REVIEW ARTICLE

Emerging Nutrient Deficiencies in Cereal Production System and their Possible Management Strategies to Achieve Nutritional Securities

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DOI: 10.18811/ijpen.v8i03.04

ABSTRACT

Rye, oats, barley, corn, triticale, millet, and sorghum are among the cereals cultivated in various countries. With more than half of the world's grain production going to wheat and rice, these two crops are the most significant on the planet. Human have traditionally consumed cereals, which are staple foods and significant nutrient sources in both developed and developing nations. Cereal goods contain a variety of micronutrients, including vitamin E, several B vitamins, magnesium, and zinc, and are a significant source of energy, carbohydrate, and protein. All living species, including crop plants, require a number of fundamental elements in order to maintain development and cell processes as well as to complete the life cycle. For the development and production of plants, vital minerals are necessary. Essential minerals are indispensable for plant growth and production. There are a variety of recognized essential mineral elements that are mostly accumulated from the soil. However, the soils of the Indian subcontinent have been deficient in some nutrients as a result of years of extensive agriculture and unbalanced fertilizer use. Under nitrogen (N), phosphorus (P), and potassium (K) nutrient stress, leaf characteristics show different deficiency symptoms, according to the plant nutrition process. For crop nutrient management, it is critical to develop a reliable, fast, and modified method for diagnosing crop nutrition. Improving fertilizer efficiency is a major concern for managing crop production and maintaining soil economic productivity.

Keywords: Crop plants, Essential elements, Deficiency, Symptoms, Management.

International Journal of Plant and Environment (2022); **ISSN:** 2454-1117 (Print), 2455-202X (Online)

INTRODUCTION

Cereals include wheat (Triticum), rye (Secale), barley (Hordeum), oat (Avena), rice (Oryza), millet (Pennisetum), corn (Zea), sorghum (Sorghum), and triticale, a wheat-rye hybrid. Because cereal crops make up a significant portion of livestock feed, they also provide essential nutrients and nutrition to people's diets indirectly through the processing of meat. In 2016, 1330.02 million tonnes of coarse grains (cereal grains other than wheat and rice) were produced (FAO-AMIS, 2017). Corn (1253.6 million tonnes), rice (paddy, 949.7), wheat (854.9 million tonnes), barley (146.3 million tons), oat (23.2 million tons), and rye (15.8 million tons) are the top cereals produced in the world (FAOSTAT, 2017). Cereals are meals in both developed and emerging countries, and they are essential sources of nutrients. Cereals are a good source of calories, starch, protein, and fibre, as well as a variety of micronutrients including vitamin E, B, magnesium, and zinc. Cereals can have a large amount of calcium and iron (FAO, 2002). Both cereal grains are high in energy, as well as the fat and protein components. Cereal grains include carbohydrates, mostly starches (65 to 75 percent of total weight), proteins (6 to 12 percent), fat (1 to 5 percent), and traces of minerals and vitamins, in addition to moisture and inedible components such as cellulose (Sarwar *et al.,* 2013).

General Structure of Cereals

Cereal is a member of the grass family (Gramineae) cultivated for the edible components of its grain or the kernel. Strictly speaking, it is a caryopsis which is composed of the fruit coat (pericarp) and a seed. The fruit coat adheres tightly to the seed coat surrounding the remainder of the seed consisting of germ and endosperm. The aleurone layer lies next to the pericarp. This layer is rich in protein and minerals. The endosperm is the large central portion of the kernel made up mostly of starch, and the germ/embryo is the small structure at the lower end of the kernel (Delcour and Hoseney 2010). There are many different types of cereals grown worldwide, each sharing some structural similarities. It is grown in large quantities due to its importance as an economic commodity and providing food and energy worldwide more than any other type of crop. Due to this, cereal grains are also known as staple crops. Not only cereal processing forms a large and important part of the food production chain, they provide versatile and essential nutrients to numerous

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How to cite this article: Fayaz, S., Kanth, R.H., Bahar, F.A., Azad, A., Hamid, N., Hussain, N, Shabir, Z. (2022). Emerging Nutrient Deficiencies in Cereal Production System and their Possible Management Strategies to Achieve Nutritional Securities. International Journal of Plant and Environment. 8(3), 31-38.

Conflict of interest: None

Submitted: 10/07/2022 **Accepted:** 20/08/2022 **Published:** 30/09/2022

populations. Cereal grains are easy to store once their enzymatic activity is in check and may be used to produce a myriad of food products (Tsadik and Emire, 2015; Amadou *et al*., 2013).

Wheat

Wheat is a major cereal crop in many parts of the world. It belongs to the Triticum family, of which there are many thousands of species with *T. aestivum* subspecies Vulgare and the hard wheat *T. durum* being the most important commercially (Hemery *et al*., 2011).Wheat is grown as both a winter and a spring cereal and, owing to the number of species and varieties and their adaptability, it is grown in many countries around the world. The great wheat-producing countries of the world include the USA, China and Russia; extensive wheat growing occurs in India, Pakistan, the European Union (EU), Canada, Argentina and Australia.

Rice

Rice (*Oryza sativa* L.) the major food source for the bulk of the world's population and about 50–58% of the world's population feeds on rice, hence called universal grain (Zhang *et al*., 2010). Globally the area under rice cultivation is about 158 million hectares with an annual production of 751.9 million tonnes and average productivity of 3.9 t ha^{-1} respectively (FAO, 2017). India ranks second in terms of global rice production followed by china and its contribution towards global rice production is 21.5 %. The area under rice cultivation in India is about 43.79 million hectares, with the production of 112.91 million tonnes and 2.6 tonnes hectare^{-1} productivity, respectively (DES, 2018-2019). The Rice crop is cultivated from time immemorial in Jammu and Kashmir and stands as the remarkable core crop of the region. The total area under rice production of the region is around 0.28 million hectares, with the production of 0.55 million tonnes and productivity of 2.1 tonnes hectare^{-1} (DES, 2018). The unmilled form of rice is a good source of micronutrients as well as macronutrients. White rice is produced after milling of rice as milling removes the micronutrient-rich bran and fat layer (Min *et al*. 2011).

Maize

Zea mays L., also referred to as corn, originated in the Western Hemisphere. It is a cheap form of starch and is a major energy source for animal feed. Although there are hundreds of different varieties, the four main categories of commercial importance are: (1) dent maize (identified by the dent in the crown of the kernel); (2) flint maize (hard, round kernels); (3) sweet corn (a dent-type maize); (4) popcorn (flint-type maize which expands when heated). Globally, Maize is cultivated on an area of 180 mha with a production of 1050 m tons ha^{-1} and productivity of 5.5 m tons hactare (FAO 2018). In India, maize is cultivated on an area of 10.3 m ha with a production of 26.26 m tons^{-1} and productivity 2.6 tons ha^{-1}(DES 2018-19). In Kashmir, area under Maize is about 3.1 lakh hactares and production is 52.7 lakh quintal with a productivity of 1.7 tons ha^{-1} (DES 2018).

Barley

Barley is a resilient plant, tolerant of a range of conditions, which may have been cultivated since 15000 BC. Cultivated barley, *Hordeum vulgare* , is mainly grown for animal feed, especially for pigs, for malting and brewing in the manufacture of beer and for distilling in whisky manufacture. A small amount of barley is used for food. Pearled barley is eaten in soups and stews in the UK and in the Far and Middle East; barley is also used in bread (as flour) and ground as porridge in some countries (Marconi *et al*., 2000). The barley head or spike is made up of spikelets, which are attached to the rachis in an alternating pattern. The outer layers of the barley kernel consist of a husk, completely covering the grain; the pericarp (to which the husk is tightly joined in most species); the testa or seed coat and the aleurone.

Oats

Oats can grow well on poor soil and in cool, moist climates and have mainly been grown for animal feed. A small proportion is produced for human consumption – oatmeal for porridge and oatcakes, rolled oats for porridge, and oat flour for baby foods and for ready-to-eat (RTE) breakfast cereals There are several different species, with the common spring or white oat (*A.sativa* L) being the most important cultivated form. *A.byzantina* is a red-oat type adapted to warmer climates where it is grown as a winter oat. An oat spikelet consists of oat kernels. Each kernel is enclosed by a hull (made up of two layers – a lemma and palea) which is only loosely attached to the groat. The groat, which makes up 65–85% of the oat kernel, is enveloped by bran layers (pericarp, seed coat and aleurone cells).

Essential Plant Nutrients

Temperature, the amount of water and sunlight available, as well as the amount of soil-accessible nutrients, all have an impact on plant growth. The nutrient elements essential for healthy growth of plants are called essential nutrients or essential mineral elements. Just 17 elements are currently considered critical (nickel being the most recently added). The word "important mineral ingredient" was coined by Arnon and Stout in 1939. They are evolved from air and water, carbon (C), hydrogen (H), and oxygen (O) are the non-mineral nutrients of the 17 essential elements. The remaining 14 mineral nutrients include six macronutrients: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S); and eight micronutrients: boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn) (Brady NC and RR Weil 2008). Beneficial elements are nutrients that do not fit into the list of 17 basic elements that are needed in unique situations (Jones and Jacobsen 2001). Each nutrient is required in varying amounts and serves a specific purpose in the plant. These nutrients have an impact on crop yields and quality depending on how much is available for plant uptake (Havlin *et al* 2005). Sugar and protein content, seed size, kernel size, fruit colour, flavour, vitamin levels, and grain hardness are important quality attributes of the crop affected by nutrients. As parts of various types of proteins and protein enzymes, nutrients derived from crops and crop products, such as nitrogen, sulphur, and phosphorus, are necessary for the growth of plant tissues and the activation of numerous metabolic processes.

Crop production is influenced by soil nutrient status and maintenance, as well as nutrient concentration in plant parts consumed as food and feed. As a result, the state of soil nutrients has a significant impact on human wellbeing. Cakmak *et al.* (2017) found that about one-third of arable soils worldwide are deficient in micronutrients, especially zinc (Zn), which has an impact on human nutrition. Micronutrient deficits impact about 2–3 billion people worldwide, mostly in developed nations, where they affect at least half of the population (Goudia and Hash 2015). This is mostly due to decades of soil depletion and insufficient and unbalanced fertiliser use, mostly of nitrogen (N), phosphorous (P), and potassium (K). While the role of micronutrients in crop production has recently been demonstrated by (Kihara *et al*., 2017). The nutritional content of crop produce has a direct or indirect effect on human nutrition (Dimkpa and Bindraban 2016). Consumption of micronutrient-deficient food crops (due to partly lack of adequate micronutrients in the soil) can result in micronutrient deficiency in humans, a condition known as "hidden hunger" (Joy *et al*., 2015). Hidden hunger, the challenge widely documented in the 2014 Global Hunger Index report (Von Grebmer *et al*., 2014), is largely a problem of inadequate intake of micronutrients. However, micronutrients (especially Zn) deficiency in humans is mostly common in areas where cereals grown in micronutrient-deficient soils dominate the diets (Zou *et al*., 2012; Dimkpa and Bindraban, 2016).

Nutrient Deficiencies Identification

When there are deficits in nitrogen (N), phosphorus (P), and potassium (K), cereal crops including rice, wheat, maize, and barley exhibit clear symptoms. These symptoms serve as the foundation for quick morphological diagnostics in the field. Because it cannot be defined and is not particularly operable, farmers find it quite challenging to use this technology expertly. Diagnostic approaches focused on morphological diagnosis can derive information from the signs of nutrition stress in a complex and quantitative manner, which can be used to automatically determine the nutrition status of cereal crops. Rice that is deficient in NPK normally presents a variety of symptoms. When there is a lack of nitrogen, old leaves, and occasionally all leaves, turn light green and chlorotic at the root. (Chen *et al.,* 2013). Except for young leaves, deficient leaves are short, erect, lemon yellow, and narrow, save from juvenile leaves, which are greener. When there is a lack of P, leaves become short, upright, and narrow if the cultivar has a propensity to produce anthocyanin. Dark-green plants with yellowish-brown leaf margins or dark brown necrotic patches first occur on the tips of older leaves when K deficiency is present. Leaf tips turn yellowish brown where there is a serious K deficiency. The colour of the older leaves changes from yellow to brown. (Chen and Wang, 2014). Therefore, the color and shape of the leaf and sheath can indicate the plant nutrient and health status, which is closely related to the nutrition content.

The aim of nutrient deficiency therapy is to improve nutrient applications in the soil while still increasing plant growth. The signs of nutrient deficiency may also be influenced by a farmer's own poor management methods, such as inadequate chemical application. A systematic approach to observing the primary plant parts, such as plant height, tillers, leaves, and roots, among others, is used to diagnose nutritional diseases when the plants are nutrient-deficient. The typical signs of nutrient inadequacy include slowed plant height growth, fewer tillers per tiller, chlorosis, necrosis (brown patches), and orange discolouration. The position of the deficiencies symptoms on the leaf and the mobility of nutrients within the plant are connected. Since the nutrient fails to migrate from lower to upper leaves, where it is required for active development, symptoms usually occur on upper leaves for a nutrient with low mobility (Chen and Wang, 2014).

Foliar Fertilizers

Nutrient-limiting mechanisms such as nutrient antagonism, intense pH, and other diverse chemistries are believed to exist primarily in the soil. By avoiding the soil and giving nutrients through aerial plant parts, soil fertilisation can be improved and the insufficient supply to the roots can be addressed. Nutrient absorption from the shoot may be influenced by the surface tension of the suspension or solution, leaf cuticular form, leaf age, and environmental factors affecting stomata operations (Fernández and Ebert 2005). According to Fenández and Ebert,2005 chlorosis in crop plants is reduced by foliar application of Fe fertilisers (2005). Additionally, foliar spraying enhances the nutrient's seed content, improving the nutritional quality of the crop (Wang et al. 2012). Even though foliar fertilisation has been demonstrated to boost production and quality in leafy vegetables, this pathway may be less effective in cereals if foliar-applied nutrients are less mobile and more likely to be digested in leaf tissues as opposed to being transported to the grains. While there is a wealth of knowledge surrounding the application of foliar Fe, additional research is required to apply other nutrients on a wide scale and to fully incorporate foliar methods into present farming practises. In order to I determine crop responses particular to each nutrient and their combinations; (ii) determine crop responses specific to each nutrient and their combinations; and (iii) obtain reliable and reproducible application regimes. By taking advantage of synergistic effects, foliar treatment may also provide extra benefits. In their study, Oprica *et al*. (2014) discovered that applying a mix of N, P, K, Fe, Cu, and Mn as foliar fertiliser enhanced the amount of nutrients in maize and sunflower leaves and seeds while also increasing yield by 50% over NPK alone. The foliar fertiliser formulation's inclusion of micronutrients is probably what helped the soil-applied fertilizer's uptake performance. By addressing the micronutrient deficiency, agronomic biofortification of crops (in soil or foliar form) with micronutrients has the potential to boost crop output and nutritional quality.

Beneficial Micro-organisms as Crop Inoculants

In addition to the well-known role of symbiotic (such as Rhizobia) and free-living (such as Azotobacter and Azospirillum spp.) N-fixation, soil microorganisms also perform a variety of other roles in plant nutrition. By making the root environment more acidic, Bacillus subtilis can increase the solubility of fixed nutrients (Zhang *et al*., 2009). Pseudomonads, Streptomycetes, and Bacilli, which produce phytohormones, siderophores, and other compounds that promote growth, are examples of bio-fertilizers. (Bulgarelli *et al*., 2013). Other soil microbes, on the other hand, function as biological control agents, reducing the effects of pathogenic species and improving plant fitness, including nutrient assimilation and disease tolerance, as well as resistance to drought and metal toxicity (Koele *et al.,* 2014). Maintaining a diverse community of rhizosphere microorganisms by proper management can therefore be advantageous in the long run. However, because of the intense and numerous associations, the beneficial processes can be extremely unique to plant species, soil, microorganisms, and nutrients. Less than 5% of the soil P is readily accessible to plants, according to estimates (Bulgarelli *et al*., 2013). In this regard, the ability of bacteria, primarily of the Bacillus, Pseudomonas, and Penicillium genera, as well as arbuscular mycorrhizal fungi (AMF), to solubilize P, primarily from tricalcium phosphate, is further demonstrated (TCP). Phosphate solubilising microbes (PSMs) perform their role by exuding organic acids such as citrate, acetate, succinate and gluconate, as well as by the enzymatic activities of phosphatases and phytases (Bulgarelli *et al.,* 2013; Koele *et al*., 2014). Given the declining quality of global phosphate resources and non-agro sectors, competitiveness for rock phosphate, discovering genuie PSMs with the most promising agronomic potentials is critical, resulting in a skyrocketing of the price of P fertilisers (Bashan *et al*., 2013). Different microbial inoculants are being developed for use in plant development on a commercial scale.

Nanotechnology in Fertilizers

The field of nanotechnology has the potential to alter the way fertilisers are currently made. Due to their small size and high surface area relative to bulk materials, nanomaterials with diameters ranging from 1 to 100 nanometers are very reactive. As of March 2011, more than 1300 goods included nanoparticles, according to the Project on Emerging Nanotechnologies, and by 2020, the industry is anticipated to reach $3 trillion. (Roco *et al.,* 2011). As a result it is expected the fertiliser industry will completely join the nanotechnology revolution. Numerous nanomaterials, such as those made from substances not often thought of as nutrients (such as titanium, silicon, and silver) and nanoforms of micronutrients like Zn, Fe, and Mn, have been demonstrated to promote crop growth (Servin *et al.,* 2015). When administered at the same concentration at comparably high doses, nanoparticles (NPs) always outperform the same dosage of the same mineral nutrient presented in ionic (salt) form for crop growth, and the concentration at which toxicity occurs is lower with NPs than with ions. (Dimkpa *et al.,* 2012a; Pradhan *et al*., 2013; Kim *et al*., 2014). The enhanced beneficial effects of NPs are mostly due to the fact that, unlike ionic fertilisers, where a substantial amount of the nutrients might be lost due to the formation of phosphate and carbonate precipitates or other soil factors, some NPs may accumulate as intact particles inside the plant root and/or shoot tissues in addition to solubilisation in the soil (Antisari *et al.,* 2013). Cu supplied as CuO NPs, for example was taken up by maize and wheat in the particle form (Wang *et al.,* 2012 and Dimkpa *et al.,* 2013). Similarly, the existence of Fe and Mn NPs in plants subjected to particulate Fe oxide and Mn (Ghafariyan *et al.,* 2013; Pradhan *et al.,* 2013), as well as MgO NPs in roots when exposure was via foliar application (Wang *et al.,* 2013). Notably, the same crop could differentially absorb different nutrient elements provided to it in particulate form through the root, as observed in wheat for CuO vs. ZnO NPs, where Cu existed in wheat shoot mainly as CuO particles and a lower amount of dissolved forms, and Zn as Znphosphate (Dimkpa *et al.,* 2013). Apparently, the ZnO NPs are dissolving in the rhizosphere and are initially absorbed by the plant as Zn^{2+}, prior to their complexation with organic phosphate or other organic molecules inside the plant (Dimkpa *et al.,* 2013; Wang *et al.,* 2013). Liu and Lal (2014) demonstrated that synthetic Nano hydroxyapatite [$Ca_5(PO_4)_3OH$] as a source of P supply modestly increased soybean growth, biomass and yield relative to regular triple super phosphate [$Ca(H_2PO_4)_2$] application. Thus, the development of 'Nano fertilisers' could be a promising technology by which both macro- and micronutrients can be delivered in Nano particulate forms so that they provide a continuous source of soluble ions as they dissolve in the rhizosphere or in planta after particle uptake. Existing fertilizers, meanwhile can be packed in ways that improve their solubility and accessibility in the rhizosphere or in plant tissue by encapsulating nutrients in biodegradable nanopolymers that detect nutrient deficiency cues like root exudate synthesis or pH and release their nutrient contents for plant uptake in time with the plant's need.

Nutrient Management

Managing fertiliser application in the field is one of the most difficult tasks since it relies on maximising fertiliser efficiency while ensuring environmental protection (Vitousek *et al.,* 2009). Nitrogen and phosphorus are the main contaminants that enter and leave fields *via* fertilizer (both inorganic and organic), or any other important source of plant nourishment, including effluent management on dairy farms. Nutrient management, according to Delgado and Lemunyon (2006) is an art and science that links tillage, irrigation, and soil and water conservation in order to maximize crop yield, quality, and net profit while minimizing the off-site flow of nutrients with minimal environmental impact.

Site-Specific Nutrient Management (SSNM)

SSNM is a crop-based technique that provides guidelines, strategies, and methodologies to help farmers decide when and how much fertiliser to apply to a crop under actual growing conditions at a specific time and place (Peng *et al.,* 2010). According to Dobermann *et al*. 2002, SSNM is the comprehensive, site-specific management of nutrients during a certain cropping season to balance nutrient supply and demand based on fluctuations in nutrient cycling through soil-plant systems. Seasonal and geographic differences in environmental yield capacity and crop nutrient demand, (2) variance in the geographical heterogeneity of fields in terms of intrinsic nutrient supply, (3) farm-specific within-season dynamics of crop N demand, and (4) site-specific cropping trends and crop management techniques are all exploited by these forms of SSNM.

Integrated Nutrient Management (INM)

INM can be defined as using inorganic and organic fertilizers, bio-fertilizers, crop residues, and other living materials in such a balance that enhances fertilizer use efficiency, thus resulting in increased crop yields while indirectly minimizing the environmental risk through balanced fertilizer application (Gruhn *et al.,* 2000). The main aim is to merge conventional approaches with new nutrient application techniques to create environmentally sustainable and economically sound cropping systems that use both organic and inorganic fertilisers sparingly

Table 1: Biological function of Essential mineral nutrients on Plants

Essential nutrient	*Function of plant*
Nitrogen	Protein builder Necessary for formation of amino acids Component of vitamins, enzymes, and chlorophyll Essential for plant cell division and plant growth
Phosphorus	Major role in the energy system of plants and encourages early root formation and growth and Increases water use efficiency
Potassium	Pottasium is associated with the movement of water, nutrients & carbohydrates in plant tissues
Sulfur	proteins, protoplasts, enzymes
Calcium	cell structure, cell division, cell elongation
Magnesium	chlorophyll, enzymes
Boron	Important in sugar transport, cell division and amino acid production.
Chlorine	Used in turgor regulation, resisting diseases and photosynthesis reaction.
Copper	Component of enzymes involved with photosynthesis
Iron	Is important for chlorophyll synthesis, metabolism, enzyme activation
Manganese	Is a component of Hill reaction-photosystem II, enzyme activation
Molybdenum	Involved in nitrogen metabolism, essential in nitrogen fixation by legumes
Nickel	Is important for iron metabolism.
Zinc	Essential for auxin activity.

and effectively (Uphoff *et al.,* 2006). INM manages all three main macronutrients, namely N, P, and K, as well as other macro and micronutrient inputs and outputs, with the goal of nutrient cycling with close synchrony between nutrient demand and application to soil. INM reduces nutrient losses due to drainage, leaching, volatilization, and immobilisation, resulting is increased fertiliser production. According to Zhang *et al*. 2012 and Wu and Ma, 2015 the key principles of INM are (1) matching the input quantity with the crop demand, and (2) synchronization in terms of the timing application with crop growth.

Integrated Soil Fertility Management (ISFM)

ISFM is a soil fertility management approach that emphasis the wise use of chemical fertilisers, organic manures, crop residues, and resilient germplasms, as well as an understanding of how to apply these techniques to local conditions, with the goal of improving the agronomic use efficiency of applied fertilisers and increasing crop yields. According to a recent report by Nhamo *et al*. 2014, both crop residues and FYM (farm-yard manure) are important for improving rice field productivity under ISFM. Rice crops grown with organic manure or symbiotic biological N fixation by legumes have a higher yield gain than those grown with inorganic fertilisers. Nhamo *et al*. 2014 also suggested a step-by-step innovative novel tactic to enhance crop production via the inclusion of various approaches of ISFM at various growth phases.

Integrated Soil–Crop System Management (ISSM)

This strategy, which was proposed by Zhang *et al*. 2012, addresses three main points: I) considering all viable alternatives to improve soil quality; (ii) using all potential nutrient sources and balancing nutrient supply with crop needs; and (iii) aligning nutrient and soil conservation techniques with high-yielding cropping systems. Countries where the N balance has already been achieved can also improve crop productivity and fertilizer use efficiency by utilizing new approaches of ISSM, such as growing better varieties, location-specific agricultural practices, slowly releasing nitrogen amendments, efficient irrigation systems, and proper rotation of crops, etc (Zhang *et al.,* 2014).

Ridge-Furrow Mulching System (RFMS)

This method involves covering the topsoil and retaining soil moisture by incorporating materials into the ridges and furrows prior to or soon after sowing, such as plastic film, seed straw, gravel, sand, and boulders. This practise can help to direct water into furrows, reduce soil evaporation, and enhance soil water penetration deeper into the soil profile, enhancing crop plant water supply. (Gan *et al.,* 2013). Under wheat-maize double-cropping systems in northwest China, for example, the RFMS practise could increase water usage efficiency (WUE) by up to 70% relative to conventional flat or well-irrigated practises, thus improving N fertiliser productivity and N uptake efficiency by up to 33% and 45 percent, respectively (Li *et al.,* 2017)

(Table. 1) Kow and Nabwami (2015) reported some biological Functions of essential nutrients for plant growth as shown in Table 1.

The beneficial components, according to Kaur et al. (2016), reported that they worked as co-factors for some particular enzymes even at low doses. Even while the beneficial elements might be essential for some plant species, they are not believed to be required for all crops. It can be difficult to distinguish between essential and beneficial effects in the case of some trace components. Elements including silicon (Si), cobalt (Co), sodium (Na), selenium (Se), and aluminium are regarded to be beneficial to plants (Al). Although not all plants need these elements, they might aid in the growth and productivity of plants. Relevantly, it is asserted that advantageous components boost resistance to biotic pressures (pathogens and herbivores)

Table 2: Effect of nitrogen deficiency and compensation on yield and its components in double-Cropping super hybrid late rice.

Years	*Treatments*	*Effective panicle per plant*	*Yield per plant (g)*	*HI (%)*
2014	CK0	2.80	9.19	60.71
	CK1	4.60	21.39	62.16
	CK2	5.20	19.41	62.10
	T1	6.20	23.90	66.77
2015	CK0	3.00	9.91	56.62
	CK1	5.60	23.63	59.07
	CK2	5.20	21.25	60.11
	T1	6.40	24.87	61.55

Table 3: Effect of K$^+$ deficiency on plant biomass of wheat seedlings and shoot area at 4/8 days after transfer day (DAT).

DAT	*Treatments*	*Dry shoot weight (mg)*	*Dry root weight (mg)*	*Dry plant weight (mg)*	*Shoot area(cm^2)*
4	Control	36.16	14.62	50.78	33.41
	K deficiency	24.6	14.74	39.34	28.01
8	Control	48.1	19.12	67.22	55.03
	K deficiency	35.4	18.43	53.83	37.94

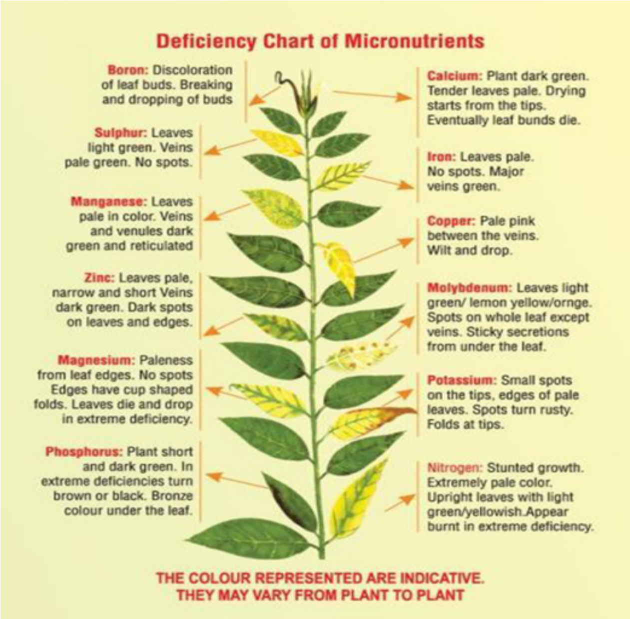

Fig. 1: Deficiency profile of Micronutrients Management used to overcome nutrient stress.

and abiotic stresses (drought, salinity, high temperatures, cold, UV stress, and nutritional toxicity or scarcity) at their low levels. Each component is important and has a role to play.

CASE STUDIES

(CK0, N fertilizer was not supplied during all stages of growth (blank control); CK1, constant supply of N throughout different stages of growth; CK2, constant N compensation at young panicle differentiation stage, after N deficiency at tillering stage; T1, double N compensation at young panicle differentiation stage, after N deficiency at tillering stage.)

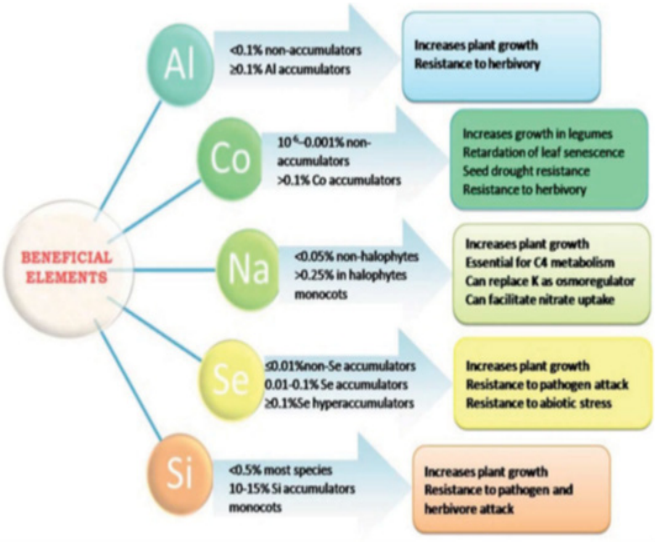

Fig. 2: Role of Beneficial element for Plant Growth and stress tolerance.

Xiong *et al.* (2018) tested the impact of nitrogen deficiency and compensation on grain production, nitrogen absorption and consumption, and rice physiological characteristics. The findings indicated that the yield per plant had a compensatory impact of the same degree. The number of productive panicles per plant was superior due to double N compensation. In 2014, different treatment classes had different yields and yield elements (Table 2). CK0 had the lowest yield per plant, effective panicle per plant, and 1000-grain weight, while T1 had the highest yield per plant, effective panicles per plant, and HI. In contrast to CK1, CK2, and T1, the yield per plant in CK0 was slightly different (P 0.05). T1 had an 11.73 percent higher yield per plant than CK1, but the disparity was not statistically important (P 0.05), indicating that T1 had an equal compensation effect (CI = 1.12). T1 had a 7.42% higher HI than CK1, which was statistically important (P 0.05).

In their experiment, (Thomburg *et al*., 2020) found that K+ deficiency had a substantial impact on wheat seedling aboveground growth and production but had no effect on root biomass. Dry shot weight, dry plant weight, and shoot area were all substantially reduced after 4 DAT and 8 DAT of K+ deficiency therapy as compared to controls as shown in (Table 3). In contrast, there was no significant difference in dry root biomass between the K^+ deficiency treatment group and the controls.

Conclusion

For deficient soil, better fertiliser management is becoming increasingly necessary for crop production. Nutrient deficiency in the soil has been a significant stumbling block to increasing growth. The demand for improved decision making for cereal production system has placed added emphasis on using proper factors of growth including nutrient management for better growth and productivity. For more than a century, mineral fertilisers have supported global agriculture, and thereby global population and wealth creation. Their commitment to the crop yield has saved millions of hectares of natural ecosystem that would otherwise have been turned to farmland. However, the lack of equilibrium in the agricultural environment, as well as the insufficient or excessive use of nutrients, remains a problem. Nutrients such as nitrogen, phosphorus often move beyond the bounds of agricultural field because of management practices used fail to achieve good congruence between nutrient supply and crop nutrient demand. Hence increasing proper nutrient supply continues to be a major challenge for world agriculture.

Aknowledgement

I am highly thankful to Dr. R.D. Tripathi Sir, Prof .Raihana. H. Kanth, for their support and guidance.

Reference

Amadou I, Gounga ME, Le G-W (2013) Millets: nutritional composition, some health benefits and processing—A review. Emirates Journal of Food and Agriculture. 25:501–508

Antisari LV, Carbone S, GattiA, Vianello G, Nannipieri P (2013) Toxicity of metal oxide (CeO2, Fe3O4, SnO2) engineered nanoparticles on soil microbial biomass and their distribution in soil. Soil Biological Biochemitry. 60:87–94.

Arnon., D. I and stout., P.R. 1939.The essentiality of certain elements in minute quantity for plants with special refrence to copper. Plant physiology.14(2)371-375.

Bashan Y, Kamnev A, de-Bashan LE (2013b) A proposal for isolating and testing phosphate-solubilizing bacteria that enhance plant growth. Biology and Fertility of Soils 49:1–2.

Brady,N.C and weil.,R.R.2008.The nature and properties of soil.15th edition .A handbook of soil science.ISBN-325448-8.

Bulgarelli D, Schlaeppi K, Spaepen S, van Ver Loren Themaat E, Schulze-Lefert P (2013).Structure and Functions of the Bacterial Microbiota of Plants. Annual Review of Plant Biology. 64:807–838.

Cakmak, I., McLaughlin, M. J., & White, P. (2017). Zinc for better crop production and human health. Plant and Soil, 411, 1–4.

Chen, Y.L.; Dunbabin, V.M.; Diggle, A.J.; Siddique, K.H.; Rengel, Z. 2013. Phosphorus starvation boosts carboxylate secretion in P-deficient genotypes of Lupinus angustifolius with contrasting root structure. Crop Pasture Science. 64, 588–599.

Chen L, Lin L, Cai G, Sun., Y and Huang., T. (2014). Identification of Nitrogen, Phosphorus, and Potassium Deficiencies in Rice Based on Static Scanning Technology and Hierarchical Identification Method. PLoS ONE. 9(11) 113200.

Chen LS, Sun YY, Wang K (2014). Identifying of rice nitrogen stress based on machine vision and multiscale information extraction. Sensing letters. 12:824–830.

Chen LS, Wang K (2014). Diagnosing of rice nitrogen stress based on static scanning technology and image information extraction. Journal of soil science plant nutrition.14(2):382–393.

Delcour JA, Hoseney R (2010) Principles of cereal science and technology. AACC International press, USA

Delgado, J.; Lemunyon, J. 2006.Nutrient management. In Encyclopedia of Soil Science 1157–1160.

DES, 2018. Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Agricultural Statistics at a Glance.

Dimkpa, C. O., & Bindraban, P. S. (2016). Fortification of micronutrients for efficient agronomic production: a review. Agronomy for Sustainable Development, 36(1), 7.

Dimkpa., CO,McLean JE, Latta DE,Manangón E, BrittDW, JohnsonWP, Boyanov MI, Anderson AJ (2012a) CuO and ZnO nanoparticles: phytotoxicity, metal speciation and induction of oxidative stress in sand-grown wheat. Journal of Nanoparticle Research 14:1125.

DimkpaCO, Latta DE,McLean JE, BrittDW, BoyanovMI,Anderson AJ (2013) .Fate of CuO and ZnO nano and micro particles in the plant environment. Environmental Science Technology 47:4734–4742.

Dobermann,A.,Witt,C.,Dawe, D.,Abdulrachman, S. Gines, H. Nagarajan, R.,Satawathananont, S., Son, T., Tan, P.S.,Wang, G.H.2002. Site–specific nutrient management of intensive rice cropping systems in Asia.Field Crops Research. 74, 37–66.

FAO (Food and Agriculture Organisation) (2002) World Agriculture: Towards 2015/2030. Summary Report. FAO, Rome.

FAO, 2017, Food and Agriculture Organization of the united Nations, Rome, Italy.

FAO-AMIS, 2017. Database. Food and Agriculture Organization of the united Nations.

Fernández V, Ebert E (2005) Foliar iron fertilization: a critical review. Journal of Plant Nutrition 28:2113–2124.

Gan, Y.; Siddique, K.; Turner, N.; Li, X.; Niu, J.; Yang, C.; Liu, L.; Chai, Q. 2013.Ridge–Furrow Mulching Systems–An innovative Technique for boosting crop productivity in Semiarid rainfed environments. Advanced Agriculture. 118, 430–476.

Genc.Y., McDonald. G. K., and Graham. R. D (2002). Critical deficiency concentration of zinc in barley genotypes different in zinc efficiency and its relation to growth responses. Journal of plant nutrition.25(3),545-560.

Ghafariyan MH, Malakouti MJ, Dadpour MR, Stroeve P, Mahmoudi M (2013) Effects of magnetite nanoparticles on soybean chlorophyll. Environmental Science Technology 47:10645–10652.

Goudia, B. D., & Hash, C. T. (2015). Breeding for high grain Fe and Zn levels in cereals. International Journal of Innovation and Applied Studies, 12(2), 342–354.

Gruhn, P.; Goletti, F.; Yudelman, M. Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture: Current Issues and Future Challenges; IFRPI 2020 Vision Brief; IFRPI:Washington, DC, USA, 2000.

Hemery Y, Chaurand M, Holopainen U, Lampi A-M, Lehtinen P, Piironen V, Sadoudi A, Rouau X (2011) Potential of dry fractionation of wheat bran for the development of food ingredients, part I: influence of ultra-fine grinding. Journal of Cereal Science .53:1–8.

Havlin JL, Beaton JD, Tisdale SL and WL Nelson (2005). Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 7th (ed.). Pearson Prentice Hall. New Jersey, 2005.

Jiwan., S. Sidhu and kabir.,Y. 2007. Functional foods from cereal grains. International journal of food properties,10:231-244.

Jones., C and Jacobsen., J.(2001). Plant nutrition and soil fertility. Nutrient Management Extension Publication .4449-2.

Joy, E. J., Stein, A. J., Young, S. D., Ander, E. L., Watts, M. J.,& Broadley, M. R. (2015). Zinc-enriched fertilisers as a potential public health intervention in Africa. Plant and Soil, 389(1–2), 1–24.

Kaur.S., Siddique., K. H. M., and Nayyer. H 2015.Beneficial elements for agriculture crops and their functional relevance in defence against stresses. Archieves of Agronomy and soil science.62:7,905-920.

Kihara, J., Sileshi, G. W., Nziguheba, G., Kinyua, M., Zingore, S., & Sommer, R. (2017). Application of secondary nutrients and micronutrients increases crop yields in sub-Saharan Africa. Agronomy for Sustainable Development, 37, 25.

Kim JH, Lee Y, Kim EJ, Gu S, Sohn EJ, Seo YS, An HJ, Chang YS (2014). Exposure of iron nanoparticles to Arabidopsis thaliana enhances root elongation by triggering cell wall loosening. Environmental Science Technology. 48:3477–3485.

Koele N, Kuyper TW, Bindraban PS (2014) Beneficial organisms for nutrient uptake. VFRC Report 2014/1. Virtual Fertilizer Research Center, Washington DC, p 63

Kow.,N and Nabwami.J,.2015. A Review of effects of nutrient elements on crop quality. African Journal of food, agriculture, nutrition and development.15(1)1684-5374.

Kumar,P.Yadava.,RK.Gollen.B.,kumar.,S.,Verma.RK.,Yadav.S.2011.Nutritional contents and medicinal properties of wheat. Life sciences and medicine research. (22) 1-10.

Li, C., Wang, C., Wen, X., Qin, X., Liu, Y., Han, J., Li, Y., Liao, Y., Wu, W.(2017) Ridge–furrow with plastic film mulching practice improves maize productivity and resource use efficiency under the wheat–maize double–cropping system in dry semi–humid areas. Field Crops Research. 203, 201–211

Liu R, Lal R. (2014). Synthetic apatite nanoparticles as a phosphorus fertiliser for soybean (Glycine max). Scientific Reports. 4:5686.

Marconi E, Graziano M, Cubadda R (2000) Composition and utilization of barley pearling by-products for making functional pastas rich in dietary fiber and b-glucans. Cereal Chemistry 77:133–139.

NIN, 2009. Nutrient Requirements and Recommended Dietary Allowances for Indians, National Institute of Nutrition, Hyderabad.

Nhamo, N.; Kyalo, G.; Dinheiro, V.2014. Exploring Options for Lowland Rice Intensification under Rain–fed and Irrigated Ecologies in East and Southern Africa: The Potential Application of Integrated Soil Fertility Management Principles. Advanced Agriculture. 128, 181–219.

Oprica DI, Cioroianu TM, Lungu M, Badea IA (2014) A New ecofriendly foliar fertilizer with bone glue suitable for crops of maize and sunflower. Review Chimica Acta. 65:1–7

Peng, S., Buresh, R.J., Huang, J., Zhong, X., Zou, Y.; Yang, J., Wang, G., Liu, Y.;,Hu, R., Tang, Q,2010. A Dobermann A decade of research on improving nitrogen fertilization in rice through site–specific nitrogen management in China. Agronomy for Sustainble Development 30, 649–656.

Pradhan S, Patra P, Das S, Chandra S, Mitra S, Dey KK, Akbar S, Palit P, Goswami A (2013) Photochemical modulation of biosafe manganese nanoparticles on Vigna radiata: a detailed molecular, biochemical, and biophysical study.Environmental Science Technology. 47:13122–13131.

Roco MC, Mirkin CA, Hersam MC (2011) Nanotechnology research directions for societal needs in 2020. Springer Science Policy Reports, New York.

Sarwar,M.H.,Sarwar,M.F.,Sarwar,M.,Qadri.,N.A and Moghal, S.2013.The importance of cereals (poeceae;Graminae) nutrition in human health:Areview.Journal of cereals and oilseeds.4,32-35.

Servin A, Elmer W, Mukherjee A, De La Torre-Roche R, Hamdi H, White JC, Bindraban PS, Dimkpa CO (2015) A review of the use of engineered nanomaterials to suppress plant disease and enhance crop yield. Journal of Nanoparticles Research. 17:92

Sharma, A., Yadav, A., Baig, V., Swarnkar, M., Singh, R. and Kumar, S. 2015. Malnutrituion and associated risk factors among under five childrens. Indian Journal of Community Health. 27 (3): 311-319.

Singh, A. K. and Singh, V. 2018. Effect of Foliar Application of Iron, Zinc and Age of Seedlings on Growth and Yield of Rice (Oryza sativa L.). International Journal of Current Microbiology and Applied Sciences 7(8): 1062-1068.

Thomburg. T.E, Liu.J., Li .Q., Xue.H ., Wang. G. Li.L., Fontana.,J.E.,. Davis.K.E., Wanying Liu Zhang.B, Zhang.Z., Liu ,M., and Pan.X (2020).Frontiers in Plant Science. (11)12-19.

Tsadik YYG, Emire SA (2015). Development of value added products from by-products of Ethiopian wheat milling industries. Journal Food Process Technology. 6:8.

Uphoff, N.; Ball, A.; Fernandes, E.C.M.; Herren, H.; Husson, O.; Laing, M.; Palm, C.A.; Pretty, J.; Sanchez, P.A.; Sanginga, N.(2006).Understanding the Functioning and Management of Soil Systems. In Biological Approaches to Sustainable Soil Systems; CRC Press: Boca Raton, FL, USA; 1–6.

Von Grebmer, K., Saltzman, A., Birol, E., Wiesman, D., Prasai, N., Yin, S., Yohannes, Y., Menon, P., Thompson, J., & Sonntag, A. (2014). Global hunger index: The challenge of hidden hunger. Bonn, Washington, D.C., and Dublin: Welthungerhilfe, IFPRI

Vitousek, P.M., Naylor, R.; Crews, T., David, M.B.; Drinkwater, L.E., Holland, E.,Johnes, P.J., Katzenberger, J., Martinelli, L.A., Matson, P.A.,(2009). Nutrient imbalances in agricultural development. Nature. 324, 1519–1520.

Wang J, Mao H, Zhao H, Huang D, Wang Z (2012a) Different increases in maize and wheat grain zinc concentrations caused by soil and foliar applications of zinc in Loess Plateau China. Field Crops Research 135:89–96

Wang Z, Xie X, Zhao J, Liu X, Feng W, White JC, Xing B (2012b). Xylem- and phloem-based transport of CuO nanoparticles in maize (Zea mays L). Environ Science Technology 46:4434–4441.

Wang, M.; Zheng, Q.; Shen, Q.; Guo, S. 2013.The critical role of potassium in plant stress response. International Journal of Molecular Science. 14, 7370–7390.

Wu, W.; Ma, B. 2015. Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: A review. Science Total Environment., 512–513, 415–427.

Wu, W.,Ma, B.L.2018. Assessment of canola crop lodging under elevated temperatures for adaptation to climate change. Agricultural For Meteorology. 248, 329–338.

Xiong.,Q.Tang.,G.Zhong.,L.He.,H. and Chen.,X.2018.Response to nitrogen deficiency and compensation on physiological characteristics, yield formation and nitrogen utilization of rice. Frontiers in plant science. (9)1075.

Zhang HM, Sun Y, Xie XT, Kim MS, Dowd SE, Pare PW (2009) A soil bacterium regulates plant acquisition of iron via deficiencyinducible mechanisms. Plant Journal 58:568–577.

Zhang, Y., Rongli, S. R., Rezaul, K.M., Zhang, F. and Zou, C. (2010). Iron and zinc concentrations in grain and flour of winter wheat as affected by foliar application. Journal of Agricultural and Food Chemistry 58(23): 12268-12274.

Zhang, F.; Cui, Z.; Chen, X.; Ju, X.; Shen, J.; Chen, Q.; Liu, X.; Zhang, W.; Mi, G.; Fan, M.(2012)Integrated nutrient management for food security and environmental quality in China. Advanced Agriculture. 116, 1–40.

Zhang, F.; Cui, Z.; Zhang,W. 2014. Managing nutrient for both food security and environmental sustainability in China: An experiment for the world. Front. Agriculture Science Engeneering. (1) 53–61.

Zhao.D., Reddy.K.R., Kakani.V.G., Reddy. V.R.(2004). Nitrogen deficiency effects on plant growth, leaf photosynthesis, and hyperspectral reflectance properties of sorghum. European journal of Agronomy (22) 391–403.

Zou, C. Q., Zhang, Y. Q., Rashid, A., Ram, H., Savasli, E., Arisoy, R. Z., et al. (2012). Biofortification of wheat with zinc through zinc fertilization in seven countries. Plant and Soil, 361, 119–130.