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Nutrient Management in Chickpea for Yield Maximization

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Chickpea is a vital global legume known for its high nutritional content and economic value. The productivity of chickpea is constrained by many factors including soil degradation and nutrient deficiencies. This report focuses on the role of micro and macronutrients (N, P, L, Zn, B, Mo) in improving plant development, growth and overall yield. Few practices, especially integrated nutrient management (INM), combining with biofertilizer provide potential in optimizing the soil fertility, restoring soil health and increasing productivity. Additionally, biofortification strategies are emerging to improve the nutritional profile of chickpea. The main challenges, despite these advancements and adaptability of chickpea, includes soil variability limited access of agricultural technologies remain. Future strategies should focus on promoting INM biofortification and integrating advanced agricultural practices to ensure sustainable chickpea production
Keywords: Chickpea, Integrated Nutrient Management

INTRODUCTION

Chickpea (Cicer arietinum L.) is the third world's largest grain legume crop in arid and semi-arid regions due to its adaptability, nutritional benefits, and role in sustainable agriculture. Chickpea is cultivated on approximately 17.8 million hectares worldwide, it is grown on approximately 17.8 million hectares, with an annual production of 17.2 million tons hectares[1]. The main producer of chickpea is india (65%), Pakistan (10%), Iran (8%) and Turkey (5.5%) [2, 3]. The chickpea benefits extend beyond its dietary importance. As a legume, chickpea contributes to food solutions, providing soil fertility, and stability of economic regions majorly like India because of dominant cultivation followed by Pakistan and Turkey[4]

Despite the resilience, Chickpea productivity remains constrained by suboptimal nutrient management, degraded soils, and water stress in rainfed areas. However, challenges such as nutrient depletion, especially in rainfed and degraded soils, have limited the productivity of chickpea crops in various regions. [5] Nutrient imbalance is one of the major abiotic constraints limiting chickpea's productivity but balanced fertilization with major and micronutrients can enhance chickpea production to the extent. Micronutrients play an important role in increasing the yield of pulses. The deficiencies of micronutrients like zinc (Zn), boron (B), and molybdenum (Mo) and imbalance macronutrients such as phosphorus (P), Nitrogen (N), and potassium (P) significantly limits yields and growth of chickpea. Furthermore, the studies also highlight the impact of these nutrients on the pod formation and seed weight and quality and overall yield. [6]

This report explores the key findings from the previous studies to explore effect of nutrient management strategies. This study includes key practices including the use of biofertilizer and nutrients which gives a roadmap in maximizing chickpea yields. (micronutrient10.pdf).It also discusses the challenges and role of agriculture in mitigation of these issues (micronutrients5pdf)

Macronutrients in Chickpea cultivation

Effective nutrition management comprises administering vital macronutrients, micronutrients, biofertilizers, and organic compounds. The objective is to maximize nutrient accessibility, improve soil fertility, and facilitate the symbiotic processes essential for leguminous crops. The macronutrients, especially Nitrogen (N), phosphorus (P), and potassium (K) play a vital role for improving chickpea growth and affecting the development of roots. [7] Nitrogen play role in chlorophyl synthesis and protein production and particularly improves initial growth stages derived from nitrogen fixation or nitrogen fertilizers, while Phosphorus plays a critical role in nodulation and enhancing nitrogen fixation and improving the overall yield and phosphate solubilizing bacteria can enhance the availability of phosphorous and make it more helpful to increase nodulation and overall yield by regulating the water balance, enzyme activation and disease resistance. Previous experiments demonstrate that the application of 20:40:20 kg N:P2O5:K2O per hectare improves root nodulation, seed yield and enhance enzymatic functions and biomass[8]

Impact of Micronutrients and integrated Nutrient Management:

The nutritive value of chickpea provides 18–22% protein, 61–62% carbohydrates, and 4.5% fat and essential micronutrients such as Calcium (280 mg/100 g) Iron (12.3 mg/100 g) and Phosphorus (301 mg/100 g).[9, 10]

Micronutrients such as zinc (Zn), boron (B), and molybdenum (Mo) are essential to improving chickpea productivity. Zinc (Zn) deficiency limits the crop maturity and is required for enzyme activation, plant metabolism and the stability of yield while boron (B) deficiency will cause poor podding and required to promote pod development and seed grain quality whereas molybdenum (Mo) deficiency cause the acidic soil when the availability is limited and Is required for nitrogenase enzymes, enhancing nitrogen uptake.[11]

Integrated Nutrient Management (INM) combination of micronutrients with biofertilizers can majorly improves the health of the soil and maun sources to optimize the chickpea yield. Previous studies suggest that seed quality can majorly be increased by mixing biofertilizers like Rhizobium and phosphorus-solubilizing bacteria (PSB) or farmyard manure (FYM), with NPK fertilizers. These biofertilizers, particularly rhizobium promotes nitrogen fixation and encouraging growth of the plant while Farmyard manure (FYM) is a organic manures or compost that increase soil structure, and microbial activity. A study in Karnataka suggests that INM strategies targeting a yield of 8.0 t/ha shows the higher uptake of nutrients uptake and improving soil fertility compared to traditional practices and a 20 kg N incorporated from FYM combined with inorganic fertilizers promotes soil fertility. [12]

Previous research conducted in west Bengal combines all three micronutrients along with biofertilizer i.e. RDF + Rhizobium + Zn (20 kg/ha) + B (0.5 kg/ha) + Mo (1 kg/ha) which shown beneficial effect on pods per plant, plant height and overall yield of grains.(micronutrients in chickpea2.pdf). These 3 nutrients and biofertilizers demonstrated the best treatment from rest treatments and notably improved grain yield, soil fertility over time and also assures the sustainability of agricultural methods.[11, 13]

Micronutrient Biofortification and Economic Implications

One alternative approach to addressing the issue of micronutrient malnutrition is known as "biofortification," which involves enhancing the fertility of the soil or the nutritional potential of crops through the use of conventional plant breeding techniques.[14]

One of the most promising candidates for biofortification ro combat micronutrient malnutrition is chickpea. The study findings shows that chickpea seeds are rich in selenium (Se), iron (Fe), and zinc (Zn), and a single serving of chickpea seeds is sufficient to fulfil a substantial portion of the daily recommended allowances for these nutrients. It is possible that the efforts made to enhance these micronutrients through biofortification, either through soil management or breeding programs. This could have significant positive effects on the health of people all over the world [15]

For example, the selected genotypes of chickpea with high Zn and Fe, combined with effective soil fertility management has proven to enhance nutritional value of harvested seeds. Adopting strategies like Integrated Nutrient Management and biofertilizers reduce dependency on costly chemical fertilizers and improve yield and profitability.[12] The previous study In Karnataka demonstrated that nutrient management strategies aimed at maximizing maize-chickpea cropping system and minimize soil degradation and carbon levels and enhance soil to make sustainable for farmer practices

Challenges in Chickpea Cultivation and Nutrient Uptake

Despite advances in nutrient management, there are several challenges that chickpea cultivation faces that hinder overall yield. These constraints are listed below:

- **Nutrient Deficiencies:** Soil fertility issues or deficiencies in phosphorus, zinc, and boron is mainly because of rainfed soils, often characterized by low organic matter. Continuous improper nutrient and monocropping management deliberately and enzyme activity leading to soil degradation [11]
- **Soil Heterogeneity**: Soil heterogeneity is an important factor for the contents of nutrients and soil reactions, which strongly affect the growth of chickpea. Alkaline soils, high $CaCO_3$ content, reduce the availability of essential micronutrients and limiting their uptake and leading to affect the yield.[16]
- **Limited Resources**: Precision Agriculture limited adoption including GPS mapping and variable rate fertilization due to financial or technical constraints coupled with limited awareness of their benefit act as a barrier to addressing soil

heterogeneity and optimize nutrient content.

Future Recommendations

Enhancing soil and advancements in Biofortification

Improving soil fertility through approaches such as combining organic and inorganic fertilizers and genetic improvement of chickpea varieties for higher nutrient uptake and overcoming micronutrient deficiencies, stress tolerance can significantly enhance productivity. Biofortification enhance the micronutrient quantity such as high zinc, boron, and molybdenum content in chickpea grains, and improves the crop quality and solution of micronutrient malnutrition. Plant breeders and soil scientists need to make a collaborative effort to develop nutrient dense varieties and high yielding

Promotion of Integrated Nutrient Management (INM) and Precision Agriculture

Expanding the use of INM practices and integrating organic amendments, biofertilizers, and balanced NPK fertilizers, can help to improve soil health and yield stability. Governments and sustainable practices and research institutions should work to provide subsidies and training programs for farmers to adapt these more easily. Additionally, precision agriculture strategies, and tools should be more easily accessible through similar support initiatives. These strategies can help to address soil heterogeneity and reduce environmental impact.

CONCLUSION

Chickpea is an important legume providing nutritional and economic benefits to millions of farmers and consumers worldwide. However, unlocking yield maximization requires a comprehensive nutrient management strategy. This review of the previous research findings particularly emphasizes nutrient management, the importance of balanced nutrient application improving soil health and mainly highlighting yield maximization. The main constraints that persist in growth and yield include macronutrients and micronutrient deficiencies but the integration of micronutrients, biofertilizers (INM practices) and advancements in biofortification, and stress-tolerant varieties significantly improve the productivity and ensure the sustainability of chickpea. Future studies focus on collaborative efforts between research institutions, farmers and policymakers critically helpful to enhance chickpea productivity and resilience. Future implications also focus on precision agriculture tools to overcome soil heterogeneity challenges by developing region specific nutrient protocol.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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