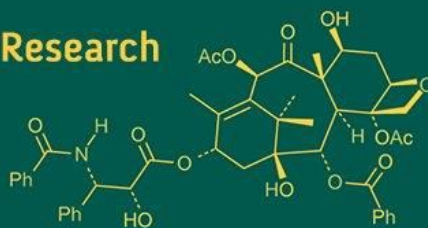
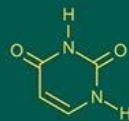
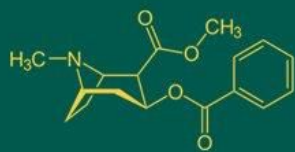


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(10): 1480-1483
www.biochemjournal.com
Received: 16-07-2024
Accepted: 21-08-2024

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Effect of Phosphorus and Sulphur on growth and yield of Chickpea (*Cicer arietinum* L.)

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DOI: <https://doi.org/10.33545/26174693.2024.v8.i10Sr.2754>

Abstract

The chickpea field study was carried out at the Department of Agronomy's Crop Research Farm during the *Rabi* (the winter) season of 2023. Along with the recommended dosages of nitrogen, phosphorus, and potassium as well as a control (30-50-30 NPK/ha), the treatment included three levels of phosphorus (40, 60, and 80 kg/ha) and three levels of sulphur (20, 30, and 40 kg/ha). Ten treatments and three replications were used in the Randomized Block Design experiment. Applying 60 kg of phosphorus and 30 kg of sulphur per hectare (treatment 5) noted Maximum height of the plant (40.93 cm), dry weight of the plant (18.17 g), number of nodules per plant (16.20), crop growth rate (15.17 g/m²/day), number of pods per plant (34.67), seed weight index (22.33 g), the yield of seeds (1.80 t/ha), and straw yield (1.19 t/ha), High overall profits (109393.33 INR/ha), net returns (69601.72 INR/ha), and B:C (1.75), were likewise recorded with the aforementioned treatment.

Keywords: Phosphorus, sulphur, chickpea, Economics

Introduction

The chickpea (*Cicer arietinum* L.), also referred to as "Gram" or "Bengal gram," is the most significant and well-known pulse crop of India. Chickpeas are widely recognized as an excellent source of protein, particularly in developing countries where the bulk of the population relies on inexpensive food to fulfill their needs. Food items include: premature color green grain (Indian form), reach maturity. Grain (desi/kabuli type), mature grain flour (besan, desi type), roasting grain (desi type), roasted grain flour (shattu, Indian type), split the grain as well as pulse (dahl, desi type), breaks down (desi type), cooked foods (made with wheat flour, desi type), desserts and bitter baked goods (made with grain flour, desi type), and various tertiary processed foods (cuisines). Chickpeas' significance to the processing industry has increased further with the growing trend of plant-based protein products (protein isolates, etc.) on the market (DES 2023, MOAF&W, GoI) ^[5]. India produced 13.75 million tonnes of chickpeas in 2021–2022 (fourth estimate), with the productivity of 12.6 q/ha, on 10.91 million ha of land (DES 2023, MOAF&W, GoI) ^[5]. Just chickpeas account for almost half of the production of pulses in India. Major states in India that produce chickpeas include Maharashtra (which contributes 25.97% of the country's production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%), and Uttar Pradesh (5.64%). In the Indian market, chickpea consumption is varied (DES 2023, MOAF&W, GoI) ^[5].

It has been established that one of the most crucial components of plant nutrition is phosphorus (P). It promoted the growth of roots, strengthened stalks and stems, enhanced flowering and seed production, more uniform and early crop maturity, enhanced legumes' ability to fix nitrogen, enhanced crop quality, and heightened resistance to plant diseases. According to Sharma et al., pulse crop output was observed to rise with phosphorus application. We discovered that chickpeas respond favourably to phosphorus fertilizer in terms of yield. Due to the considerable energy required for the symbiotic nitrogen fixation process, legumes often have higher P requirements. Because of symbiotic fixation, the demand of P as ATP or ADP molecules in leguminous crops is not only essential but also significantly higher.

Since sulphur aids in the metabolism of nitrogen through protein in pulse crops, it mostly affects the protein content of chickpeas. Additionally, sulphur enhances the S-containing

amino acids in crops, which directly affects their nutritional value. Since it is also essential for the production of chlorophyll, improves oil biosynthesis, and speeds up the degradation in protein, carbohydrates, and lipids, sulphur is currently regarded as the fourth main dietary element after NPK. Legumes' ability to fix nitrogen is improved when they receive a sufficient amount of mineral nutrients. It is essential for the production of iron-sulphur proteins known as ferredoxins, as well as chlorophyll and a few plant hormones including biotin as well as thiamine. It is a component of the three sulfur-containing amino acids that make up protein: cysteine, cysteine, along with methionine. In addition to being an essential part of the nitrogenase enzyme, that is necessary for fixing nitrogen, iron helps in the synthesis of chlorophyll. In the metabolism of nucleic acids, it is essential Srinivasarao et al. (2004) [12]. The current study, "Effect of Phosphorus and Sulphur on Growth and Yield of Chickpea (*Cicer arietinum* L.)," was conducted during the *Rabi* season of 2023–2024 at the Crop Studies Farm of Allahabad, India School of Agriculture, Sam Higginbottom at the University of Agriculture, Technology, and Sciences, Prayagraj. Examining how phosphorus and sulphur affect chickpea growth and yield as well as assessing the financial viability of various treatment combinations were the study's goals.

Materials and Methods

The research study was carried out at the CRF, the Department of Agronomy, SHUATS, during the *Rabi* season of 2023. The soil of the field, which is part of the central Gangetic alluvium, is neutral and deep. The experimental field's soil was sandy loam in texture, nearly neutral in reaction (pH 7.7), with organic carbon content of 0.57%, available nitrogen (N) at 172.48 kg/ha, available phosphorus (P) at 27.01 kg/ha, and available potassium (K) at 291.3 kg/ha. The treatment consists

Treatment No.	Phosphorus (kg/ha)	Sulphur (kg/ha)
1	40	20
2	40	30
3	40	40
4	60	20
5	60	30
6	60	40
7	80	20
8	80	30
9	80	40
10	0	0

The ANOVA was calculated according to Gomez and Gomez.

Result and Discussion

Morphological observation

Plant height (cm)

The maximum plant height (40.93 cm) was recorded in T₅ at 80 DAS, while, treatment T₆ and T₇ was found statistically at par with the T₅. Plants may have taken in more nitrogen and phosphorus as a result of the beneficial bacteria' N fixation and P solubilization, which allowed the plants to grow taller (Singh et al. 2016) [11]. It is provided in table 1.

Number of nodules per plant

Highest number of nodules per plant (16.20) was observed in treatment-5 (phosphorus 60 kg/ha + sulphur 30 kg/ha) at 80 DAS, However, treatment T₈ and T₇ was found to be

statistically at par with the highest. This occurred as a result of the crop receiving an adequate amount of phosphorus, which may have encouraged enhanced root growth and nodulation, increasing the upper soil layer's absorption and accessibility of N, P, and S (Alukh and Pasricha 2017) [1]. It is provided in table 1.

Plant dry weight (g/plant)

Higher plant dry weight (18.17 g/plant) was recorded in T₅ at 80 DAS, However, treatment T₆ and T₇ was observed to be statistically at par with the T₅. This might be the case because phosphorus, which an energy-bonding substance, is essential for energy transformation needed for almost all metabolic functions, such as respiration, cell lengthening and division, photosynthesis, stimulation of amino acids for the production of proteins, and metabolism of carbohydrates, all of which raise a plant's dry mass and other growth traits. Similar findings have also been reported by Saraf. It is provided in table 1.

Crop growth rate (g/m²/day)

The highest crop growth rate of 15.17 g/m²/day was observed in Treatment-5, which involved applying phosphorus at 60 kg/ha and sulphur at 30 kg/ha, during the period of 60-80 days after sowing (DAS). However, treatments T₇ and T₆ showed statistically similar growth rates, indicating no significant difference compared to the highest. It is provided in table 1.

Yield parameters

Number of pods/plant

A significantly higher number of pods per plant (34.67) was recorded in Treatment-5 (phosphorus 60 kg/ha + sulphur 30 kg/ha) at harvest. However, Treatments T₆ and T₇ were found to be statistically comparable to the highest. It has been given in table 2.

Weight of 100 seeds (g)

A higher seed index (22.33) was observed in Treatment-5 (phosphorus 60 kg/ha + sulphur 30 kg/ha) at harvest. However, Treatments T₆ and T₇ were statistically comparable to the highest. It has been given in table 2.

Seed yield (t/ha)

At harvest, treatment-5 showed a higher seed output (1.80 t/ha). Nonetheless, it was discovered that treatments T₆ and T₇ were statistically comparable to the best. According to a 2007 study by Kumar *et al.*, the application of phosphorous accelerated the production of photosynthesis while their movement from source to sink, increasing yield and contributing to character traits. It has been given in table 2.

Straw yield (t/ha)

At harvest, Treatment-5 showed a greater straw output (1.19 t/ha). Nonetheless, it was discovered that Treatments T₆ and T₄ were statistically equivalent to the best. It has been given in table 2.

Economics

Cultivation cost (INR/ha)

The control plot had the lowest cultivation costs (32861.61 INR/ha), while T₅ had the greatest cultivation costs (41892.61 INR/ha) due to greater phosphorus and sulphur dosages. Table 3 presents information about the economics of

cultivating chickpeas as influenced by phosphorus and sulphur.

Gross return (INR/ha)

The higher gross return was obtained in the T₅ (109393.33 INR/ha) In table 3. Data refer to to economics of growing chickpea as part by sulphur and phosphorus has been exhibited.

Net return (INR/ha)

The higher net return was found in the application of Phosphorus 60 kg/ha along with Sulphur 30 kg/ha (69601.72 INR/ha) In table 3. Statistics pertaining to economics of growing chickpea as influenced by sulphur and phosphorus has been exhibited.

Benefit cost of ratio (B:C)

The higher B:C ratio was found in the T₅ (1.75). In table 3. Statistics pertaining to economics of growing chickpea as inclined by sulphur and phosphorus has been exhibited.

Table 1: Response of Phosphorus and Sulphur Growth attributes of Chickpea (*Cicer arietinum* L.)

	Treatments	Plant height (cm)	No. of nodules/plant	Plant dry weight (g)	Crop growth rate (g/m ² /day)
		80 DAS	80 DAS	80 DAS	60-80 DAS
1.	P 40 kg/ha along with S 20 kg/ha	30.23	10.30	10.87	6.67
2.	P 40 kg/ha along with S 30 kg/ha	31.30	10.50	12.67	10.17
3.	P 40 kg/ha along with S 40 kg/ha	31.76	11.50	14.77	11.72
4.	P 60 kg/ha along with S 20 kg/ha	38.60	11.96	15.73	12.39
5.	P 60 kg/ha along with S 30 kg/ha	40.93	16.20	18.17	15.17
6.	P 60 kg/ha along with S 40 kg/ha	39.43	12.16	16.50	13.33
7.	P 80 kg/ha along with S 20 kg/ha	38.03	14.50	16.07	15.11
8.	P 80 kg/ha along with S 30 kg/ha	34.00	15.30	16.07	13.11
9.	P 80 kg/ha along with S 40 kg/ha	34.93	12.50	15.63	12.44
10.	Control RDF (30-50-30 kg/ha)	36.20	11.93	14.73	11.11
	F test	S	S	S	S
	S.Em(±)	1.45	1.03	0.90	1.57
	CD (p=0.05)	3.40	3.08	2.69	4.68

Table 2: Response of Phosphorus and Sulphur on Yield attributes of Chickpea (*Cicer arietinum* L.)

	Treatments	No. of pods /plant	Seed index (g)	seed yield (t/ha)	Straw yield (t/ha)
1.	P 40 kg/ha along with S 20 kg/ha	24.73	20.43	1.39	0.82
2.	P 40 kg/ha along with S 30 kg/ha	27.27	21.00	1.41	0.81
3.	P 40 kg/ha along with S 40 kg/ha	27.83	21.67	1.43	0.83
4.	P 60 kg/ha along with S 20 kg/ha	32.07	21.00	1.73	1.13
5.	P 60 kg/ha along with S 30 kg/ha	34.67	22.33	1.80	1.19
6.	P 60 kg/ha along with S 40 kg/ha	32.33	22.00	1.77	1.16
7.	P 80 kg/ha along with S 20 kg/ha	32.17	22.00	1.63	1.03
8.	P 80 kg/ha along with S 30 kg/ha	30.83	21.67	1.65	1.05
9.	P 80 kg/ha along with S 40 kg/ha	29.70	21.67	1.69	1.08
10.	Control RDF (30-50-30 kg/ha)	28.67	22.00	1.42	1.05
	F test	S	S	S	S
	S.Em(±)	1.76	0.72	0.08	0.08
	CD (p=0.05)	5.25	2.15	0.26	0.25

Table 3: Response of Phosphorus and Sulphur on Economic attributes of Chickpea (*Cicer arietinum* L.)

	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	P 40 kg/ha along with S 20 kg/ha	37663.61	84173.33	46509.72	1.23
2.	P 40 kg/ha along with S 30 kg/ha	38603.61	85626.67	47023.06	1.22
3.	P 40 kg/ha along with S 40 kg/ha	39543.61	86866.67	47323.06	1.20
4.	P 60 kg/ha along with S 20 kg/ha	38851.61	105260.00	66408.39	1.71
5.	P 60 kg/ha along with S 30 kg/ha	39791.61	109393.33	69601.72	1.75
6.	P 60 kg/ha along with S 40 kg/ha	40731.61	107533.33	66801.72	1.64
7.	P 80 kg/ha along with S 20 kg/ha	40012.61	99060.00	59047.39	1.48
8.	P 80 kg/ha along with S 30 kg/ha	40952.61	100506.67	59554.06	1.45
9.	P 80 kg/ha along with S 40 kg/ha	41892.61	102573.33	60680.72	1.45
10.	Control RDF (30-50-30 kg/ha)	32861.61	87016.67	54155.06	1.65

Conclusion

The control plot had the lowest cultivation costs (32861.61 INR/ha), while T₅ had the greatest cultivation costs (41892.61 INR/ha) due to greater phosphorus and sulphur dosages. Table 3 presents information about the economics of cultivating chickpeas as influenced by phosphorus and sulphur.

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