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Role of boron and zinc in growth & production of pulse crops

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Abstract
Pulses crops require the micronutrients boron and zinc in order to flourish. Zinc is required for enzyme activation, photosynthesis, and protein synthesis, while boron is important for cell wall formation, cell division, and sugar transport. Seed germination, root growth, plant growth, yield, and quality of pulses crops are all improved by an adequate and well-balanced application of boron and zinc. Reduced crop establishment, growth, production, and quality may result from insufficient amounts of certain micronutrients. Therefore, it is essential for sustainable agriculture and food security to gain insight into the function of boron and zinc in the cultivation of pulses crops.

Keywords: Boron, Zinc, micro and macro nutrients, sustainable agriculture, crop production, enzyme activation, photosynthesis

Introduction
Due to its high protein content, pulses have gained significant importance as a food crop worldwide and inside India. P. K. Joshi & P. P. Rao (2017) [6]. Dietary pulses play a significant role. It plays a significant part in combining and intercropping different crops. The most efficient crop requires a negligible amount of water compared to others. Add nitrogen from the air to the soil. The majority of pluses are either non-manured or require minimal manuring. It grows rapidly, makes good profits, helps agriculture and the environment, and is a vital source of protein. Sustainability. Some pulses are used as green manure and tilled into the soil. As a leguminous plant, they have a beneficial effect on the ecosystem because of their ability to fix nitrogen. Grown in tandem with crops, they require less fertilizer Akibode, C. S., & Maredia, M. K. (2012) [1]. Pulses are grown in vast quantities in India. The protein level of pulses, at 20–25% by weight, is double that of wheat and three times that of rice. Despite this, it is the largest pulse crop worldwide. Since pulses are pooled, the country's food grain output is only 7.10% Singh, N. (2017) [20]. Pulses can be cultivated in a wide range of environments. After grains, it is the second most common food group in India. More than 95% of the country's total pulses production comes from just a few varieties, including grass pea, lentil, Mung bean, chickpea, Black gramme, Pigeon pea, cowpea, etc. (Siddiq, M., *et al.*, 2022) [18]. India is responsible for 33% of the world's pulses area and 22% of global production. Rainfed farming accounts for the vast majority of its production in India; only 8% of the country's 22.47 million hectares of pulses crop land is irrigated. India has the potential to produce 2500–3500 kg ha^{-1} (tonnes) of pulses annually, but only produces 550–625 kg ha^{-1} (tonnes). This is significantly lower than the yields achieved in the United States and China, where the average is 1600–900 kg ha^{-1}. Other factors contributing to the low productivity of pulses include the fact that they are grown on marginal and sub-marginal land, in rainfed conditions, with low input usage (less than 15% It is both the largest producer (17–19 MMT) and consumer (21–23 MMT). In the last five decades, production of pulses has increased from 13 million to 19 million tonnes, and today there are 23 mha. Imports of between 0.5 and 1.5 mt are necessary since production has not kept up with rising demand (Zhang, N., *et al.*, 2022) [24]. Since pulses have been forced onto low endorsed land, with a riskier produce condition, the country's production of pulses has increased just marginally over the previous two and a half decades. They ensure soil fertility and prevent nitrogen loss, and they are being developed and promoted to mitigate the effects of drought. Pulse crop byproducts make excellent animal feed. Rainfed regions are ideal for growing pulses since they require less water and have other favorable conditions, such as:

- Access to high-yielding plants that thrive in a variety of climates and soil types.

- Technology advancements in crop production
- Increased adoption of cutting-edge farming and production methods by educating and empowering farmers.

Micronutrients function in pulses

The nutritional density of the legume class known as "pulses" is well-documented. They provide vital nutrients, both micro and macro, that the body needs to function properly. In order to carry out even the most fundamental of physical processes, the body needs a steady supply of macronutrients. Carbohydrates, proteins, and fats are the three main macronutrients. Because of its high protein content, pulses are frequently consumed by vegetarians and vegans. The carbohydrates in pulses are a great source of fuel, and they contain very little fat. Micronutrients are nutrients required by the body in minute quantities to maintain normal functioning. Pulses are a good source of many important micronutrients, such as:

Table 1: Micronutrients function in pulses

Nutrients	Functions in pulses
Iron	Iron, a mineral necessary for the development of healthy blood, may be found in plentiful supply in pulses. A lack of iron, which plays a role in carrying oxygen to bodily tissues, can cause anemia.
Zinc	Zinc, found in abundance in pulses, is an essential mineral for proper immune system function, wound healing, and cell growth.
Magnesium	Magnesium, which is abundant in pulses, is essential for proper muscle and nerve function, as well as maintaining healthy blood sugar levels and blood pressure.
Potassium	Potassium, a mineral essential for proper fluid balance, muscle, and nerve function, is abundant in pulses.
B vitamins	Folate, thiamine, and riboflavin are just a few of the B vitamins that can be found in abundance in pulses. Vitamins play critical roles in generating energy, making new blood cells, and copying genetic material (DNA). Pulses, in general, are a nutrient-dense food because they supply several macro- and micronutrients. Pulses are a great food to add to your diet if you're looking to improve your health and well-being.

Micro and Macro Nutrient status if soil

Soil's micro and macro nutrient status can differ greatly from one location and climate and soil type to the next (Bhatt, R., *et al.*, 2023) [3] due to these and other factors. However, pulses (legumes) in general have a few distinguishing features that make them great for soil fertility. Some of the most important macro and micronutrients for pulses are listed below:

Macronutrients

Table 2: Shows the difference between micro and macro nutrient

Micro and Macro Nutrient	Important status of soil
	Macro nutrients
Nitrogen	The nitrogen in the air can be converted into a form that legumes can use thanks to the symbiotic link between legumes and nitrogen-fixing bacteria. As a result, unlike other crops, nitrogen is not always a limiting factor for pulses (Simon, Z., *et al.*, 2014) [19].
Phosphorus	Root growth, seed production, and cellular respiration are all facilitated by phosphorus. Because their seed is so phosphorus-rich, legumes have a higher phosphorus demand than most other crops (Simon, Z., *et al.*, 2014) [d19].
Potassium	Potassium aids in water regulation, disease resistance, and enzyme activity in plants. In comparison to other crops, legumes have a relatively low potassium demand (Simon, Z., *et al.*, 2014) [19].
	Micronutrients
Iron	Legumes rely on iron for processes including photosynthesis, respiration, and nitrogen fixation. Chlorosis (leaf yellowing) is a symptom of iron insufficiency (Krouma, A., *et al.*, 2012) [11].
Zinc	Legumes require zinc for proper seed development and general plant growth (Yusefi-Tanha, E., *et al.*, 2013) [22].
Manganese	Yusefi-Tanha, E., *et al.* (2013) [22] found that legumes require manganese for proper photosynthesis and enzyme activity.
Copper	Protein synthesis and disease resistance are two of the many functions that copper serves in legumes (Yusefi-Tanha, E., *et al.*, 2013) [22].

Organic matter in the soil, in addition to enhancing soil structure and water-holding capacity, is beneficial to legumes. Nutrient availability for legumes can also be affected by soil pH (Nath, C. P., *et al.*, 2023) [13]. It's worth noting that different types of pulses and growth environments may have different nutrient needs. Soil testing and discussions with a local agronomic or extension agent are essential for understanding your pulse crop's unique nutritional requirements.

Importance of Boron and Zinc in pulses

Micronutrients like boron and zinc are extremely important for plants of all kinds, including pulses. Pulses are consumed all around the world due to their high protein content and notably high demand in areas with lower per capita protein intake. Even though pulses only need trace amounts of boron and zinc, a lack of these elements can have a significant impact on the plant's development, growth, and production.

Growth and development of plants rely on cell division and differentiation, processes that boron is necessary for. The metabolism of carbohydrates, nucleic acids, and proteins all benefit greatly from it (Killilea, D. W., & Killilea, A. N., 2022) [9]. Plants' structural integrity relies heavily on their cell walls, and boron plays a crucial role in their formation (Dong, Z., *et al.*, 2023) [5]. The lack of boron in pulses can cause the stems to become brittle, the roots to not grow properly, and the leaves to become abnormally small and misshapen (Cakmak, I. *et al.*, 2023) [4]. Lack of boron can also reduce

seed production and crop yields (Yin, A., *et al.,* 2021) [21]. Boron is essential for floral and fruit growth.

Pulses rely heavily on the micronutrient zinc for proper growth and development. In addition to playing a role in photosynthesis, hormone synthesis, and protein synthesis (Zafar, M., *et al.*, 2023) [23], it is also engaged in a number of other processes. Enzymes that catalyze reactions including photosynthesis, respiration, and the breakdown of carbohydrates rely heavily on zinc as a precursor. Stunted development, leaf yellowing, and reduced yields are all symptoms of zinc deficiency in pulses (Saquee, F. S. *et al.*, 2023) [17] so making sure you get enough of this mineral is important. Seed germination and seedling growth can be slowed by a lack of zinc, therefore it's important to get enough of this mineral before planting.

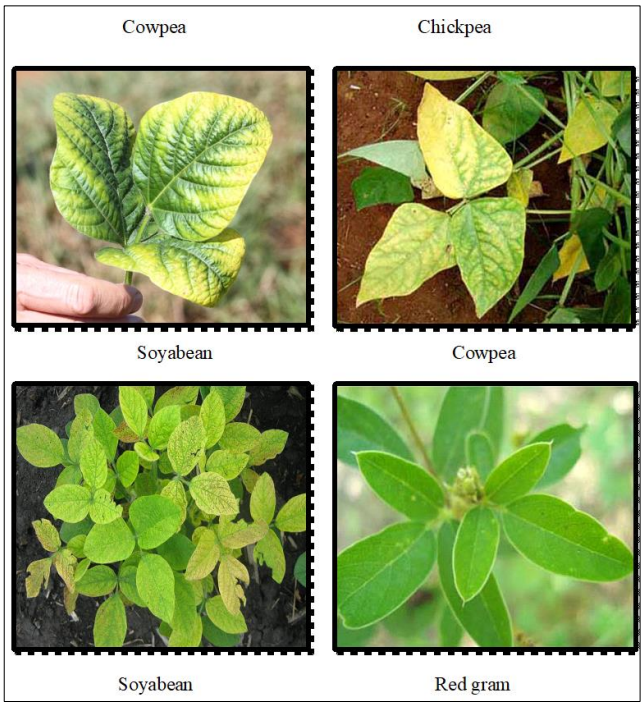
In developing countries, where diets generally lack essential micronutrients, pulse's relevance is especially noteworthy. Children and pregnant women are particularly vulnerable to the negative effects of a lack of these micronutrients on their health and wellbeing. Since so many people rely on pulses as a primary source of dietary protein, it is crucial that they be cultivated with adequate amounts of boron and zinc to promote optimal growth and development and protect the health of those who eat them.

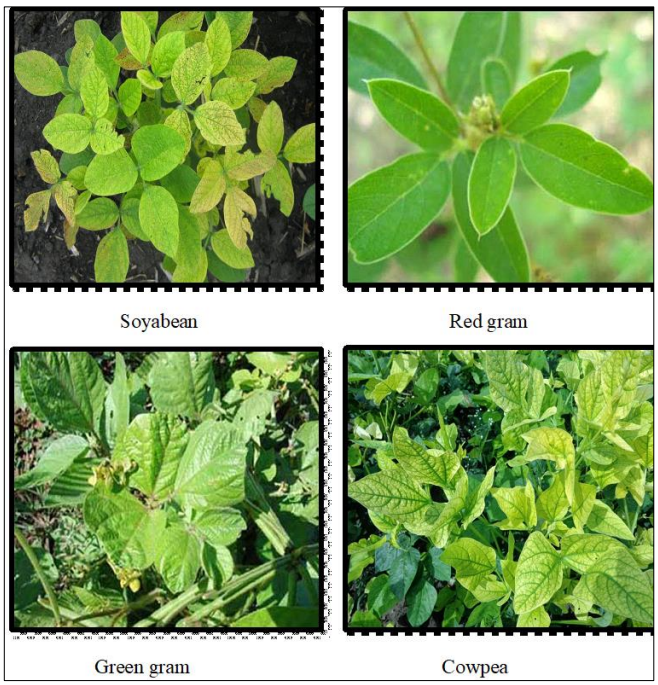
Different nutrients deficiency and symptoms in the pulse's crops

The common deficiencies and symptoms in pulses crops

Table 3: Different nutrients deficiency and symptoms in the pulse's crops

S. No	Crop Name	Nutrient	Deficiency symptoms
1.	Cowpea	Nitrogen	Overall stunted growth and pale green color of leaves. Reduced leaf size and sparse foliage. Older leaves turn yellow and eventually die. Delayed flowering and pod formation. Reduced seed production and smaller seed size
2.	Chickpea	Phosphorus	Stunted growth and purplish discoloration of leaves. Reduced branching and root development. Delayed maturity and poor flowering. Poor seed formation and smaller seed size. Increased susceptibility to diseases and pests.
3.	Soyabean	Potassium	Chlorosis or yellowing of leaf margins and tips. Marginal scorching or necrosis of older leaves. Reduced leaf size and curling of leaf margins. Weak stems and lodging. Reduced pod development and seed size.
4.	Cowpea	Magnesium	Interveinal chlorosis, where the veins remain green while the areas between them turn yellow. Leaves may exhibit a "marble" appearance due to green veins and yellow patches. Leaves may curl upwards and show signs of necrosis. Reduced growth and premature leaf drop. Reduced pod formation and seed development.
5.	Soyabean	Iron	Interveinal chlorosis, where the veins remain green while the areas between them turn yellow. Young leaves are more affected, while older leaves may remain green. Reduced growth and stunted plants. Delayed flowering and poor pod development. Reduced seed production and smaller seed size.
6.	Red gram	Zinc	Chlorosis between the veins, affecting younger leaves. Leaves may exhibit small brown spots or necrotic patches. Reduced leaf size and distorted leaf shape. Delayed maturity and poor pod formation. Reduced seed production and abnormal seed development.
7.	Green gram	Boron	**Stems:** Brittle, hollow, and weak stems with a reduced diameter which can lead to plants falling over. Stems may also turn brown. **Growth:** Stunted growth and reduction in plant height **Roots:** Reduced root development and black root **Flowers:** Reduction in the number of flowers **Fruit set:** Decreased fruit and deformed pods with fewer seeds
8.	Cowpea	Manganese	Interveinal chlorosis, like iron deficiency, but with more pronounced yellowing between veins. Leaves may develop necrotic spots and show signs of brittleness. Reduced growth and stunted plants. Delayed flowering and poor pod development. Reduced seed production and smaller seed size.





Role of Zinc and Boron in plant yield and attributes

Plants can't flourish and expand without the micronutrient boron. It's crucial for things like cell wall formation, root expansion, pollen generation, and fruit and vegetable maturation. Boron's significance doesn't end there; it's also required for the absorption and use of nutrients like nitrogen, phosphorus, and potassium (Behera, B., *et al.*, 2023) [2] in the body. Plant growth, yield, and quality traits are all improved by boron application in pulses. Legume seed quality, yield, and nodulation might all suffer from a lack of boron, according to the research. Root nodules, which are essential for nitrogen fixation in legumes, develop best in the presence of boron (Kirkby, E. A., 2023) [10]. The protein content of pulses crops like chickpea and lentil has been shown to increase after boron administration. Increased protein buildup in the seed may result from boron's ability to stimulate the activity of enzymes involved in nitrogen metabolism (Kafeel, U., *et al.*, 2023) [7]. However, too much boron can be harmful to plants, resulting in stunted development and fewer fruits and vegetables. Soil tests and crop needs should inform the amount of boron that should be applied. The growth, production, and quality aspects of pulses crops, such as root development, nodulation, and seed protein content, are all positively affected by boron's presence. However, the precise amount of boron should be used to avoid toxicity. Plants can't flourish without the presence of zinc, a vitamin. It's essential for photosynthesis, glucose metabolism, hormone synthesis, and protein synthesis, to name a few of the many physiological processes that rely on it. Zinc is essential for increasing production and quality in pulse crops including lentils, chickpeas, and beans.

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

Table 4: Roles of zinc element in plant yield and attributes in pulse crops

Zinc element roles in plants	Description
Improved seed germination	Germination cannot occur without zinc because it is used to make enzymes that break down the seeds' stored food stores. Low seed germination and yields have been linked to zinc deficiency (Nautiyal, P.C., *et al.*, 2023) [14].
Enhanced root development	Plants need zinc to grow robust roots that can take up more nutrients and water (Rizzo, A. J., *et al.*, 2023) [16] and thrive. Root growth can be hindered in zinc-deficient plants, which can restrict their ability to absorb nutrients and result in lower yields.
Increased plant growth	Plant growth hormones, such as auxins, are crucial in controlling plant growth and development, and zinc is a necessary component in their formation. Lack of zinc in the soil may cause plants to grow slowly and produce fewer fruits and vegetables (Kaur, H., *et al.*, 2023) [8]
Improved resistance to stress	Plants benefit from zinc's ability to resist a variety of abiotic stresses, including drought and high temperatures. Mishra D. *et al.* (2023) [12] explain that it has a role in the formation of antioxidants, which protect plants from oxidative stress and cell damage.
Better quality crop	Protein synthesis requires zinc, which is why it's so crucial to plant health. Protein content and nutritional value of zinc-deficient crops may be diminished (Pagano, A., *et al.*, 2023) [15] due to zinc deficiency.

Conclusion

In conclusion, zinc is a vital element for pulse crops, increasing both productivity and quality. Seed germination, root growth, plant expansion, resilience to stress, and protein synthesis all rely on it. By using the right fertilization techniques, farmers can increase crop yields and quality by maintaining optimum soil zinc levels. Pulse crops rely heavily on boron and zinc for their development and growth. Zinc is important in enzyme activity and protein synthesis, while boron is essential for cell wall production and seed development. Pulse crops' productivity and quality might suffer from any nutritional deficiency. Farmers need to keep an eye on their crops' nutritional levels and use boron and zinc fertilizers as needed to maintain healthy plant growth and high yields. However, high quantities of these minerals can be hazardous to plants, thus care must be taken to avoid over-

fertilization. In general, optimizing the yield and quality of pulse crops requires careful boron and zinc management.

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