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Research Article

Integrated foliar application of potassium with soil applied nitrogen and phosphorus improves productivity of chickpea (*Cicer arietinum* L.)

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ABSTRACT

Optimal nitrogen and phosphorus fertilization can enhance growth and yield of chickpea. However, little is known about nitrogen and phosphorus fertilization supplemented with foliar application of potassium on productivity of chickpea. Therefore, a study was designed with the aim to explore–efficiency of soil applied nitrogen and phosphorus in combination with foliar potassium nutrition on performance of chickpea. The chickpea cultivar Bittle-98 was grown in plastic pots filled with 10 kg of soil following Randomized Complete Design (RCBD). Various treatments comprising control (T1), nitrogen 160mg/pot (T2), phosphorus 385mg/pot (T3), nitrogen 160mg/pot + 0.75% K2SO4 foliar (T4), phosphorus 385mg/pot +0.75% K2SO4 foliar (T5), and nitrogen 160mg/pot + phosphorus 385mg/pot+0.75% K2SO4 foliar (T6) were tested. The T6 resulted in maximum plant height (64.37cm), number of pods per plant (45.46), seeds per pod (1.40) 100-seed weight (18.03g), SPAD counts (34.52), seed yield (35.80g/pot), and biological yield (85.24g/pot) than rest of the treatments. The yield in response to T3 was significantly higher than T2, mainly because of higher pods frequency, indicating that phosphorus is more imperative than nitrogen to harvest maximum yield of chickpea. The yield obtained was in the order of T6>T5>T4>T3>T2. It is revealed that soil applied nitrogen plus phosphorus supplemented with foliar potassium is an effective strategy to harvest higher yield of chickpea. Recommended soil application of nitrogen and phosphorus with foliar 0.5% K2SO4 is suggested to harvest maximum yield of chickpea.

Keywords: Chickpea; nutrients; growth; productivity.

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INTRODUCTION

Pulses are rich source of proteins. Among pluses, chickpea is one of the largest and highly cultivable pulse crops which plays a pivotal role for satisfying the nutritional requirements of human (Rajput, 2018). It is leading common pulse crop of Pakistan, cultivated on an area of 0.83 million ha with production of 0.238 million tons (Govt of Pakistan, 2022-23). Being leguminous, it fixes atmospheric nitrogen in available form through symbiosis with rhizobial strains.

Among the various factors contributing to low yields of chickpea, inadequate and unbalanced fertilization is the most significant factor. Generally, nitrogen and phosphorus as soil dressing are recommended for chickpea (DAI, 2024), neglecting the importance of potassium, mainly because of its higher cost and unavailability. Higher yields and crop quality can be obtained with optimal N, P, and K. Nitrogen had the most significant impact on plant growth and development, followed by P and K (Jiaying et al., 2022). Nitrogen fertilizer application is known to significantly increase shoot dry weight, yield and N, P and K accumulation in seed of chickpea (Demirbas et al., 2018).

Phosphorus is essential for improving flower formation, seed production, early maturity, nitrogen fixation, quality enhancement, and disease resistance (Zeid et al., 2015). Potassium has been considered as the “quality element” for crop production (Chauhan et al., 2022). Potassium, unlike nitrogen and phosphorus, does not directly contribute to the composition of any plant product. However, potassium plays a crucial role, both directly and indirectly, in enzyme activation, photosynthesis, respiration, protein synthesis, water uptake, osmoregulation, and the growth and yield of plants (Maleki et al., 2018). Potassium also plays a key role in nitrogen metabolism (Xu et a., 2020) and thus improves nitrogen use efficiency. co-application of phosphorus with nitrogen (Ivanov et al., 2021) and phosphorus with potassium is proved to offer higher yield than their individual use in chickpea (Ali et al., 2010; Tembhare et al., 2022). Expensive potassium fertilizers are the primary reason for avoiding potassium application in pulses. Foliar can be an alternative and cost effective strategy to provide the crops with this important nutrient. Foliar application of potassium is thus suggested to improve growth, physiology and productivity of crops (Ali et al., 2016; Irshad et al., 2022). The foliar applied nutrients are ready absorbed by the foliage and translocated than soil applied ones and improves effectiveness of applied fertilizer (Ivanov et al., 2021) Thus foliar feeding of potassium is economical more feasible than soil application. Keeping in view the above challenges, a study was planned to test the hypothesis that soil application of nitrogen and phosphorus with foliar potassium will improve productivity of chickpea.

MATERIALS AND METHODS

The pot experiment was conducted at department of agronomy, PMAS Arid Agriculture University Rawalpindi, Pakistan in Rabi 2023-24. Triplicate plastic pots (diameter 25 cm and depth 30 cm) arranged according to Randomized Complete Block Design (RCBD) were filed with 10 kg of soil. The chickpea cultivar Bittle-98 was sown and four plants per pot were maintained after seedling establishment. The treatments comprising recommended nitrogen (35kg/ha), phosphorus (85kg/ha) and foliar application of potassium outlined in Table (1) were tested. Per se, each pod received 160mg nitrogen, and 385mg of phosphorus.

Table 1. Various treatments of nitrogen and phosphorus.

Treatments
T1=Control
T2= Nitrogen 160mg/pot
T3= Phosphorus 385mg/pot
T4= Nitrogen 160mg/pot + 0.75% K_2SO_4 foliar
T5=Phosphorus 385mg/pot +0.75% K_2SO_4 foliar
T6= Nitrogen 160mg/pot + phosphorus 385mg/pot+0.75% K_2SO_4 foliar

All the phosphorus as single super phosphate and nitrogen as urea was applied as basal dose, while foliar application of K2SO4 was made at start of flowering and repeated at pod setting stage. All other agronomic practices were kept normal and constant, and the pots were irrigated when required. The SPAD values were recorded seven days after the final foliar application of K2SO4. Whereas, the data pertaining to plant height, number of pods per plant, number of seeds per pod, 100-seed weight, seed yield and biological yield was recorded after harvesting following standard procedure. The data collected was analyzed following Fisher’s Analysis of Variance technique and the means were compared by Least Significant Difference (LSD) at 5% probability (Steel and Torrie, 1980) by statistical software Statistix 8.1.

RESULTS AND DISCUSSION

The significantly higher plant height (64.37cm) was recorded in response to T6 against minimum for T1(53.47). However, the plant height in response to T6 and T4 was at par. The maximum number of pods was recorded in response to T6 (45.46) followed by T5 (39.66) against minimum for T1 (28.51). The number of pods in response to T3 and T4 were at par. Similarly, T5 and T6 resulted in higher number of seed per pod and did not differ significantly with 1.35 and 1.40 seed per pods, respectively. The 100-seed weight ranged between 14.78g to 18.03g for fertilizer treatments. The control treatment did offer the least seed test weight of 14.66g (Table 2). The seed test weigt in response to T2(14.78g), T3(14.89g) and T4(15.55g) did not differ significantly (α=0.5). However, the highest seed test

weight of 18.08g was observed in response to T6 followed by T5 (16.88g). Similarly, the maximum SPAD count (34.52), seed yield (33.80g/pot) and biological yield (85.28g/pot) were witnessed in response to T6. Foliar treatment of K2SO4 with phosphorus (T5) resulted in high yield (28.68g/pot) than combined with nitrogen (T4). Conversely, Foliar application of K2SO4 with N (T4) offered higher biological yield than foliar K2SO4 + soil phosphorus (T5) with respective biological yield of 78.33 g/pot and 66.77g/pot (Table 2). Chickpea is mainly grown on marginal soils with inherently low fertility. Nitrogen, phosphorus and potassium are deficit in soil under chickpea cultivation in Punjab (Pakistan).

Table 2. Effect of nitrogen and phosphorus supplemented with foliar application of potassium on yield and yield attributes of chickpea.

Treatments	Plant height (cm)	Pods/plant	Seeds/ pod	100-seed wt. (g)	SPAD count	Seed Yield (g/pot)	Biol. yield (g/pot)
T1=Control	53.47d	28.51e	1.25d	14.66d	24.80d	13.37f	53.03f
T2= Nitrogen 160mg/pot	57.40c	31.08d	1.28cd	14.78cd	32.47b	17.45e	72.65c
T3= Phosphorus 385mg/pot	54.61cd	35.01c	1.33bc	14.89cd	29.19c	19.44d	63.88e
T4= Nitrogen 160mg/pot + 0.75% K_2SO_4 foliar	60.99ab	36.16c	1.31bcd	15.77c	32.80b	22.73c	78.30b
T5=Phosphorus 385mg/pot +0.75% K_2SO_4 foliar	57.89bc	39.66b	1.35ab	16.88b	31.90b	28.68b	66.77d
T6= Nitrogen 160mg/pot + phosphorus 385mg/pot+0.55% K_2SO_4 foliar	64.37a	45.46a	1.40a	18.03a	34.52a	35.80a	85.24a
LSD value	3.43*	2.38*	0.07*	1.09*	1.20*	1.38*	2.33*

*Significant; Values sharing common letters did not differ significantly (α=0.05)

The N, P and K are indispensable to improve growth, yield and yield attributes of chickpea (Rajput, 2018; Tembhare et al., 2022). Nitrogen is a crucial nutrient for plant growth and development, plays a key role in photosynthesis, phytohormonal regulation, proteomic changes, and overall, to complete plant lifecycle. Excessive and inefficient use of nitrogen fertilizer increases crop production costs and contributes to atmospheric pollution (Anas et al., 2020). Phosphorus is crucial for various cellular processes, including maintenance of membrane structures, synthesis of biomolecules, and formation of high-energy molecules, cell division, enzyme activation/inactivation and carbohydrate metabolism. At whole plant level, it improves seed germination, development of roots, flower and seed; stalk and stem strength; crop yield with improved quality. In addition, P increases the N-fixing ability of legumes. Hence, P is essential at all developmental stages, right from germination till maturity (Malhotra et al., 2018). Whereas, potassium is essential for maintaining cellular organization, protein synthesis, regulates membrane permeability, osmotic balance, stabilizes enzyme's structure and activity, and regulates stomatal conductance (Chauhan et al., 2022). Therefore, application of nitrogen, phosphorus (Ali et al., 2010; Mohmmand et al., 2022) and potassium (Mahmood et a., 2017; Chauhan et a., 2022) is reported to improve yield of chickpea on soils deficit in these macro nutrients. Earlier, soil application of N and Pat 24kg/ha and 60 kg/ha, respectively, is shown to improve yield of chickpea (Ali et al., 2010). However, combined application of N, P and K lead to substantial increase in yield of chickpea (Sabri and Dizayee, 2023). The highest dry matter yield, net photosynthetic rate, ATP content, as well as NADH, cytochrome oxidase, dehydrogenase, and ATPase activities are reported in the plants that received sufficient N, P and K (Jiaying et al., 2022). Our results are in line with findings of (Rajput, 2018), who found that combined application of N and P with K significantly increased chickpea yield compared the one without K application. However, foliar application of potassium (3% K2O) is more efficacious than soil amendments with potassium to increase growth, biological and grain yield (Ali et al., 2016). Exogenous application of potassium improves net photosynthesis rate, assimilate rate which results in higher crop output (Ali et al., 2016). Potassium fertilization is thus proved to improve yield of chickpea (Chauhan et al., 2022) and supports our results (Table 2). The higher yield in response to foliar applied potassium with soil applied N and P can partially be explained by the facts that exogenous application of potassium enhances chlorophyll content,

photosynthetic rate, leaf area, regulates stomatal conductance, transpiration, and carboxylation efficiency and improves of S, P, K, Cu, Mn and Fe uptake in plants (Ávila et al., 2022). We found that foliar application of potassium combined with soil application of phosphorus (T5) resulted in higher yield than combined foliar application of potassium with nitrogen (T4). It can be due to nitrogen fixing ability of chickpea with little rely on external nitrogen fertilization. The application of phosphorus improves nodulation in chickpea (Khan et al., 2021) and further decreases extern need of nitrogen fertilization. Phosphorous application is indispensable for growth and development of chickpea, and to maximize yield (Mohmmand et al., 2022). Our results are supported by Mohmmand et al. (2022) who narrated that phosphorus application in chickpea significantly improves yield and yield components of chickpea.

CONCLUSION

The present study highlighted the effect of foliar application of potassium in combination with N and P. Foliar application of potassium improves effectiveness of soil applied N and P. The combined application of recommended N and P supplemented with foliar supply of 0.75% K2SO4 is recommended to harvest maximum yield of chickpea. Further field experiments are suggested to rationalize combine soil application rate of nitrogen, phosphorus and foliar concentration of potassium for chickpea.

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