutrient toxicity or deficiency) as well as biotic stresses (pathogens and herbivores). The essential-to-lethal range for these elements, though, is quite narrow (Ahmad et al. 2012; Fahad et al. 2015). The effect of beneficial elements at lower doses merits more concern when it comes to using them to fertilize crops in order to boost crop production under stress and to improve plant nutritional value as a feed or food (Meena et al. 2014). A more proactive approach to plant nutrition might involve mineral elements at levels effective for best growth as well as nutrients necessary for survival (Coleman et al. 2014). We describe the mechanisms of absorption of various beneficial elements, their advantages, and the function of these elements in imparting tolerance to abiotic and biotic stresses in this paper. Sufficient intracellular doses of beneficial metal ions (in traces) are needed not only for optimal plant growth and development but also for pathogen infectivity and plant defences (Dighton and Krumins 2014).

Metal defences are primarily based on hyperaccumulators of important facets, anti-plant pathogen hypothesis stress signalling, and metal ion intermodulation is linked to plant responses to both abiotic and biotic stress factors and is an emerging research field in metal hyperaccumulator and non-hyperaccumulator plants (Bhardwaj et al. 2014). The impact of useful elements at low levels receives more respect in this period of research in order to fertilize crops with these nutrients to improve crop production in stressed environments as well as boost plant nutritional value as feed or food (Osorio Vega 2007). Unlike the toxic effects, the processes that accompany the beneficial effects (at low levels) to the plants have not been thoroughly investigated (at high levels). More research into how these elements protect against pathogens and abiotic stress factors is needed, particularly at the molecular level (Compant et al. 2010). It is necessary to investigate how these components have synergistic or antagonistic effects on plants developing in unstressed and stressed conditions. Foliar spray of these components must be checked in plants growing in stressful conditions (Ilangumaran and Smith 2017). Useful elements for agricultural crops, as well as their practical significance in stress defences, are a tool for increasing crop yield (van Boekel et al. 2010).

Beneficial Element Interaction with Environment

Plant behaviour is a strong demand for the supply of essential mineral nutrients, which affects many important functions (White and Brown 2010). Useful elements are not required for plant growth and development, but when they are present, they help to promote growth and development by stimulating resistance mechanisms against biological and abiotic stressors, promoting the use of other uses, and compensating for or alleviating the harmful effects of other elements (Broadley et al. 2012; Anjum et al. 2015). Plants' response mechanisms to environmental factors such as drought, heavy metal toxicity, high salt content soils, pests, or pathogens may contain useful elements. This analysis highlights the beneficial effects of aluminium (Al), methyl (Ce), cobalt (Co), iodine (I), lanthanum (la), sodium (Na), selenium (Se), silicon (Si), titanium (Ti), and sodium (N) in some plants that have observed major shifts, as well as the possible uses of novel ingredients in aluminium agricultural output (Paustenbach et al. 2013; Malagoli et al. 2015; Zhang et al. 2017; Muhammad et al. 2018). Aluminium controls flower colour, promotes plant growth and root production, extends the life of certain vases, and slows antioxidant mechanisms (Muhammad et al. 2018). Selenium can boost oxidative stress tolerance, slow the process of aging, enhance growth, and raise heavy metal consumption (Asemi et al. 2015). Silicon can counteract the toxic effects of heavy metals, drought, and salinity, leading to pest and disease tolerance, forming nanostructures, improving the multi-body and stiffness of plant tissue, stimulating antioxidant mechanisms, reducing ethylene synthesis, and extending vase existence (Zhu and Gong 2014). Sodium can act as a regulator, extend vase life, and induce the synthesis of amino acids like alanine. Titanium enhances N, P, K, Ca, and Mg experience, increases starch synthesis, reduces *Xanthomonas* damage, and produces better plant growth. Sodium is used as a secondary metabolism agent to boost plant growth (Vankova 2014). Plant nutrients are needed for plant growth and development. If there are not enough of them, it causes a particular deficient symptom. If a single plant nutrient is completely deficient, growth will halt and the plant cannot finish its life cycle. Recent scientific evidence indicates that there are 14 important plant nutrients based on these standards (Lambers et al. 2008). Plant nutrients are classified as macronutrients or micronutrients based on whether they are found in greater or lesser quantities in plants requiring several g/ha (Lambers et al. 2008). Present chapter emphasizes the role that useful elements such as Na, Si, Co, Se, and Al perform. Sodium could stimulate plant growth, especially in some C4 plants, by facilitating substrate movement between the mesophyll and the bundle sheath. It can also partially substitute K as an osmoticum, and applying Na fertilizers to sugar beet leads to an improvement in the leaf area index early in the growing season (Mahmoud et al. 2012), and under moderate drought stress, this increases light penetration and improves water usage quality of leaves (Elser 2012; Kirkby 2012). Silicon contributes to cell wall integrity by connecting polyuronides and promoting lignin synthesis. It may increase plant and leaf erectness, reduce water consumption, and safeguard plants from pests and diseases. Silicon is also useful in reducing the harmful effects of other metals such as Fe, Al, Cd, and Zn, that can be due to the presence of Si and metals in the apoplasm or symplasm (Cao et al. 2017). Cobalt is required for N2 fixing plants as it is a component of the coenzyme cobalamin (vitamin B12), that is required for nodule metabolism (Khan and Khan 2010). Se has a similar chemistry to S and can partially replace S in proteins, especially in Se hyperaccumulating plants. Since selenium is necessary for livestock, Se fertilization may also be helpful to human and animal health in areas with Se-deficient soils (Broadley et al. 2012). Aluminium is helpful to certain plants, such as tea, and can reduce proton toxicity and enhance antioxidant enzyme activity (Hayat et al. 2012, Chauhan et al. 2021) (Figures 1.1–1.5).

Aluminium (Al) in Plants

Aluminium (Al) is an amphoteric material that has no known biological role. Aluminium is the third most abundant chemical element in the lithosphere (Samac and Tesfaye 2003). Al is used in nature mostly as slightly soluble oxides and silicates, rather than as a free metal (Grzybkowski 2006). The supply of Al and, as a result, Al's ability to communicate with plants is largely limited to acidic environments (Neal 2008). Al (H_2O) 6^{3+} is the leading monomeric Al species in aqueous media with a pH below 5. The key toxic Al species is thought to be this Al type, which is typically written as Al^{3+}. Different inorganic (e.g. fluoride, sulphate, silicon) and organic ligands (e.g. organic acids, phenolics, hydroxamates) are present in the chemically complex soil solutions. Aluminium (Al) is the third most common element in the Earth's crust and a key element hindering plant growth and reducing crop yield in acidic soil (Kopittke et al. 2005). While extensive research has been conducted on the phytotoxic effects and mechanisms underlying of Al when applied hydroponically, soil is a difficult medium containing various mineral elements that can associate with Al and other substances, as well as their bioavailability in plants (Yang and Watts 2005; Zheng 2010). We determine the process of Al in enhancing plant growth, increasing phosphorus supply and efficiency in plants, and reducing H+, iron, and manganese toxicity in acidic conditions in this study. Moreover, we explore the potential mechanisms of Al-induced increased abiotic stress tolerance (Chauhan et al. 2021).

Aluminium (Al) in Soil – Aluminium, a Friend or Foe of Higher Plants in Acidic Soils

Aluminium is even more accessible to the plants in acidic soils (soils with a very low pH), so acid-loving crops like blueberries and cranberries are also among the more aluminium-resistant varieties (Zheng 2010). Since calcium (Ca) cations in gypsum compete with aluminium (Al) cations, they become less soluble in water by plants. While aluminium (Al) seems to be the most affordable metal in the Earth's crust, its availability is affected by soil pH. Regardless its ample supply Al is not recognized as an important factor, and no experimental evidence for a biological function has been presented so far (Poschenrieder et al. 2008). Al may be beneficial or harmful to plants and other organisms, depends upon factors including metal concentration, chemical form of Al, growth conditions, and plant types (Watanabe and Osaki 2002). In this article, we review latest events in the study of Al in plants at the physiological, biochemical, and molecular levels, with an emphasis on the beneficial effect of Al in plants (stimulation of root growth, increased nutrient uptake, the increase in enzyme activity, and others) (Gupta and Huang 2014). Furthermore, we explore the potential mechanisms needed to enhance the growth of plants grown in acidic soils, along with mechanisms of tolerance to the toxic effect of Al. Acid soils, also known as ultisols or oxisols, have a pH of 5.5 or below and are commonly found in tropical and subtropical areas, accounting for about 30% of the total area of the planet and 50% of the world's agricultural land, as well as 25–80% of vegetable production (Gupta and Huang 2014; Silva 2017). Soil acidification may arise as a result of both natural and anthropogenic processes (Figure 1.1). The majority of acid soils are found in the tropics and subtropics, where acidification occurs naturally. This condition could be exacerbated by environmental pollution caused by the use of fertilizers and acidifying chemicals and the use of fossil energy sources (Iqbal 2012). For example, coal and oil, which emit nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) into the atmosphere, and when combined with oxidizing agents, produce nitric acid (HNO_3) and sulphuric acid (H_2SO_4), rising acid rain accumulation and acidification of bodies of water and soil. Besides that, organic material decomposes; imbalances in the N, S, and C cycles; increased cation absorption over anions; and nutrients supplied by leguminous crops all increase the levels of H^+ and lower soil pH (Figure 1.1)

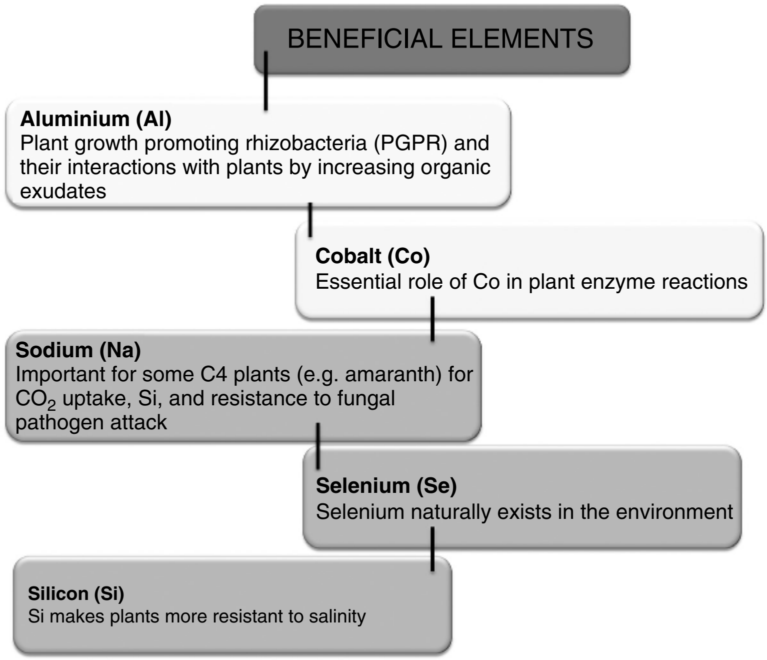

Figure 1.1 The schematic illustration of different beneficial trace elements necessary in plants' life. These natural elements play vital role in plant life cycle, i.e. defence, growth, and development.

(Nunes-Nesi et al. 2014; Sade et al. 2016; Singh et al. 2017). Acid soils are distinguished by poor nutrition and contamination by metals including manganese (Mn), iron (Fe), and aluminium (Al), with Al contamination being the primary factor affecting plant growth in acid soils (Kichigina et al. 2017).

Cobalt (Co) in Plants

Cobalt has previously been recognized as an important mineral for animals. After all, our awareness of the critical role in plant enzymatic reactions remains limited (Simonsen et al. 2012). Cobalt's most well-known role in plants is for N-fixing microorganisms like Rhizobia, that live symbiotically with legume plants (Gad et al. 2011). The overall effect of cobalt (Co) and copper (Cu) on plant toxicity are rarely reported, despite the fact that these two metals coexist frequently in soil. This study summarizes current knowledge of Cu-Co tolerance and deposition in plants (Nagajyoti et al. 2010; Lwalaba et al. 2019). Accretion of foliar Cu and Co to >300 g g-1 is pretty uncommon worldwide and is renowned from the Copperbelt of Central Africa. Cobalt deposition has also been reported in a small number of Ni hyperaccumulator plants found on ultramafic soils worldwide. Since foliar Cu-Co deposition is highly dose dependent, none of the alleged Cu or Co hyperaccumulator plants tend to follow the basic concept of hyperaccumulation (Faucon et al. 2018). Plant tissue Cu concentrations are unusually high only when plants are dealing with high soil Cu

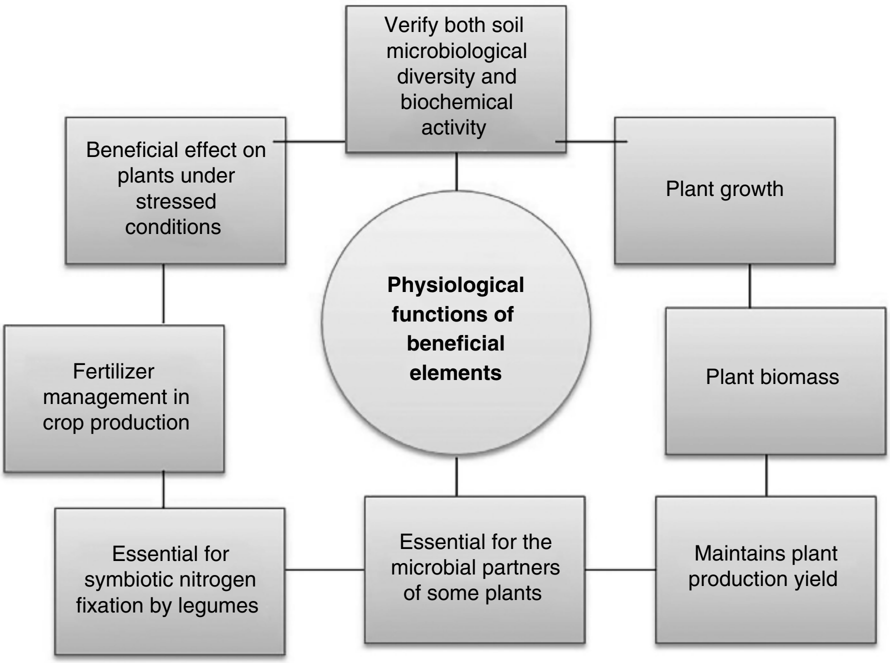

Figure 1.2 The role of different micro and macro essential nutrients involved in plant growth, development, and protection against different stress and disease at micro level.

concentration with a low shoot translocation factor. Although most Cu tolerant plants are Excluders sensu Baker and therefore setting Cu hyperaccumulation threshold values is useless (Lange et al. 2017). Cobalt deposition has also been found in a small number of nickel (Ni) hyperaccumulator plants found on ultramafic soils worldwide (Khan and Khan 2010). Due to their dose-dependent deposition features, the practical application of Cu–Co accumulator plants in phytomining is restricted; however, due to the extremely low metal content of Co, field trials on highly contaminated mineral wastes may be warranted (Sandrin and Hoffman 2007).

Cobalt (Co) in Soil

The European soil contains cobalt concentrations between 1 and 20 mg/kg on an average of the dry weight, whereas it has also been observed that these concentrations became higher in the areas those were geologically rich in cobalt including North Wales (Phoon et al. 2012). Similar levels of cobalt at over 2500 mg/kg dry weight were also observed by Paveley (1998). This element has been proved essential for the leguminous crops symbiotic nitrogen fixation by functioning as a coenzyme involved in nodule formation, growth, and N2 fixation that plays a critical role as cofactor of cobalamin (vitamin B12) (Weisany et al. 2013). The beneficial trace elements are those that are held essential for most of the crops but actually may be fixed vital towards the particular plant taxon (Sessitsch et al. 2013).

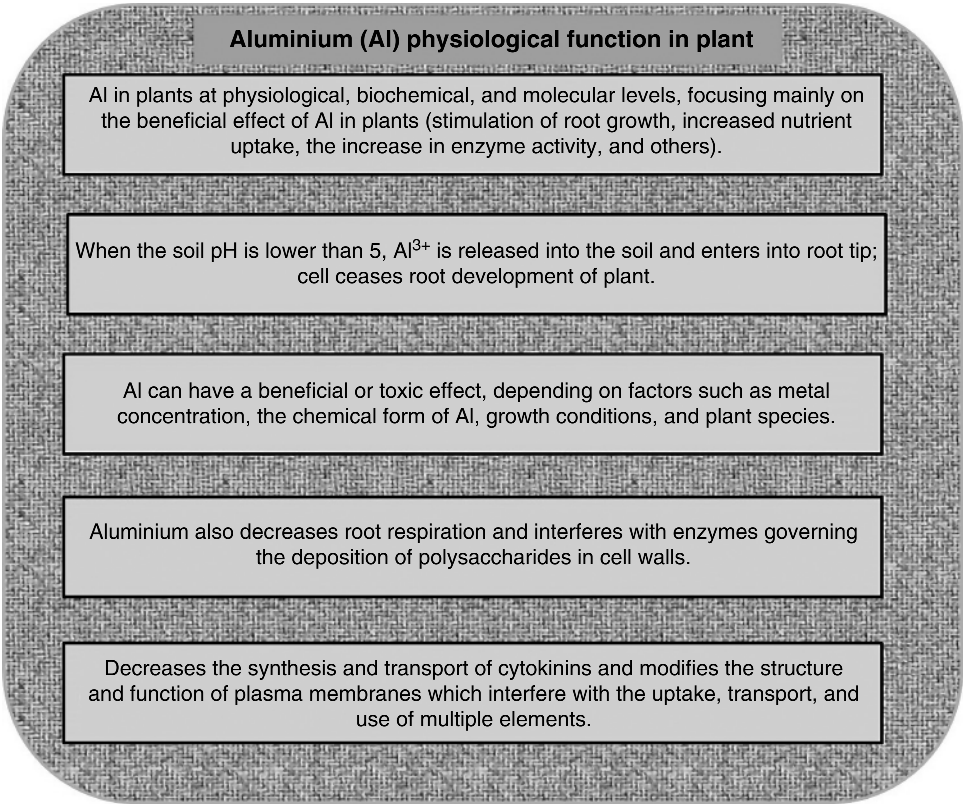

Figure 1.3 Role of aluminium for proper molecular functioning in life cycle of plant life. Aluminium takes part in disease control, nourishment, and other biochemical processes.

The pre-eminence between the essential and beneficial is most of the time difficult in the case of some trace elements. The elements including aluminium (Al), selenium (Se), silicon (Si), sodium (Na), and cobalt (Co) are believed to be beneficial for the plant growth. All these mentioned elements are not critically required for all the plants but may be supportive in growth and overall plant yield (Broadley et al. 2012). In fact, these beneficial elements evidently increase the plant resistance towards biotic stresses (herbivores, pathogens) and abiotic stress factors like high or low temperature, salinity, drought, UV stress, and nutrients deficiency or toxicity) at their low concentration levels (Ashraf and Foolad 2007).

Whereas their range being essential to lethal is somewhat too narrow, the low levels of the beneficial elements need more attention with respect to their use as fertilizer to increase crop nutritional value as food or animal feed and boosting up the crop production under the stressed field conditions. A more comprehensive perspective towards plant nutrition requirements would not be confined to essential nutrients towards survival but must also include other mineral elements at different levels beneficial for the magnificent plant growth (Pineda et al. 2010). Now, we discuss the uptake mechanism of different beneficial elements and their role in conferring tolerance against biotic as well as abiotic stress conditions with their favourable aspects (Vinocur and Altman 2005). The findings of the study

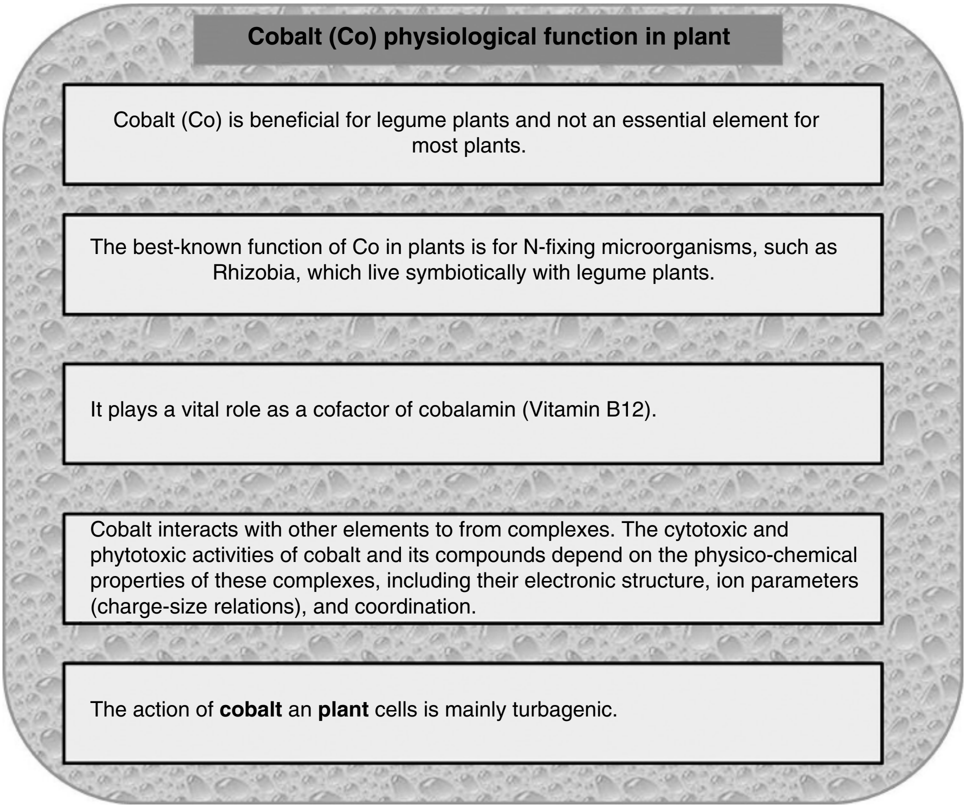

Figure 1.4 Explanation of cobalt's features involved in plant life cycle during different stages of growth and development.

suggest that the presence of trace elements in excess in the soil results in disturbing its homeostasis. They verify both biochemical activities as well as microbial biodiversity. If the recommended amount of an element is exceeded, it may hinder biological activity, which may limit plant development.

Cobalt has been proved to be the most toxic soil element. It not only induces very reduced resistant and enzymatic activities but also resulted into a substantial spring barley yield reduction. The soil reaction towards and Sn^{2+} excess was negative, but the problem scale was also not so alarming. The plants reacted extraordinarily positive to its increased doses in the soil. The barley crops grown during spring season did not face significant changes. In conclusion, this study is a crucial link in a sequence of studies on the perception of the quality of the environment where we function. It concedes the presence of the side effects to the soil contamination with the trace elements induced by the growing push towards an elevated standard of consumerism and living.

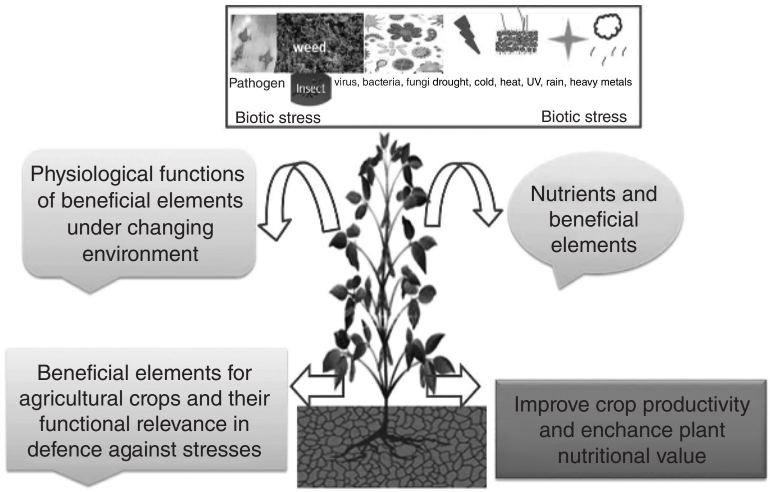

Figure 1.5 Schematic representation of relationship between plant and essential micro and macro elements that exists in the environment. These elements play vital role in plant and its development under different environmental conditions.

Silicon (Si)

The application of silicon (Si) has been discussed broadly in the recent years due to its effectiveness to increase plant resistance against the salinity (Guntzer et al. 2012; Kim et al. 2014, Dhiman et al. 2021) increase in the biomass of the crops and conversely decreases the uptake of different toxic elements. Silicon (Si) carries the properties to influence accumulation and uptake of various nutrients that are rarely investigated, especially the cereal crops like rice and cash crops like sugarcane those that are proved to be Si accumulator, and this element has been found to be beneficial for them (Tuna et al. 2008). Silicon (Si) is the most common element on the Earth surface. Whereas it is not completely available to the plants, as it remains locked in the minerals like recalcitrant silicate but a very trace fraction is available for the plants (Ahmad et al. 2007, Tripathi et al. 2020). The silicon soluble fractions are pH dependent and redox in nature (Diegoli et al. 2006).

The silicon configures towards the solid phase phytoliths once it is absorbed by the plants those that are recycled to the soil solution by the dead plants decay and will become available for the plants through soil again (Greger et al. 2018). The silicon is absorbed by the plants in the shape of undissociated silica acid (Ma and Yamaji 2008), which moves in the similar form through the plant xylem (Mitani et al. 2005). Silicon's uptake is considered to be passive (Su et al. 2010). In the past few years, different silicon transporters have been found in the plant roots' endo- and exodermis layers (Van Bockhaven et al. 2013). The silicon elements have been primarily found in the higher plant levels like monocotyledons with a higher content in rice up to 10% and the grasses with DW 0.3–1.2%. The plant tissues contain Si found as Si-organic, hydrogen bound complexes, and infuses the vessels and epidermis walls, where it serves as reducers of fungal infections, water transpiration, and provides strength towards the plant tissues (Allakhverdiev et al. 2010). The silicon elements are associated with the plant cell wall proteins, lignin, and polysaccharides (Guerriero et al. 2016). Most of the Si part is available in the plant in the form of narrowly dissolved phytoliths (Klotzbücher et al. 2016). The silicon impacts the distribution, uptake, and function of the different mineral nutrients present in the plants. In line with the literature, out of all the macronutrient elements, phosphorus (P), magnesium (Mg), nitrogen (N), potassium (K), calcium (Ca) are impacted in different ways (Ma and Yamaji 2008). Out of all micronutrients, manganese (Mn) and boron (B) look to be strongly impacted by the silicon (Alloway 2008). Uptake of other elements like Cl, Fe, and Zn by plants is also influenced by the silicon (Greger et al. 2011). Keeping in view the different Si effects, it looks that it might possible that various plant species nutrients acquisition and uptake modification differ within various plant taxons due to silicon presence. To study the non-uniformity of silicon elements on the plant nutrient uptake, it becomes valuable to differentiate between the studies made through hydroponic or directly through the Earth's surface. Through earth surfaces, the silicon impacts (Romero-Aranda et al. 2006) less or more availability and nutrient elements binding to the soil particles for the plant uptake. The silicon is well known in the reduction of P soil sorption, especially at lower pH levels, thus increasing the P portion availability in the soil surface for the plant (Hernandez-Apaolaza 2014). The phosphorous elements are sorbed mainly onto the Al, Fe, and Mn hydroxides in the soil. The silicon elements are associated with the Mn and Fe (III) and ultimately changes the availability of Mn and Fe and reduces the pool of hydroxides (Sommer et al. 2006). Up to now, a general silicon assembly impacts the plant's uptake of elements, status of different essential nutrients, and distribution is still missing (Greger et al. 2018). The main purpose of current study is to investigate the impacts of silicon on the plant's uptake and distribution of variable mineral nutrients in different five plant taxons and together with review of the literature obtained a common overview of silicon impacts on the plant elements status. We compared and probed different plant species like wheat and maize (monocotyledons), pea, lettuce, and carrot (dicotyledons) – wheat as a silicon accumulator, maize as C4 plants, wheat and maize as cereals, peas as nitrogen fixating plants, lettuce as a leafy vegetable, and carrot as root vegetable.

The plant cultivation media may impact both plant solution uptakes from the soil and elements availability as well as their distribution with the plant anatomy. Here in this study, we discussed and compared the silicon influence on: (i) plant nutrients presence in the different soil types and (ii) plants nutrients uptake from different soil nutrient solutions.

Function of Silicon

It seems that the silicon elements are beneficial for the plants when they are under stressful conditions (Ahmed et al. 2013, Shivaraj et al. 2021). This element has been observed to improve in the delay wilting and drought tolerance in various crops and increase plants' abilities to resist against micronutrients where the irrigation is withheld and other metals like copper, iron, zinc, manganese, and aluminium toxicities (Hasanuzzaman et al. 2017). Moreover, the silicon has been observed to support in the increase of the plants' stem strength. For instance, during a study rice and wheat plant were facing silicon deficiencies, their stems became weak and easily collapsed due to rain or wind pressures – a condition that is called as lodging, whereas poinsettias with silicon treatments have shown resistant and reduced stem collision and breakage. The silicon has been observed to increase plants' resistance against various attacks by fungal pathogens (Meharg and Meharg 2015). Contingent upon the phytophthora and powdery mildew, disease attacks were delayed in the silicon treated plants like gerbera (Phytophthora) and rose, sunflower zinnia and cucumber (powdery mildew), but the plant treated with silicon and untreated had the same amount of disease attack after three weeks (Moyer 2007). The modes of silicon actions are still ambiguous and uncertain and more research work is needed for the verification of these benefits.

Silicon in Soil

Silicon (Si) amount is ample in the lithosphere and is the second most abundant element in the Earth's crust (Ma 2010; Tripathi et al. 2020). Most of the soils contain 30% silicon, out of which majority has been found in rocks and minerals. Si is spotted and named as a beneficial quasi-essential nutrient. The Earth's surface layers are largely composed of Si that is observed primarily as secondary alumino silicates, silicate minerals, and multiple form of silicon dioxide (SiO_2) (Bhat et al. 2019). Whereas the riches of Si in the soils is not a sign that higher supplies of soluble Si are always available for the uptake of the plant (Sacala 2009). In the current chapter, the findings of multiple years of research work conducted in relation to Si are combined to create understanding regarding state of knowledge regarding Si fertilization for farmer's guidelines in the crop production process. Silicon is also used in the form of mono silicic acid (H_4SiO_4) by plants (Babu et al. 2016). That is found in both silicon's adsorbed and liquid phases in the soils. The total amount of mono silicic acid in the soil solution got affected by the pH of the soils, the amount of minerals, organic matter, clay, and Al/Fe hydroxides/oxides those are jointly in relation with the geological soil age (Tubaña and Heckman 2015). Fertilizer applications may cause rapid increase in the mono silicic acid concentration in the soil solutions. So, the Si concentration increases through fertilization, which has become a routine in areas with intensive crop production practices, especially for soils that are intrinsically low with the soluble silicon nutrients (Bhat et al. 2019).

Different procedures have been developed to estimate critical silicon levels in the soil and the available silicon in plants through the method of five-day Na_2CO_3-NH_4NO_3 extraction for the analysis of the silicon soluble fraction in the solid-state fertilizers that was among the most advanced methods in the agricultural research work in past few years (Sohail et al. 2020). These estimates were the key integrant essentially needed for the formation and execution of fruitful silicon management in the overall crop production system. However, multiple characteristics of the silicon remained understudied in the research work of the soil sciences, like the silicon impacts on the nutrient's status in plants is not well known and these features must be focused on in future studies (Lee et al. 2010). It is well known regarding silicon benefits for the plants under stressful conditions (Greger et al. 2018). The primary goal was to create a future analysis of the silicon impact: I The accumulation of diverse nutrients in hydroponically produced wheat, maize, peas, lettuce, and carrots (ii) The presence of nutrients in various soil types, including sand, clay, submerged soil, and alum shale soil (Greger et al. 2018). The silicon effects were homogenous in all the examined plant species and samples of soil types tested. According to the results, silicon increased the P, Mn, S, Zn, and Ca availability for the plants and availability of Fe and Cl also started to increase. Whereas availability of Mg and K were not significantly impacted by silicon (Sarwar et al. 2010). Moreover, the nutrients uptake from the soil solution like Mg, S, Ca Fe, Mn, and B increased; K, Zn, Cu, and N decreased, and P increased/decreased but Mo and Cl remained uninfluenced (Sharma and Chettri 2008). So, in conclusion we assumed that, during crop production, Si level in the soils maintained may be supportive in the availability of nutrients in the soil solution that would likely compensate for the decrease in nutrient elements in the plant tissue concentrations. The current finding indicates that silicon may also impact the plant nutrients uptake during a non-stressful condition.

Sodium in Plants

Sodium is not an important plant nutrient as others because a plant can complete its life cycle without it and can be replaced by other nutrients like potassium that plays a vital role during osmosis (Jones and Jacobsen 2005; Wakeel et al. 2011). However, sodium is important plant constituent as feed. Therefore, it is an important element for plants. For example, there are some exceptional cases of natrophilic crops from Chenopodioideae family, where some positive impacts on quality and yield were observed when fertilizers were applied with sodium combinations (Rodríguez-Navarro and Rubio 2006). An important industrial crop of this group like sugar beet (*Beta vulgaris*) is a famous example whose sodium requirements are very high. The glucose synthesis towards fructose is supported by the stored sodium of beet (Mengel et al. 2001). The efficiency of plant water use is also controlled by sodium by controlling the plants' osmotic cell pressure. Sometimes, sodium ions serve as substitute of K ions in various metabolic as well as osmoregulatory function. So, both of the nutrients remain interchangeable towards the various levels according to the group of the plants. Sodium plays a vital role for the uptake of carbon dioxide in some C4 plants like amaranth (Subbarao et al. 2003).

Sodium in Soil

Sodium presence in the soil is in the form of compounds, most commonly as salts (Warton et al. 2003). Clay minerals are adsorbed by the sodium, but the binding is mostly weaker than the K ions, therefore the sodium leach down propensity is always higher (Vimonses et al. 2009). In areas with the high rainfall, such as tropical to subtropical areas, soils are mostly depleted in sodium and washed down deeper into the lower soil layers (Kosmas et al. 2000). Conversely, sodium accumulation occurs mostly in the top soils of the arid to semi-arid climatic areas because of the exceeded evaporation levels of soil water (Rasouli et al. 2013). Ultimately deterioration of the soil structure occurs that has impacts on the air balance and the water contents of the soil. Moreover, the pH levels move towards more alkalinity with an increase in sodium contents (Liu et al. 2006).

Selenium (Se)

Selenium is a naturally occurring metalloid element that occurs in all kinds of climatic conditions like other elements. Moreover, it is believed to be a nonrenewable and limited resource of the Earth's crust (El-Ramady et al. 2016).

Selenium in Environment

More so than the silver elements, selenium is a backbone element of the Earth's surface. It is present in the atmosphere as a micron on the derivative. There are 40 well-known Se minerals, and the majority of them are found alone. In some cases, these minerals contain 30% of the selenium but rarely found in association with sulphide elements in zinc, lead, and copper metals (Purves 2012). Its main producers are United States, Russia, Bolivia, and Canada. About 1500 tons per year selenium is produced worldwide and 150 tons is recycled from industrial wastes like old photocopiers. Selenium is present in the climate and released through human activities and natural process. Over fertilization of agricultural soil is near about 400 mg ton^{-1}, as phosphorous fertilizers are also present naturally and added as micronutrients. Selenium is a natural element that cannot be destroyed or created easily, but it has capacities to change its form and increase water in the soil. Selenium waste from air ultimately ends up in the soil deposit sites (Kesler et al. 2015). Selenium remains fixed in the soil before reacting with oxygen. It cannot be soluble in the water and unmovable and low risky towards organisms. The soil acidity and oxygen levels increase the flow and movement of selenium that are caused usually through human activities like industrialization and other agricultural activities. Similar to that, the present chapter examines the several activities of selenium in plants, including acquisition, metabolism, and translocation. Plants utilize the released Se, which also meets the needs of humans and other animals in terms of Se. In the environment, selenium may be found in both organic forms like SeCys and SeMet and inorganic forms like cerel nitrate saline and character nitrate. Se is transferred to the plant roots' plasma membrane via a sulphate conveyor (El-Ramady et al. 2016).

Physiological Functions of Beneficial Elements Under A Changing Environment

The low-level benefits of nutrients Al, Co, Na, and Se are not well discussed in comparison with their harmful effects when applied at higher concentration levels. A clear understanding of beneficial part of these nutrients is essential to get increase in the plant nutritional values and overall productivity to feed the growing world populations. The climatic factors impact the plant growth by reducing their beneficial nutrients uptake through different ways like sunlight effects on the vegetative and flower completion stage and decreases the leaves colour shadow (Pilon-Smits et al. 2009; El-Ramady et al. 2015).

The photoperiod changes and control in different plants could affect its flowering stage. Similarly, temperature impacts the seed dormancy, germination, plant respiration, nutrients uptake, chlorophyll content, and plant organs transpiration. Due to the severe temperature impacts like heat or chilling factor on the photosynthesis process, the plants' overall health undergoes stressful conditions that result in the less availability of nutrients and make the plants nutrient deficient. In the end, the stressed plant is more vulnerable towards different infections caused by insects (El-Ramady et al. 2016).

5-Beneficial Elements Against Stresses

Healthy plants with no nutrient deficiencies are self-defenders and save themselves from different climatic stresses and severe losses. The elements with the recommended levels of concentrations support the plants against different stress conditions. The most dangerous abiotic stress condition is drought that causes severe molecular, physiological, and biochemical damage to the plants that eventually lead towards the significant losses in the yield. Drought has been described as the most significant threat towards world food security due to its limiting ability of crop productivity as well as the quality of crop production. The plant under drought stress loses its bud, root growth that causes reduction in photosynthesis, and its other important physiological activities (El-Ramady et al. 2015). Moreover, antioxidant plants' defence mechanism is also damaged due to severe drought stress. According to credible studies, the function and value of silicon towards its interactive network of plant drought stress resistance and other dynamic pathways are well documented. Silicon protects plants from the severe impacts and destructive activities of the drought stress conditions (Kong et al. 2005, Tripathi et al. 2020). In the Chapter 1 of this book, importance of silicon against drought stress crops has been discussed. It also discusses the role of silicon in the improvement of mineral distribution, physiological plant functions, enhancement of antioxidant defence system, oxidative markers release, and the future prospects in the counterproductive impacts of arid stress climatic conditions. In the current climatic change scenarios and overall increase in the food demand due to the increasing population levels, there is significant issue in the provision of so-called human's food security. The poor crop yields and nutritional values have become an essential worldwide issue by affecting billions of human populations. Whereas there is a belief that agronomic practices and new technologies can support by preventing the consequences of global warming and unpredictable climatic patterns (Lenz and Lens 2009). With increase in global temperature, many other abiotic stress factors have threatened agricultural sustainability and overall ecosystem. So, in the previous few decades the coercion of abiotic factors has become a serious concern for plant scientists. The survival through long-term or time-bound severe climatic changes, the plants must adapt the tolerance and resistance mechanism at organ level, cellular level, or the whole organism level (Hawrylak-Nowak et al. 2018). The plants' proper functioning depends at a higher extent on an adequate nutrient's levels. It is well described that the essential nutrients have a significant role in plant development, growth, and climatic stress resistance. According to the reports, the higher levels of nutrient concentrations in the plant's tissues may alter plants' responses towards stress conditions and cause increase in their nutritional value. Moreover, some beneficial nutrients like Se and Si at lower concentration levels can express positive impacts on the plant metabolic activities and contribute towards the increase in plant resistance against harmful climatic changes. So, as a result, different elements are discussed with various chemical compositions, examined as plants' abiotic stress reactive enhancers, including beneficial and essential for the plants. Most of them have potential to increase in crop quality and yield under stress conditions (El-Ramady et al. 2016).

Conclusion

In conclusion, the essential elements including Al, Co, Na, Se, and Si are recommended beneficial and important for the plants. The elements Na and Si are critical for different plant groups, whereas Se and Al are suggested as determining for some hyperaccumulator plant taxa.

The Co elements are essential for plant microbial partners in the trophic association rather than the plant themselves. Other elements like Cr and Fl are rarely explored and have beneficial functions towards plant biology. So, as humanity is facing multiple intimidating challenges including climate change and undemand-free growth, the discussed factors have significant importance. In the current scenario, more detailed research work on the benefits of the essential elements is recommended.

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