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IMPORTANCE OF MICRONUTRIENTS IN PULSE CROP

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Abstract

The growth, development, and overall productivity of pulse crops are all considerably aided by the presence of micronutrients. The micronutrients zinc (Zn), boron (B), iron (Fe), manganese (Mn), molybdenum (Mo), and copper (Cu) are essential for a variety of physiological and biochemical processes. In pulse crops, these micronutrients are also essential for nitrogen fixation, enzymatic activity, and photosynthesis. As a result of deficiencies in certain nutrients, the plant may experience stunted growth, a low yield, and a decrease in the quality of its seeds. Crop performance has been found to significantly increase when micronutrients are applied, whether by soil enrichment or foliar sprays. This is especially true when the crop is subjected to stressful circumstances. In addition, pulses that have been enhanced with micronutrients assist to the improvement of human nutrition, which helps to address the problem of micronutrient inadequateness. As a means of bolstering sustainable agriculture and ensuring food security, this abstract emphasises the need of using micronutrient management methods in order to improve the production of pulse crops and the nutritional value of these crops.

keywords: *Micronutrients, Pulse, Crops*

Introduction

In addition to supplying crucial proteins, necessary minerals, and dietary fibre for human nutrition, pulses also contribute to the fertility of soil through the process of biological nitrogen fixation. Pulses are an essential component of sustainable agriculture. Because of insufficient nutrition management, particularly with regard to micronutrients, the productivity of pulse crops frequently stays below satisfactory, despite the fact that they are of great importance. Zinc (Zn), iron (Fe), boron (B), manganese (Mn), molybdenum (Mo), and copper (Cu) are examples of micronutrients that are required in modest quantities but are essential for the metabolic processes that plants go through. These activities include enzyme activation, photosynthesis, and nitrogen fixation. It is becoming increasingly common for soils to have deficits in micronutrients as a result of extensive cropping, uneven fertilisation, and soil deterioration. Because of these deficits, the vigour of the crop may decrease, the pods may not form properly, and the quantity and quality of the pulses may suffer. In order to effectively address this dilemma, it is necessary to have a full understanding of the function that micronutrients play in the development and production of pulse crops. In this introduction, the significance of micronutrients in the cultivation of pulse crops is discussed. Particular attention is paid to the function that micronutrients play in plant physiology, the implications of deficiencies, and the possible advantages of incorporating micronutrient management strategies into cultivation systems. These kinds of activities are absolutely necessary in order to successfully satisfy the nutritional requirements of a growing population while also increasing the yield and sustainability of pulse crops. In pulse crops, the importance of micronutrients extends beyond the growth of the plant to include the effect on the health of the soil and the sustainability of the ecosystem. Biological nitrogen fixation is a process that is mediated by symbiotic bacteria in the root nodules of pulse crops. These nutrients play a crucial role in boosting chemical nitrogen fixation. Molybdenum and iron are two examples of micronutrients that have a direct role in the operation of nitrogenase enzymes. These enzymes are responsible for facilitating the transformation of atmospheric nitrogen into forms that plants can use. Inadequate levels of these nutrients can cause disruptions in the nitrogen fixation process, which in turn can result in poor plant growth and decreased soil fertility. In addition, pulses are acknowledged for the substantial contribution they provide to the problem of ensuring food and nutritional security. Consuming pulses that have been fortified with key micronutrients can be an effective way to treat malnutrition, particularly in areas where plant-based diets are the primary diet. Pulses that are high in iron and zinc, for instance, have the potential to assist in the reduction of prevalent deficiencies that can result in anaemia and stunted growth in humans. Therefore, the role that micronutrients play in pulses is congruent with the efforts that are being made all over the world to promote agricultural output as well as human health. The difficulty, on the other hand, is in efficiently addressing shortages in micronutrients in soils. Micronutrients are vital, but their needs are relatively low, and conventional fertilisation procedures tend to concentrate on macronutrients rather than micronutrients. This imbalance not only hinders the performance of crops, but it also makes the deterioration of soil worse over time. Innovative approaches, including as foliar sprays, biofortification of seeds, and fertilisers that are supplemented with micronutrients, have emerged as potentially useful methods to solve this problem. The purpose of this research is to attempt to offer a comprehensive examination of the relevance of micronutrients in the production of pulse crops. This presentation will examine the physiological functions that important micronutrients play, as well as their impact on crop production and quality, as well as effective management strategies that may be used to minimise deficiencies. Additionally, the article will emphasise the potential of pulse crops that are loaded with micronutrients in terms of improving global food security and combatting malnutrition.

Micronutrients function in pulses

It is well-documented that the legume class known as "pulses" contains a high levels of nutritious richness. As a result, they supply the body with the essential nutrients, both micro and macro, that it need in order to function correctly. When it comes to carrying out even the most fundamental of physical activities, the body need a consistent supply of macronutrients in order to function properly. Among the macronutrients, carbohydrates, proteins, and fats are the three most important ones. People who follow a vegetarian or vegan diet typically take pulses because of the large amount of protein that they contain. Pulses are an excellent source of fuel due to the presence of carbs, and they contain a negligible amount of fat. The term "micronutrients" refers to the nutrients that the body needs in extremely small amounts in order to continue functioning normally. Pulses are an excellent source of a considerable number of essential micronutrients, including:

Table 1: Micronutrients function in pulses

Nutrients	Functions in pulses
Iron	Pulses are a good source of iron, which is a mineral that is essential for the formation of healthy blood. Pulses may be found in abundant supply. Anaemia can be caused by a deficiency in iron, which is needed for the transportation of oxygen to the tissues of the body.
Zinc	Zinc is a mineral that is abundant in pulses and is necessary for healthy cell development, wound healing, and immune system function.
Magnesium	The considerable magnesium found in pulses is crucial for the correct functioning of muscles and nerves, as well as for regulating blood sugar and blood pressure.
Potassium	Peripheral blood has a high concentration of potassium, a mineral that is crucial for normal neurone, muscle, and fluid function.
B vitamins	In particular, pulses are rich in riboflavin, thiamine, and folic acid, all of which are B vitamins. Vitamins are essential for many bodily functions, including energy production, red blood cell production, and DNA replication. Because they include a variety of macro- and micronutrients, pulses are often considered a nutrient-dense meal. Incorporating pulses into your diet can have a positive impact on your health and wellness.

Key Micronutrients

Iron

Iron (Fe) is one of the most essential elements for living creatures and plays an important role in a variety of metabolic activities, including electron transport and the production of deoxyribonucleic acid. Fe is essential for the production of oxygen transport proteins in the human body, such as haemoglobin and myoglobin, as well as enzymes that are involved in electron transfer and oxidation-reduction reactions. This component of haemoglobin is responsible for transporting oxygen from the lungs to the tissues throughout the body. The Recommended Dietary Allowance (RDA) for iron is 8 milligrammes per day for adult males and 18 milligrammes per day for adult females, as stated by the Food and Nutrition Board of the Institute of Medicine, National Academy of Sciences. More than two billion people throughout the world are affected by iron deficiency, which is regarded to be the most prevalent of the numerous micronutrient deficiencies. It is also the primary factor that occurs in the development of anaemia. Loss of energy, dizziness, and poor pregnancy outcomes such as preterm deliveries, babies born with a low birth weight, delayed growth and development in newborns, and reduced cognitive abilities are all possible results that can be caused by this condition.

Zinc

Zinc is an additional essential mineral that is required by humans. It plays a role in a wide range of biological processes, including the facilitation of wound healing through its participation in membrane signalling systems, the promotion of cell growth and proliferation, the prevention of oxidative damage to cells through the quenching of reactive oxygen species, and the reduction of the risk of having a number of cancers, including prostate and pancreatic cancer. The recommended daily allowance (RDA) for zinc is 11 milligrammes per day for adult males and 8 milligrammes per day for adult females. There are a number of negative effects that can result from a zinc deficiency, such as a compromised immune system, recurring infections, mental illness, and developmental and reproductive delays. Due to the fact that it plays a large part in the process of cell division, it has a substantial impact on pregnant women.

Selenium

The human body is protected against infection, oxidative stress, and the advancement of cancer by se, which is a necessary micronutrient. Se is required for growth and development. The recommended daily intake (RDI) for selenium is 55 microgrammes per day for both males and females. Se deficiency has been linked to a number of disorders in humans, including Keshan, Keshin-Beck, and myxedematous cretinism, among others.

Iodine

In addition to being a key component of the thyroid hormones thyroxine (T4) and triiodothyronine (T3), iodine is also necessary for the appropriate development, growth, and metabolism of the developing body. For both adult males and females, the recommended daily intake (RDI) for iron is 150 microgrammes per day, as stated by the Food and Nutrition Board of the Institute of Medicine. Hypothyroidism, goitre, cretinism, mental retardation, and decreased fertility are all symptoms of iodine deficiency, which is also responsible for an increase in the number of deaths that occur during pregnancy and mortality in infants.Due to the fact that it is essential for the development of the brain, deficiencies that occur during pregnancy might result in cognitive impairment in the children. Deficiency of iodine in human populations is distinct from deficiencies of other micronutrients since it is prevalent in both underdeveloped nations and rich countries across the world. One possible explanation for this is that agricultural soils and diets based on cereals contain a relatively low concentration of this mineral.

Carotenoids

Pigments that are naturally generated by plants are known as carotenoids. Carotenoids can only be obtained from meals originating from plants because both people and animals are unable to produce them on their own. Carotenoids may be found in the human body, where they function as significant antioxidants and play a vital part in a variety of physiological processes. More than 600 different carotenoids have been identified thus far. Age-related macular degeneration can be avoided with the use of lutein and zeaxanthin. Not only does lutein lower the likelihood of developing cataracts, but it is also linked to the prevention of cardiovascular disease. It is essential for animals to consume vitamin A in order to maintain adequate eyesight, bone development, and cell division. As a result of its ability to stimulate osteoblastic bone formation and inhibit osteoclastic bone resorption, β-Cryptoxanthin plays a significant role in the process of bone development. Carotenoids possess powerful anti-cancer effects and shield cellular organelles from oxidative damage by effectively scavenging free radicals that are produced as a result of a variety of metabolic activities. Due to the fact that they increase the amount of iron that is available to humans from plant-based meals, carotenoids are regarded to be promoters of iron absorption. As an instance, it was claimed that the inhabitants of Venezuela had an improvement in their Fe status with the incorporation of vitamin A into their food options.

Folates

Folates are vitamins B9 that play a role as cofactors in a variety of metabolic processes that occur in the human body. These processes include nucleotide biosynthesis and amino acid metabolism. Folates are important for human growth and development since they are necessary for these processes. Folates are essential for the manufacture of a variety of biomolecules in plants, including lignin, alkaloids, and chlorophyll, including chlorophyll. Given that humans are unable to produce folates on their own, they must obtain their nutrition from either plant or animal sources. An insufficient amount of folates has been linked to an increased likelihood of developing a number of chronic disorders, including neural tube abnormalities, decreased cognitive function, Alzheimer's disease, cardiovascular diseases, and some forms of cancer. During pregnancy, it is strongly suggested that women consume diets that are rich in folate since these diets successfully minimise the risk of neural tube abnormalities in babies. There is a correlation between insufficient folate consumption during pregnancy and an increased risk of premature birth as well as foetal development disturbance. researchers found a link between the amount of folate in seminal plasma and the amount of folate in blood plasma; hence, folates are also essential for the reproductive health of humans.

Importance of Boron and Zinc in pulses

Boron and zinc are two examples of micronutrients that are of utmost significance for plants of all types, including pulse crop plants. Pulses are consumed all over the world because of the large amount of protein that they contain, and there is a particularly strong demand for them in regions that have a lower protein consumption per capita. In spite of the fact that pulses require only minute quantities of boron and zinc, the absence of these elements can have a major influence on the development, growth, and output of the plant. Cell division and differentiation are processes that are essential for the growth and development of plants. Boron is required for both of these processes. According to Killilea, D. W. and Killilea, A. N. (2022), it has a significant impact on the metabolism of three different types of molecules: proteins, nucleic acids, and carbohydrates. According to Dong, Z., et al. (2023), the structural integrity of plants is significantly dependent on their cell walls, and boron possesses a significant function in the creation of these cell walls. The absence of boron in pulses can result in the stems being brittle, the roots not growing properly, and the leaves becoming unusually tiny and malformed (Cakmak, I. et al., 2023). These side effects can be caused by a lack of boron. Additionally, a deficiency in boron might lead to a decrease in the generation of seeds and agricultural yields (Yin, A., et al., 2021). Boron has a crucial role in the development of flowers and fruits. Zinc is an essential micronutrient for the growth and development of pulses, which are dependent on it extensively. In addition to its participation in the processes of photosynthesis, hormone production, and protein synthesis (Zafar, M., et al., 2023), it is also involved in a variety of other activities. Zinc is an essential precursor for enzymes that catalyse processes like as photosynthesis, respiration, and the breakdown of carbohydrates. These enzymes are vital to the process. Deficiency in zinc in pulses can cause a number of symptoms, including stunted development, yellowing of the leaves, and decreased yields (Saquee, F. S. et al., 2023); therefore, it is essential to ensure that you consume an adequate amount of this mineral. Because zinc deficiency can interfere with the process of seed germination and the growth of seedlings, it is essential to ensure that sufficient amounts of this mineral are present prior to planting. It is especially significant that pulses are relevant in developing nations since the diets of these countries typically lack important micronutrients. It is also important to note that children and pregnant women are more susceptible to the adverse consequences that a deficiency in these micronutrients can have on their health and well-being. Given the fact that a large number of people rely on pulses as their major source of protein in their diet, it is of the utmost importance that they be grown with sufficient quantities of boron and zinc in order to ensure that they grow and develop to their full potential and to safeguard the health of those who consume them.

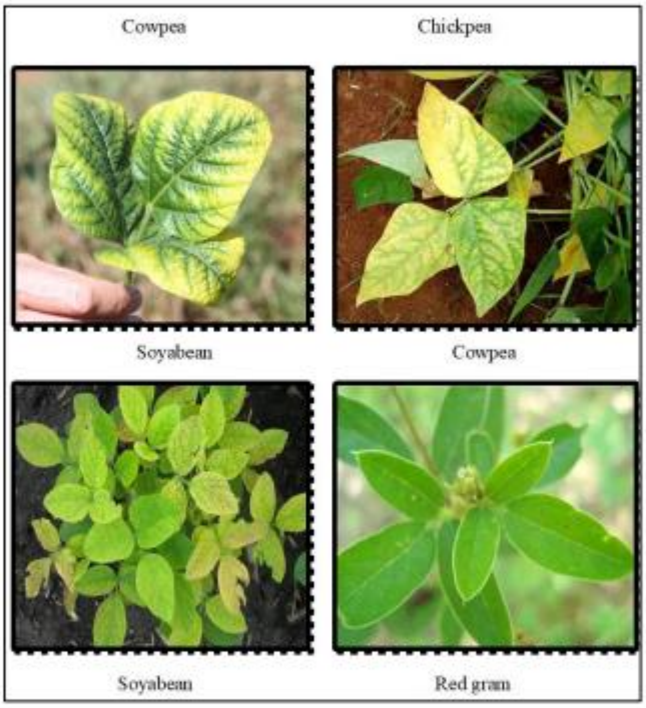
Signs and symptoms of nutritional deficiencies in pulse crops

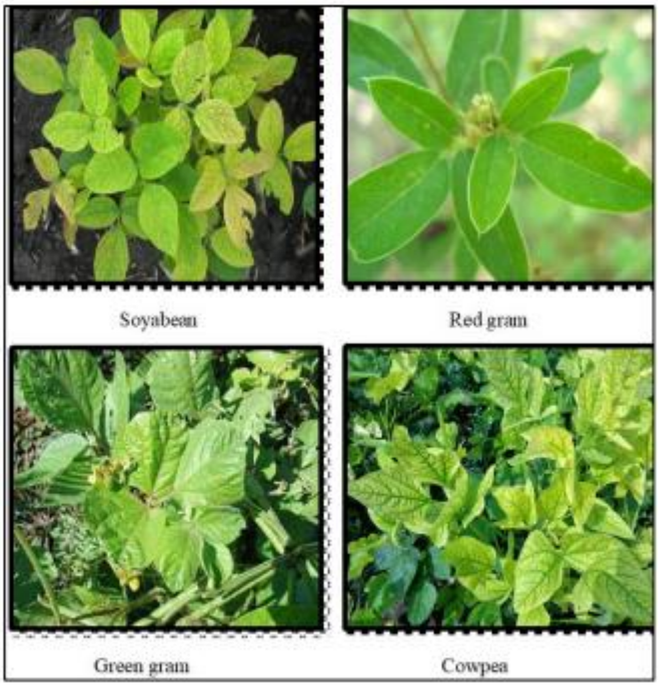
Characteristics and deficits that are frequently seen in pulse crops

Table 2: The pulse crops exhibit a variety of symptoms and deficiencies in terms of nutrients.

S. No	Crop Name	Nutrient	Deficiency symptoms
1.	Cowpea	Nitrogen	In general, the growth is stunted, and the leaves have a light green colour. a smaller leaf size and a reduced amount of foliage. Eventually, the leaves that are older will turn yellow and perish. The blooming and pod development process is delayed. a decrease in seed output and a reduced size of the seeds
2.	Chickpea	Phosphorus	The leaves have a purple hue and their development has been stunted. The growth of roots and branches was diminished. The blossoming is weak and the maturity is delayed. Seed development that is poor and seed size that is lower. A higher risk of contracting infections and being attacked by pests.
3.	Soyabean	Potassium	The yellowing of the leaf edges and tips, also known as chlorosis. Necrosis or marginal scorching of elder leaves might be observed. a reduction in leaf size as well as a curling of the leaf margins? stems that are weak and lodging. development of pods and seed size were both reduced.
4.	Cowpea	Magnesium	There is a condition known as interveinal chlorosis, in which the veins continue to be green but the spaces between them turn yellow. It is possible for leaves to have a "marble" look because of the presence of

			green veins and yellow areas. Necrosis can cause the leaves to arch upwards and exhibit symptoms of curling. slowed growth and dropped leaves before their time. both the creation of pods and the development of seeds fell.
5.	Soyabean	Iron	There is a condition known as interveinal chlorosis, in which the veins continue to be green but the spaces between them turn yellow. To a greater extent, younger leaves are harmed, although older leaves may continue to be green. plants with stunted growth and reduced development. Flowers blooming later than expected and inadequate pod development. Both the number of seeds produced and their size have decreased.
6.	Red gram	Zinc	The younger leaves are affected by chlorosis that occurs between the veins. It's possible that the leaves will have some brown spots or necrotic regions. Leaf size was reduced, and the form of the leaf was twisted. Poor pod formation and delayed maturity are also symptoms. Irregular seed growth and decreased seed output are both symptoms.
7.	Green gram	Boron	Stems: Stems that are brittle, hollow, and weak, with a decreased diameter, which can cause plants to topple over. Stems may also develop a brown colour. Stunted growth and a decrease in plant height describe the plant's growth. Reduced root growth and black root appearance in the roots Flowers: A significant decrease in the total quantity of flowers Decreased fruit and pods that are malformed and contain fewer seeds indicate fruit set.
8.	Cowpea	Manganese	Although it is similar to iron insufficiency, interveinal chlorosis is characterised by a more prominent yellowing between veins. These necrotic patches and symptoms of brittleness might appear on the leaves of the plant. plants with stunted growth and reduced development. Flowers blooming later than expected and inadequate pod development. Both the number of seeds produced and their size have decreased.





Zinc and Boron's Impact on Plant Yield and Characteristics

Boron is a micronutrient that is essential for the growth and development of plants. It is essential for several processes, including the creation of cell walls, the extension of roots, the production of pollen, and the maturity of fruits and vegetables. Boron's relevance does not end there; it is also necessary for the body to absorb and make use of nutrients such as nitrogen, phosphorus, and potassium (Behera, B., et al., 2023) in order to function properly. Boron is applied to pulses, which results in improvements in plant growth, production, and quality attributes. The research suggests that a deficiency in boron may have a negative impact on the quality of legume seeds, as well as their yield and nodulation. According to Kirkby,

E. A. (2023), the presence of boron is optimal for the development of root nodules, which are particularly important for the process of nitrogen fixation in legumes. It has been demonstrated that the injection of boron results in an increase in the amount of protein stored in pulse crops such as chickpea and lentil. According to Kafeel, U., et al. (2023), the capacity of boron to enhance the activity of enzymes involved in nitrogen metabolism may be responsible for the increased protein accumulation that occurs in the seed. On the other hand, an excessive amount of boron can be detrimental to plants, leading to a restricted growth pattern and a reduced yield of fruits and vegetables. The quantity of boron that should be administered should be determined by soil testing and the requirements of the crop. In the presence of boron, the growth, production, and quality characteristics of pulses crops, such as the development of roots, the formation of nodules, and the amount of protein found in seeds, are all positively impacted. However, in order to avoid toxicity, the exact quantity of boron that is utilised should be maintained. The presence of zinc, a vitamin, is essential for the growth and development of plants. There are a great number of physiological activities that are dependent on it, some of which include photosynthesis, glucose metabolism, hormone production, and protein synthesis. It is needed for all of these processes. When it comes to enhancing output and quality in pulse crops like lentils, chickpeas, and beans, zinc is a vital component.

Key roles of zinc element in plant yield and attributes in pulse crops

Table 3: The roles that zinc plays in the production of plants and their characteristics in pulse crops

Zinc element roles in plants	Description
Improved seed germination	Zinc is essential for the production of enzymes that are responsible for breaking down the stored food reserves in seeds, and without zinc, germination cannot take place. It has been established that zinc deficiency is associated with low seed germination and yields (Nautiyal, P.C., et al., 2023).
Enhanced root development	Plants require zinc in order to develop strong roots that are able to absorb a greater quantity of nutrients and water (Rizzo, A. J., et al., 2023) and to flourish. There is a possibility that zinc deficiency could inhibit root development in plants, which will in turn limit their capacity to absorb nutrients and lead to decreased yields.
Increased plant growth	Zinc is an essential component in the production of plant growth hormones, some of which include auxins. These hormones play an important role in regulating the growth and development of plants. According to Kaur, H., et al. (2023), a deficiency in zinc in the soil may cause plants to develop more slowly and produce a less quantity of fruits and vegetables.
Improved resistance to stress	Zinc's capacity to withstand a wide range of abiotic conditions, such as drought and high temperatures, is beneficial to plant life. In their study, Mishra D. and

	colleagues (2023) indicate that it plays a part in the development of antioxidants, which are substances that protect plants from oxidative stress and cell damage.
Better quality crop	Because zinc is necessary for the production of proteins, it is of utmost importance to the health of plants. Both the protein content and the nutritional value of crops that are zinc deficient may be reduced (Pagano, A., et al., 2023) as a result of zinc deficit.

Conclusion

Micronutrients are indispensable for the optimal growth, productivity, and quality of pulse crops. They play vital roles in physiological processes such as nitrogen fixation, enzymatic activity, and chlorophyll synthesis, which are critical for the overall health and yield of the plants. Deficiencies of key micronutrients, including zinc, iron, boron, manganese, molybdenum, and copper, not only affect crop performance but also reduce the nutritional quality of pulses, limiting their ability to address human dietary needs. Adopting sustainable micronutrient management practices, such as soil testing, targeted supplementation through micronutrient-enriched fertilizers, and foliar applications, can significantly enhance the productivity and nutritional value of pulses. Additionally, biofortification strategies offer a dual advantage of improving soil fertility while delivering micronutrient-rich crops to consumers, thereby addressing global challenges of malnutrition and food security. The integration of micronutrient management into pulse crop cultivation systems is essential for achieving higher yields, better quality, and sustainable agricultural practices. Future research should focus on optimizing application methods, understanding soil-plant interactions, and developing innovative technologies to efficiently manage micronutrient deficiencies. By prioritizing micronutrient management, farmers, researchers, and policymakers can collectively contribute to ensuring food security, improving public health, and sustaining the environment.

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