Influence of Different Levels of Phosphorus and Biofertilizers on Growth, Yield and Quality of Chickpea

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Abstract:

This research was conducted at the Research Farm, Department of Agronomy, AKS University, Satna (M.P.), during the *Rabi* season of 2022–2023. Employing a Factorial Randomized Block Design, the study encompassed twelve treatment combinations derived from four phosphorus levels (P0= Control, P1= 20 kg P_2O_5/ha, P2= 40 kg P_2O_5/ha and P3= 60 kg P_2O_5/ha) and three biofertilizer levels (B1=*Rhizobium*, B2=PSB, and B3=KSB, each at10 ml/kg seed), each replicated three times. The findings underscored the significant influence of phosphorus levels on various chickpea plant characteristics, including height, branch number, and nodulation per plant. Notably, the highest phosphorus level (90 kg P_2O_5/ha) consistently yielded the tallest plants with the most branches and nodules, alongside maximizing pod number, seeds per pod, grain and stover yield, and elevating protein content. Furthermore, inoculation with *Rhizobium* at 10 ml/kg seed demonstrated enhanced growth attributes, yield components, and protein content compared toother inoculation levels. In conclusion, the study highlights that applying 90 kg phosphorus per hectare and *Rhizobium* inoculation at 10 ml/kg seed significantly augments chickpea crop growth, yield, and protein content, advocating for their advantageous integration into agricultural practices.

Keywords: Biofertilizers, Chickpea, Growth, Phosphorus

Introduction

Chickpea (*Cicer arietinum* L.) is an important crop grown during the *Rabi* season in India and ranks as the third most important crop globally. Despite this, on a global scale, it comes in fifth place in terms of both area and production among legumes. Pulses, including chickpea, hold a crucial role in farming systems world wide. In India, chickpea, also known as Gram or Bengal gram, stands out as the primary pulse crop, primarily cultivated during the *Rabi* season. Belonging to the *Leguminoceae* family and *Papilionaceae* subfamily, chickpea is pivotal in Indian agriculture.

India leads in chickpea production, contributing to around 70% of the world's output. Major chickpea-growing states in India include Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, and Gujarat. Overall, pulses cover approximately 28.83 million hectares in India, yielding 25.72 million tons annually with a productivity of 0.8 tons per hectare. During the 2019-20 period, chickpea cultivation encompassed 13.7 million hectares globally, producing a total of 14.24 million tons with an average yield of 1038 kg per hectare (FAO, 2019). In India, chickpea cultivation spanned over 10.56 million hectares with a production of 11.23 million tons and a productivity of 121 kg per hectare. In Madhya Pradesh alone, chickpeas were cultivated over an area of 35.90 lakh hectares, yielding 45.95 lakh tons (Anonymous, 2018).

Chickpea stands out as a valuable source of highly digestible dietary protein (17-21%), carbohydrates (61.5%), and fats (4.5%).Itis also rich in essential nutrients like calcium, iron, niacin, vitamin B, and vitamin C. The presence of malic acid in its leaves makes it beneficial for stomach ailments and blood purification. Additionally, chickpea enriches the soil through symbiotic nitrogen fixation (Dotaniya *et al*. 2014). As a pulse crop, it offers better quality protein for human consumption compared to other pulse crops, containing various essential nutrients such as carbohydrates, proteins, iron, zinc, calcium, and magnesium (Jukanti *et al*., 2012). The protein content in chickpeas ranges from 17% to 23%.

Phosphorus stands out as a crucial element in plant nutrition, particularly renowned for its significance in enhancing the productivity of pulse crops. It plays a pivotal role in stimulating various asects of plant growth, including early root development, leaf expansion, branching, flowering, grain yield, and hastening maturity. Moreover, phosphorus serves as a fundamental component of essential nucleic acids such as phospholipids, chromosomes, and coenzymes like nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). Its presence is indispensable for vital processes like cell division, as well as the development of seeds and pods.

Research indicates that the application of phosphorus leads to a significant increase in the production of pulse crops. However, the response to phosphorus supplementation varies depending on factors like climate, crop variety, soil type, and nutrient availability during the growth phase. Notably, legumes such as chickpeas exhibit a higher demand for phosphorus due to its critical role in root development and metabolic activities. Phosphorus is integral to essential biological molecules like DNA, RNA, ATP, and the photosynthetic system. It catalyzes numerous biochemical reactions essential for plant growth, from the early stages of seedling emergence to the formation of grains during maturity (GulpadiyaandChhonkar,2014)

Inoculating Rhizobium bacteria has been shown to increase grain yield in pulse crops by 10 to 15% (Ali and Chandra, 1985), while phosphate-solubilizing bacteria (PSB) enhance soilphosphorusavailabilitybyconvertinginsolublephosphoruscompoundsintosolubleforms (Parveen*etal*.,2002). This microbial culture can function as a versatile biofertilizer, potentially boosting crop yields (including legumes, vegetables, etc.) by 10-30%. Utilizing Rhizobium, PSB, and potassium-solubilizing bacteria (KSB) cultures has been linked to improved nodulation, crop growth, nutrient uptake, and ultimately, crop yield (Das*etal*.,2013). Specific microorganisms like PSB and KSB, found in the plant rhizosphere, have the ability to convert otherwise inaccessible inorganic phosphorus and potassium in to soluble forms usable by plants (Saxena *et al*., 2016). Therefore, implementing effective nutrient management practices alongside the use of Rhizobium, PSB, and KSB can enhance both the yield and quality of chickpeas while preserving soil fertility (Singh and Singh, 2014). Keeping the above- mentioned facts in mind, an investigation was planned to find out the impact of phosphorus levels and biofertilizers on growth, yield and quality of chickpea.

Materials and Methods

This research was carried out at the Research farm of the Department of Agronomy, AKS University, Satna (M.P.) during the *Rabi* season of 2022–2023. The soil of the experimental site displayed somewhat neutral characteristics, with a pH value of 7.56. Analysis revealed low levels of accessible nitrogen (196.70 kg ha^{-1}) and organic carbon (0.52 percent), along with moderate levels of phosphorus (15.6 kg ha^{-1}) and potassium (302.40 kg ha^{-1}). The study focused on Chickpea (JG-63) as the target crop, employing a factorial randomized block design comprising twelve treatment combinations. These combinations stemmed from four phosphorus levels (P0=Control, P1=30kgP2O5/ha, P2=60kgP2O5/ha, and P3=90kgP2O5/ha) and three biofertilizer levels (B1=*Rhizobium*, B2=PSB, and B3=KSB, each at10ml/kg seed). Each treatment combination was replicated three times. Application of treatments was carried out at sowing as a basal dressing, utilizing single super phosphate (SSP) and liquid biofertilizer cultures. Urea and MOP were supplied to meet the nitrogen and potassium requirements (20 kg N/ha and 40 kg P2O5/ha). On October 25th, 2022, seeds @ 80 kg/ha were sown in furrows and promptly covered with soil to safeguard against bird damage. Prior to planting, seeds underwent treatment with Bavistin to mitigated is ease incidence. Planting was conducted in the afternoon, with seeds spaced at 30x10 cm intervals (row-to-row and plant-to-plant) and sown at a depth of 6-8 cm.

Result and discussion

Effect of phosphorus levels

Data analysis revealed a significant influence of phosphorus levels on various characteristics of chickpea plants, encompassing plant height, branch number, and nodulation. This effect was consistently observed across all growth stages throughout the experimental period. Across each developmental phase, plant height, branch number, and other growth attributes displayed a positive correlation with phosphorus concentration. Remarkably, the treatment with the highest phosphorus level (90kg/ha), followed by 60kgP2O5/ha, exhibited the tallest plants (40.17 cm) and the greatest number of branches (19.04). Furthermore, phosphorus application led to a substantial increase in nodule quantity (21.42). Phosphorus plays a crucial role in fostering symbiotic relationships with in plants, facilitating the exchange of photosynthates with bacteria and rhizobia, thereby enhancing nitrogen fixation. Additionally, phosphorus application promotes root growth, creating an ideal environment for nodule formation, consequently augmenting both nodule quantity and weight. These findings align with previous studies by Rao *et al*. (2020), which reported similar results. Enhanced growth characteristics observed are attributed to improved nodulation and extensive root development facilitated by optimal phosphorus doses, ultimately resulting in healthier crop growth and increased leaf area for photosynthesis. These findings are consistent with the results documented by Shukla *et al*. (2017), Raghvendra *et al*. (2018), and Nissa *et al*. (2019).

The highest phosphorus levels (90 kg P2O5/ha) were correlated with the maximum number of pods per plant (50.09), seeds per pod (2.04), grain (17.83q/ha), stover (34.59q/ha) production, and a higher 100 seed weight (20.46 g). Grain production depends on factors like productive branches and seed weight, both of which show positive responses to phosphorus application, as evidenced by Mohammad *et al*. (2022). Higher phosphorus doses led to increased Stover yield compared toother treatments, likely due to concurrent enhancements in plant height, branches per plant, and fresh and dry plant weights. These results align with findings from Kumar *et al*. (2019), Lalrinzuali *et al*. (2021), Mohammad *et al*. (2022), and Mishra *et al*. (2023).

The research noted a significant increasing rain protein content with rising phosphorus levels, peaking at 21.36% with an application of 90 kg P_2O_5/ha. This rise in protein content could possibly be attributed to the stimulation of atmospheric nitrogen fixation, facilitated by heightened symbiotic bacterial activity. Moreover, phosphorus plays a crucial role in nucleic acid composition. Thus, ensuring adequate phosphorus supply through soil application may enhance nucleic acid synthesis, consequently boosting protein content in grains. Similar findings were reported by Chauhan *et al*. (2017), Vikram *et al*. (2018), and Akansha *et al*. (2021).

Effect of biofertilizers

Inoculating *Rhizobium* at a rate of 10ml/kg seed led to notable improvements in growth parameters, resulting in higher values for plant height (36.84cm), number of branches per plant (16.73), and number of root nodules per plant (16.95).These observed enhancements in plant height, branch quantity, and nodule count per plant are likely attributable to increased nitrogen uptake facilitated by the robust and efficient root system promoted by this treatment. Nitrogen plays a crucial role in various organic compounds essential for living organisms, including amino acids, proteins, nucleotides, and chlorophyll. Consequently, improved nitrogen utilization efficiency fosters robust and vigorous plant growth during the early developmental stages. The heightened nitrogen levels observed in plants may be attributed to enhanced N_2 fixation, facilitated by increased nodule formation. Katiyar *et al*. (2020), and Kumar *et al*. (2022) have also documented the beneficial impacts of applying Rhizobium culture on growth characteristics in chickpea.

The experimental findings showcased a notable enhancement in yield characteristics and chickpea grain output upon the application of biofertilizer inoculation. Additionally, the current study unveiled augmented straw production resulting from biofertilizer inoculation. Specifically, *Rhizobium* inoculation at a rate of 10 ml/kg demonstrated a marked increase in various parameters including pod number (45.15), seed count per pod (1.72), seed index(18.94 g), grain yield (16.00 q/ha), and stover yield (31.94 q/ha). This can primarily be attributed to the increased nitrogen availability to plants facilitated by biological nitrogen fixation in the rhizosphere, courtesy of the *Rhizobium* culture, which promotes enhanced root development. Consequently, the greater nitrogen availability likely contributed to vigorous plant growth, resulting in increased accumulation of dry matter and ultimately, improved flowering and ear head development. The observed increase in yield is likely a result of enhanced germination stimulation and subsequent increases in plant biomass due to the nitrogen fixed by the Rhizobium culture. These findings align closely with the research of Katiyar *et al*. (2020), and Kumar *et al*. (2022).

Seed inoculation with Rhizobium at a rate of 10 ml/kg demonstrated a significant elevation in grain protein content (19.81%) compared to other inoculation levels. This finding is consistent with the research conducted by Somnath *et al*. (2006), which also reported a notable increase in grain protein content due to biofertilizer inoculation. Protein synthesis relies heavily on nitrogen, with amino acids being its primary constituents. The increased nodule formation resulting from *Rhizobium* inoculation facilitated greater nitrogen fixation, thereby enhancing nitrogen availability and subsequently elevating protein content. The beneficial impact of symbiotic interactions on chickpea grain protein content due to *Rhizobium* introduction is supported by the studies of Dubey and Naveen (2008), Kumar and Majumdar (2008), and Pawar *et al*. (2008).

Conclusion

From the summary of results, the following conclusions emerge: Application of 90 kg P2O5ha^{-1} surpassed other phosphorus doses, exhibiting significantly higher growth and yield-related factors along with grain and stover yield. Similarly, seed inoculation with *Rhizobium* at 10 ml/kg led to increased grain and stover yield. Hence, the combined use of 90kg of phosphorus and *Rhizobium* at 10 ml/kg was deemed advantageous.

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Table1: In fluence of different phosphorus and biofertilizers on growth, yield and quality of chickpea.

Treatments	Plant height(cm)	Number of branches per plant	Number of root nodules per plant	Number of pods per plant	Number of seeds per pod	Seed index (g)	Grain yield (q/ha)	Stover yield (q/ha)	Protein content (%)
Phosphorus levels									
P_0	30.27	12.91	7.93	32.89	1.13	15.04	13.40	24.57	17.89
P_1	33.97	14.96	16.80	43.58	1.33	17.45	14.40	31.38	18.50
P_2	36.99	16.36	19.98	46.36	1.58	18.51	15.24	33.97	19.60
P_3	40.17	19.04	21.42	50.09	2.04	20.46	17.83	34.59	21.36
S. Em±	**0.49**	**0.32**	**0.27**	**0.52**	**0.07**	**0.40**	**0.25**	**0.42**	**0.15**
C.D.(P=0.05)	**1.44**	**0.94**	**0.79**	**1.53**	**0.21**	**1.17**	**0.73**	**1.23**	**0.44**
Biofertilizer levels									
B_1	36.84	16.73	16.95	45.15	1.72	18.94	16.00	31.94	19.81
B_2	35.73	16.08	16.20	43.30	1.47	17.84	15.06	31.29	19.45
B_3	33.48	14.63	15.70	41.23	1.38	16.82	14.60	30.15	18.76
S. Em±	**0.43**	**0.28**	**0.24**	**0.45**	**0.06**	**0.35**	**0.22**	**0.37**	**0.13**
C.D.(P=0.05)	**1.26**	**0.82**	**0.70**	**1.32**	**0.18**	**1.03**	**0.65**	**1.09**	**0.38**