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Boini Jyothi Kumar
Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Biswarup Mehera
Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Boini Jyothi Kumar
Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of potassium and sulphur on growth and yield of chickpea (*Cicer arietinum* L.)

Boini Jyothi Kumar and Biswarup Mehera

Abstract
A field experiment was conducted during Rabi season of 2021 at experimental field of the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj and Uttar Pradesh, India to determine the "Effect of potassium and sulphur on growth and yield of Chickpea (*Cicer arietinum* L.)". The experiment consisted of 3 levels of potassium 10 kg/ha, 15 kg/ha, 20 kg/ha and 3 levels of sulphur fertilizer of 20 kg/ha, 25 kg/ha and 30 kg/ha. The experiment was laid out in Randomized Block Design (RBD) with three replications. Full doses of Nitrogen, Phosphorus and Potassium fertilizers were applied as basal. Variety used was Pusa 372. Report of the study indicate that, among different levels of potassium and sulphur the treatment with potassium at 20 kg/ha and sulphur at 30 kg/ha produced significantly highest plant height (51.63 cm), higher number of nodules (29.46), dry weight/plant (25.05 g), highest crop growth rate (12.56), highest number of pods per plant (45.74), number of seeds per pod (1.88), seed yield (2.03 t/ha), stover yield (4.45 t/ha), and Harvest index (31.29%). However, the treatment with potassium at 20 kg/ha and sulphur at 30 kg/ha was found to be effective in highest gross return (1,23,260.4 INR/ha), net return (87,830.4 INR/ha) and Benefit cost ratio (2.47) when compared to the other treatments.

Keywords: Chickpea, potassium, sulphur, yield

Introduction

Chickpea (*Cicer arietinum* L.) is one of the foremost rabi pulse crop of Maharashtra and premier pulse of India. Pulses consist a group of Leguminosae family which fixes atmospheric Nitrogen and plays an important role in maintain bio fertility. Pulses play important role in sustainable agriculture production and provide nutrition. Chickpea (*Cicer arietinum* L.) is the third most important legume in the world. India alone contributes more than 62-67% of the total global production. Chickpea is good rotational and remunerative pulse crop in India.

Chickpea occupies 30 % of area and 37% of production of total pulse of the country out of total area of pulses in the world more than 75% area line in India. However, India generally imports 2 million tonnes of pulse every year from Turkey, Australia, Canada and USA. To make up this short fully supply besides of course, further demand from a burgeoning population, at least 23.38 million tonnes of pulses are required by 2015 which is expected to touch 29.30 million tonnes by 2020 (Anonymous, 2016) [1]. Pulses are the most important sub constituent of human diet. Gram is mostly consumed in the form of processed whole seed and dal but also used for preparing a variety of snacks, sweets and condiments, which are very useful for stomach ailments and blood purification. Pulses and their crop residues are major source of high quality and nutritive value of livestock feed.

Potassium is one of the major elements taken up by the plant. Plants absorb it in larger amounts as compared to other minerals except nitrogen. It helps in formation of proteins and chlorophyll. It has most importance for imparting drought and disease resistance and has synergistic effect with nitrogen and phosphorus. Though, it is not a constituent of organic structures but it regulates enzymatic activities (over 60 enzymes require K for activation), translocation of photosynthates (Mengel and Kirkby, 1987) [9] and considerably improves seed yield of chickpea if applied as a fertilizer (Samiullah and Khan, 2003). Potassium is one of the three major essential nutrients required by crop plants. It is absorbed by the plants in large amounts than any other mineral element except nitrogen (Brady, 1990) [3]. Potassium is the utmost importance for water status of plant meristemetic tissues, enables the plant to resist pest and diseases and regulates enzymatic activities and translocation of photosynthates (Mengel and Kirkby, 1987) [9]. Sulphur, in chickpea, mainly influences the protein content. Sulphur helps towards conversion of nitrogen into protein in pulse crops.

It promotes nodule formation on roots of leguminous plants. Sulphur is taken up from the soil solution by the plant in the sulphate form (SO42-). In legumes Sulphur is necessary for the efficient fixation of nitrogen by the plant (Scherer, 2009).
Sulphur is now recognized as major plant nutrient along with nitrogen (N), phosphorus (P) and potassium (K). It is a key element of higher pulse production, is required in the formation of proteins, vitamins and enzymes. Besides, it is involved in biological nitrogen fixation. Deficiencies of sulphur in Indian soil is widespread due to extensive use of sulphur free fertilizer coupled with extensive cultivation of high sulphur demanding crop, Moreover, sulphur requirement of crop plants is quite high, with high yielding varieties and increased cropping intensity large amounts of nutrients are removed from the soil gradually.
Sulphur deficiency is becoming more critical with each passing year which is severely restricting crop yield, produce quality, nutrient use efficiency and economic returns on millions farms. Like any essential nutrient, sulphur also has certain specific function to perform in the plant. thus, sulphur deficiencies can only be corrected by the application of sulphur fertilizer (Tendon & Messick 2007) [16]. Application of fertilizer to alkaline soils has been reported to reduce the pH of soil (Taalab *et al*. 2008) [15].

Materials and Methods
The experiment was conducted during the *rabi* season of 2021-2022 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj. The Crop Research Farm is situated at 250 57' N latitude, 870 19' E longitude and 98 m altitude from the sea level. During Rabi season 2021 on sandy loam soil, having nearly neutral in soil reaction (pH 7.5), organic carbon (0.28), available nitrogen (205 Kg/ha), available phosphorus (22.0 kg/ha) and available potassium (217.6 kg/ha). The climate of the region is semi-arid subtropical. The treatments comprised of T1- Potassium 10 kg/ha + sulphur 20 kg/ha, T2- potassium 10 kg/ha + sulphur 25 kg/ha, T3- potassium 10 kg/ha + sulphur 30 kg/ha, T4- potassium 15 kg/ha + sulphur 20 kg/ha, T5- potassium 15 kg/ha + sulphur 25 kg/ha, T6- potassium 15 kg/ha + sulphur 30 kg/ha, T7- potassium 20 kg/ha + sulphur 20 kg/ha, T8- potassium 20 kg/ha + sulphur 25 kg/ha, T9- potassium 20 kg/ha + sulphur 30 kg/ha. These were replicated thrice in Randomized Block Design. The recommended dose of fertilizer is 20- 40-20 kg/ha NPK. Recommended dose of fertilizer was applied at the time of sowing in the form of Urea, SSP, MOP.

Chemical analysis of soil
Composite soil samples are collected before layout of the experiment to determine the initial soil properties. The soil samples are collected from 0-15 cm depth and were dried under shade, powdered with wooden pestle and mortar, passed through 2 mm sieve and were analyzed for organic carbon by walkey and black method by Jackson (1973) [7]. Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asjia (1956) [14], available phosphorus by Olsen's method by Olsen's (1954), available potassium was determined by using the flame photometer normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973) [7].

Statistical analysis
The data recorded were different characteristics were subjected to statistical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez (2010) [5]. Critical difference (CD) values were calculated the 'F' test was found significant at 5% level.

Results and Discussion
Plant height (cm)
There was a steady increase in the plant height recorded 20,40,60,80,100 DAS was progressively increased with the advancement during experimentation. The analysis on plant height was significantly higher in all the different growth levels of potassium and sulphur. At harvest, maximum plant height (51.63 cm) was recorded with application of 20 kg/ha potassium + sulphur 30 kg/ha which was significantly superior over all other treatments and statically at par with treatment of potassium 20 kg/ha + sulphur 25 kg/ha (51.44 cm). It might be due to the results revealed that the plant height, number of branches per plant, fresh weight and dry matter accumulation could be attributed to the fact that potassium enhances plant vigour and strengthens the stalk, further synergistic effect with nitrogen and phosphorus resulted in better plant growth characters. Similar findings were reported by DAS (1999).

Number of nodules per plant
There was steady development in the root nodules from 20 to 60 DAS and 60 to at harvest root nodules decrease. At harvest, maximum number of nodules/plant (29.46) was recorded with application of potassium 20 kg/ha + sulphur 30 kg/ha which was significantly superior over all other treatments and statistically at par with application of potassium 20 kg/ha + sulphur 30 kg/ha (28.47). it might be due to the results revealed that the application of potassium 20 kg/ha + sulphur 30 kg/ha has highest nodule formation which was maximum with 60 kg being at par with 40 and 80 kg K2O per hectare but significantly different with rest of the doses. These findings were also reported by Kurdali *et al*. (2002) [8] in chickpea.

Yield attributes and Yield
Observations regarding the response of potassium 10 kg/ha, 15 kg/ha, 20 kg/ha and sulphur 20 kg/ha, 25 kg/ha, 30 kg/ha on yield and yield attributes of chickpea. The observation showed that the yield and yield attributes there was significant difference between treatments.

Number of pods/plant
Treatment with application of potassium 20 kg/ha + sulphur 30 kg/ha was recorded maximum number of pods/plant (45.74) which was significantly superior over all other treatments and statistically at par with treatment of potassium 20 kg/ha + sulphur 25 kg/ha (45.55).

Number of seeds/pod
Treatment with application of potassium 20 kg/ha + sulphur 30 kg/ha was recorded maximum number of seeds/pod (1.88) which was significantly superior over all other treatments and statistically at par with treatment of potassium 20 kg/ha + sulphur 25 kg/ha (1.84). Maximum number of seeds/pod found with sulphur 30 kg/ha, same result found by Hussain (2010) [6].

Test weight

Treatment with application of potassium 20 kg/ha + sulphur 30 kg/ha was recorded maximum number of test weight (201.94 g) which was significantly superior over all other treatments and statistically at par with treatment of potassium 20 kg/ha + sulphur 25 kg/ha (200.80).

Seed yield (t/ha)

Treatment with application of potassium 20 kg/ha + sulphur 30 kg/ha was recorded maximum number of seed yield (2.03) which was significantly superior over all other treatments and statistically at par with treatment of potassium 20 kg/ha + sulphur 25 kg/ha (1.99). It might be due to the results revealed that among all the treatments Sulphur besides improving vegetative growth it activates certain photolytic enzymes and co-enzymes (Bixby and Beaton, 1970) [3]. Thus, these bio-activities of sulphur might have played important role in improving yield attributing characters and total yield of chickpea. Similar findings were reported by Patel *et al.*, (2014) [12].

Stover yield (t/ha)

Treatment with application of potassium 20 kg/ha + sulphur 30 kg/ha was recorded maximum number of stover yield (4.45) which was significantly superior over all other treatments and statistically at par with treatment of potassium 20 kg/ha + sulphur 25 kg/ha (4.40). It might be due to the result revealed that among all the treatments, potassium 20 kg/ha + sulphur 30 kg/ha T9 treatment recorded maximum growth attributes, yield and yield attributes which is closely followed by T8 potassium 20 kg/ha + sulphur 30 kg/ha. Application of potassium 20 kg/ha + sulphur 30 kg/ha also exhibited maximum values of gross return, net return and benefit cost ratio. Similar findings were reported by Srinivasulu *et al.*, (2016) [13].

Table 1: Effect of Potassium and Sulphur on Plant height in Chickpea.

Plant height (cm)						
S. No.	Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS
1.	potassium 10 kg/ha+ sulphur 20 kg/ha	6.86	9.76	24.47	30.54	37.09
2.	potassium 10 kg/ha+ sulphur 25 kg/ha	7.03	10.15	25.55	32.87	39.24
3.	potassium 10 kg/ha+ sulphur 30 kg/ha	7.26	10.32	25.87	33.25	40.54
4.	potassium 15 kg/ha+ sulphur 20 kg/ha	6.92	9.87	24.64	31.66	38.14
5.	potassium 15 kg/ha+ sulphur 25 kg/ha	7.56	10.72	26.56	34.34	45.16
6.	potassium 15 kg/ha+ sulphur 30 kg/ha	7.65	10.86	27.37	35.23	47.85
7.	potassium 20 kg/ha+ sulphur 20 kg/ha	7.45	10.49	26.25	33.78	42.41
8.	potassium 20 kg/ha+ sulphur 25 kg/ha	7.78	10.99	27.53	35.09	51.44
9.	potassium 20 kg/ha+ sulphur 30 kg/ha	7.85	11.05	27.57	36.04	51.63
	F test	NS	NS	S	S	S
	SEm (±)	0.02	0.01	0.01	0.01	0.07
	CD (P=0.05)	-	-	0.04	0.03	0.22

Table 2: Effect of Potassium and Sulphur on Nodules in Chickpea

Nodules/plant (No.)						
S. No	Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100DAS
1.	potassium 10 kg/ha+ sulphur 20 kg/ha	5.56	28.22	47.79	32.85	23.15
2.	potassium 10 kg/ha+ sulphur 25 kg/ha	5.95	29.29	50.07	34.26	25.06
3.	potassium 10 kg/ha+ sulphur 30 kg/ha	6.07	29.88	50.46	34.85	25.95
4.	potassium 15 kg/ha+ sulphur 20 kg/ha	5.86	28.95	49.47	33.06	24.45
5.	potassium 15 kg/ha+ sulphur 25 kg/ha	6.34	30.76	52.64	36.27	27.13
6.	potassium 15 kg/ha+ sulphur 30 kg/ha	6.39	31.57	53.36	38.66	27.75
7.	potassium 20 kg/ha+ sulphur 20 kg/ha	6.26	30.25	51.84	35.45	26.46
8.	potassium 20 kg/ha+ sulphur 25 kg/ha	6.47	32.72	54.26	39.97	28.47
9.	potassium 20 kg/ha+ sulphur 30 kg/ha	6.56	33.32	54.43	40.35	29.46
	F test	NS	S	S	S	S
	SEm (±)	0.01	0.02	0.02	0.01	0.01
	CD(P=0.05)	-	0.05	0.05	0.04	0.04

Table 3: Effect of Potassium and Sulphur on Dry weight in Chickpea

Dry Weight (g/plant)						
S. No.	Treatments	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS
1.	potassium 10 kg/ha+ sulphur 20 kg/ha	0.34	1.80	4.77	9.49	17.57
2.	potassium 10 kg/ha+ sulphur 25 kg/ha	0.37	1.86	5.43	10.13	18.93
3.	potassium 10 kg/ha+ sulphur 30 kg/ha	0.38	2.08	5.78	10.33	19.30
4.	potassium 15 kg/ha+ sulphur 20 kg/ha	0.41	1.89	4.95	9.66	19.86
5.	potassium 15 kg/ha+ sulphur 25 kg/ha	0.40	2.26	6.58	12.45	21.38
6.	potassium 15 kg/ha+ sulphur 30 kg/ha	0.46	2.38	6.75	13.73	22.63
7.	potassium 20 kg/ha+ sulphur 20 kg/ha	0.47	2.14	6.14	11.86	20.73
8.	potassium 20 kg/ha+ sulphur 25 kg/ha	0.50	2.40	6.89	15.33	24.80
9.	potassium 20 kg/ha+ sulphur 30 kg/ha	0.52	2.45	6.94	15.51	25.05
	F test	NS	S	S	S	S

	SEm (±)	0.01	0.02	0.05	0.11	0.15
	CD(P=0.05)	-	0.06	0.15	0.32	0.44

Table 4: Effect of Potassium and Sulphur on Crop Growth Rate in Chickpea

			Crop Growth	Rate (g/m^2/day)	
S. No.	Treatments	20-40 DAS	40-60 DAS	60-80 DAS	80-100 DAS
1	potassium 10 kg/ha+ sulphur 20 kg/ha	2.42	4.96	11.20	10.13
2	potassium 10 kg/ha+ sulphur 25 kg/ha	2.49	5.95	11.16	11.34
3	potassium 10 kg/ha+ sulphur 30 kg/ha	2.83	6.18	10.92	11.61
4	potassium 15 kg/ha+ sulphur 20 kg/ha	2.46	5.11	11.19	13.66
5	potassium 15 kg/ha+ sulphur 25 kg/ha	3.09	7.20	13.12	11.56
6	potassium 15 kg/ha+ sulphur 30 kg/ha	2.93	7.29	14.97	11.49
7	potassium 20 kg/ha+ sulphur 20 kg/ha	2.79	6.66	12.87	11.54
8	potassium 20 kg/ha+ sulphur 25 kg/ha	3.17	7.46	17.39	12.46
9	potassium 20 kg/ha+ sulphur 30 kg/ha	3.22	7.48	17.62	12.56
	F test	NS	S	S	NS
	SEm (±)	0.10	0.09	0.20	0.31
	CD (P=0.05)	-	0.28	0.58	-

Table 5: Effect of Potassium and Sulphur on Relative Growth Rate in Chickpea

		Relative	Growth Rate	(g/g/day)	
S. No.	Treatments	20-40 DAS	40-60 DAS	60-80 DAS	80-100 DAS
1.	potassium 10 kg/ha+ sulphur 20 kg/ha	0.082765	0.048851	0.043935	0.021252
2.	potassium 10 kg/ha+ sulphur 25 kg/ha	0.080817	0.05352	0.040157	0.022274
3.	potassium 10 kg/ha+ sulphur 30 kg/ha	0.085385	0.051206	0.03787	0.022383
4.	potassium 15 kg/ha+ sulphur 20 kg/ha	0.076316	0.048243	0.042849	0.026605
5.	potassium 15 kg/ha+ sulphur 25 kg/ha	0.086519	0.053481	0.039354	0.019594
6.	potassium 15 kg/ha+ sulphur 30 kg/ha	0.082142	0.052192	0.0423	0.018179
7.	potassium 20 kg/ha+ sulphur 20 kg/ha	0.075896	0.052596	0.040728	0.020129
8.	potassium 20 kg/ha+ sulphur 25 kg/ha	0.078437	0.052754	0.046085	0.017937
9.	potassium 20 kg/ha+ sulphur 30 kg/ha	0.077591	0.051995	0.046271	0.017894
	F test	NS	NS	NS	NS
	SEm (±)	0.00	0.00	0.01	0.00
	CD (P=0.05)	-	-	-	-

Table 6: Effect of Potassium and Sulphur on yield attributes in Chickpea.

S. No.	Treatments	Pods/plant (No.)	Seeds/pod (No.)	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1	potassium 10 kg/ha+ sulphur 20 kg/ha	37.20	1.30	188.57	1.38	3.32	29.34
2	potassium 10 kg/ha+ sulphur 25 kg/ha	39.27	1.44	191.92	1.54	3.57	30.12
3	potassium 10 kg/ha+ sulphur 30 kg/ha	42.81	1.57	194.72	1.63	3.76	30.30
4	potassium 15 kg/ha+ sulphur 20 kg/ha	38.88	1.40	193.50	1.49	3.46	30.08
5	potassium 15 kg/ha+ sulphur 25 kg/ha	44.19	1.64	195.96	1.74	3.99	30.35
6	potassium 15 kg/ha+ sulphur 30 kg/ha	44.84	1.74	198.37	1.85	4.17	30.79
7	potassium 20 kg/ha+ sulphur 20 kg/ha	43.82	1.65	196.59	1.69	3.93	30.05
8	potassium 20 kg/ha+ sulphur 25 kg/ha	45.55	1.84	200.80	1.99	4.40	31.13
9	potassium 20 kg/ha+ sulphur 30 kg/ha	45.74	1.88	201.94	2.03	4.45	31.29
	F test	S	S	S	S	S	NS
	SEd (±)	0.12	0.02	0.34	0.02	0.03	0.36
	CD (P=0.05)	0.37	0.06	1.01	0.06	0.09	-

Conclusion
It is concluded that the treatment combination T9 Potassium 20 kg/ha + sulphur 30 kg/ha along with recommended dose of fertilizer was found to be the best treatment that recorded highest plant height, number of nodules per plant, number of pods/plant, seeds per pods, highest test weight, seed yield, stover yield. It also fetched the maximum gross return, net return, and benefit cost ratio.

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