Impact of different sources of Phosphorus and Sulphur Levels on Growth, Yield Attributes and Performance of Chickpea Under Light Textured Soil

ABSTRACT:

Background: Pulses are most important source of dietary protein, belonging to the family of *Leguminosae* and strictly harvested for their dried seeds. Phosphorus and sulphur nutrients play a vital role in quality production and nutritional values. Phosphorus rich organic manure (PROM) have potential to release organic acids to enhance native soil phosphorus mineralization.

Methods: This investigation was carried out at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agriculture University, Bikaner during *Rabi* season of 2021-22 with the use of different levels of phosphorus and sulphur to investigate the growth rate, yield parameters and performances of chickpea. The experiment was laid out in factorial randomized block design comprising three phosphorus sources with a certain amount of 32 kg P ha^{-1} through di ammonium phosphate (DAP), single super phosphate (SSP) and PROM and four sulphur levels (control, 20, 40 and 60 kg ha^{-1}) and it was replicated thrice.

Result: The application of 32 kg P_2O_5 ha^{-1} through PROM significantly increase higher growth parameters, yield attributes and yield in comparison to 32 kg P_2O_5 ha^{-1} through DAP and SSP. Among sulphur levels, upto 40 kg S ha^{-1} showed significantly higher growth rate and yield characters. The PROM can be a better strategy for the improvement of growth and yield characters.

Key words: Nutritional Values, Phosphorus Rich Organic Matter, Quality, and Soil fertility

INTRODUCTION:

Nowadays farmers are using excess amount of chemical fertilizers for the crop production. However, excess use of chemicals and fertilizers is the main cause of soil deterioration and poor product quality. Therefore, the present investigation was carried with different sources of phosphorus through organic and inorganic sources along with different levels of sulphur to knowing their effects in crop production for better quality and nutritional values. Pulses are a significant source of protein in the diet and possess unique qualities that boost the biological value of protein and restore soil fertility. Chickpea (*Cicer arietimum* L.) plays a vital role in pulse production as well as in consumption by Indians and originated in south eastern turkey and derived from the greek word 'kikus' meaning force or strength. Chickpea 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 (Singh *et al*., 2018). India holds the record for both chickpea production and acreage worldwide. It has18–22% protein, 52–70% carbohydrates, 4–10% fat and adequate amounts of calcium, phosphorus, iron and vitamins. Additionally, it is critical for sustainable agriculture since it enhances the biological and physico-chemical characteristics of the soil. Its deep roots also allow the soil to open up, improving aeration and raising the amount of organic matter in the soil due to high leaf fall (Grasso *et al*., 2022).

Crop growth and development are primarily dependent on the development of root system. Phosphorus is one of the main macro-nutrient that has significant roles in root formation, growth, flowering and ripening. Improved root growth in pulses facilitates improved *Rhizobium* bacterial nodulation. A sufficient amount of phosphorus causes the plant to mature more quickly and speeds up the development of pods and nodulation (Abbas *et al*., 2021).

Sulphur is one of essential nutrient element require for growth and metabolism, however, fertilizer recommendations do not adequately account for this important nutrient. It is an essential component of higher pulse production and is important for the synthesis of enzymes, vitamins and proteins in plants. Because nitrogen is fixed by symbiosis with *Rhizobium* bacteria, the study of phosphorus and sulphur to legumes is therefore more important than that of nitrogen (Jamal *et al*., 2010). Consequently, this experiment was conducted using different phosphorus sources and sulphur levels.

MATERIALS AND METHODS:

Experimental Site:

The experiment was conducted at the Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Rabi*, 2021. The plot size was 4.2 m x 4.0 m with total 604.8 m^2, under loamy sand soil which was slightly alkaline in reaction, poor in organic carbon (0.09), low in available nitrogen (115.4 kg ha^{-1}), phosphorus (14.5 kg ha^{-1}) and sulphur (7.3 kg ha^{-1}) but medium in available potassium (212.35 kg ha^{-1}). The GNG-1581 cultivar was used for sowing with 80 kg/ha at 30 x 10 cm of crop geometry.

Treatment details

This experiment was laid out in factorial randomized block design with 12 treatment combinations replicated thrice. The treatment details were given as:

List 1. Treatment details

Treatments code		Details
Phosphorus source (32 kg ha^{-1})		
P_1	:	DAP
P_2	:	SSP
P_3	:	PROM
Sulphur levels (kg ha^{-1})		
S_0	:	Control
S_1	:	20
S_2	:	40
S_3	:	60

Source and mode of Application

Phosphorus was applied through DAP, SSP and PROM and sulphur was applied through Gypsum as per the treatment as a basal application.

Methods used for observation used

Crop growth rate (CGR): Crop growth rate was computed between 30-60 DAS, 60-90 DAS and 90 DAS -harvest. Using the dry weight measured at various intervals, the crop growth rate was computed. It indicates the overall growth rate of crop and is measured after a set amount of time, regardless of the previous growth rate. The value was calculated by using the formula suggested by Hunt (1978):

$$\text{CGR}\ (\text{g m}^{-2}\ \text{day}^{-1})\ \frac{W_2 - W_1}{t_2 - t_1}$$

Where, $W_2 - W_1$ = Difference in oven dry biomass at the time interval

$t_2 - t_1$ = Time interval in days

Relative growth rate (RGR): This parameter indicates rate of growth per unit dry matter. It was computed by using formula as suggested by Radford (1967):

$$\text{RGR}\ (\text{g g}^{-1}\text{day}^{-1})\ \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where, $\ln W_2 - \ln W_1$ = Natural logarithm of dry matter at time t_2 and t_1, respectively

Pods plant^{-1}: The pods were counted manually from five randomly selected plants at the time of harvest and average was calculated for the results.

Seeds pod^{-1}: At the time of harvesting, number of pods was counted from randomly selected from each plot and their total seeds were averaged to record the number of seeds pod^{-1}.

Test weight: The test weight was calculated based on counting of thousand seeds randomly by taking handful of samples and weighed on electronic balance.

Seed, straw and biological yield: Each net plot's total biomass was threshed, winnowed, cleaned and dried. The resulting grains, straw or haulm were weighed in kilograms net plot^{-1} before being converted to kilograms ha^{-1}. The sum of seed and straw yield was biological yield.

Harvest index: It was computed by using the formula given by Donald (1962).

$$\text{Harvestindex (\%)} = \frac{\text{Economical yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})}$$

Statistical analysis

The methodology described by Panse and Sukhatme (1985) was followed to statistically analyze the data collected in order to determine the significance of variance at 5% level of significance. The "F" test was determined to be significant at the five percent and one percent levels of significance after the crucial differences were computed to evaluate the significance of treatment means.

RESULTS AND DISCUSSION

The Growth rate, yield attributes and yield were significantly influenced by different sources of phosphorus and levels of sulphur throughout the growth period and at harvest.

Crop growth rate (CGR):

Effect of source of phosphorus: The fig. 1 shows that maximum crop growth rate was recorded by the application of 32 kg P_2O_5 ha^{-1} through PROM and significantly superior over application of phosphorus through DAP and SSP with the tune of 16.01, 8.17% at 30-60 DAS and 30.09, 12.96% at 60-90 DAS and 40.55, 16.98% at harvest, respectively.

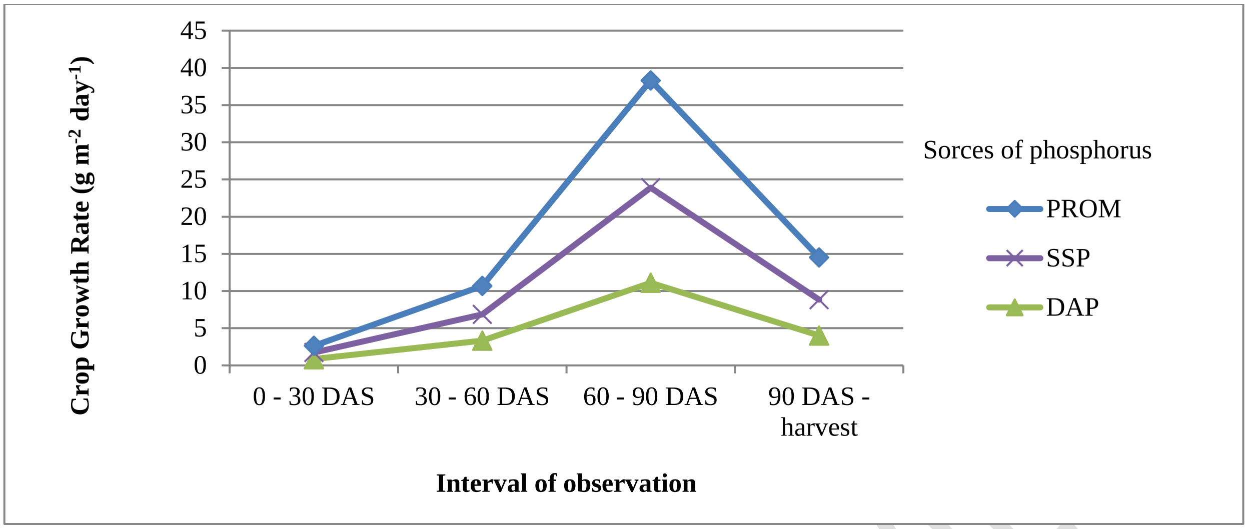

Fig 1: Crop growth rate as influenced by different sources of phosphorus

Effect of levels of sulphur: Sulphur application had significant effect on crop growth rate at 30-60 DAS, 60-90 DAS and at harvest (Fig. 2). Application of 40 kg S ha^{-1} significantly increased the crop growth rate compare to control and 20 kg S ha^{-1} by 13.14, 6.32% at 30-60 DAS and 33.87, 11.60% at 60-90 DAS and 45.67, 14.43 at harvest, respectively.

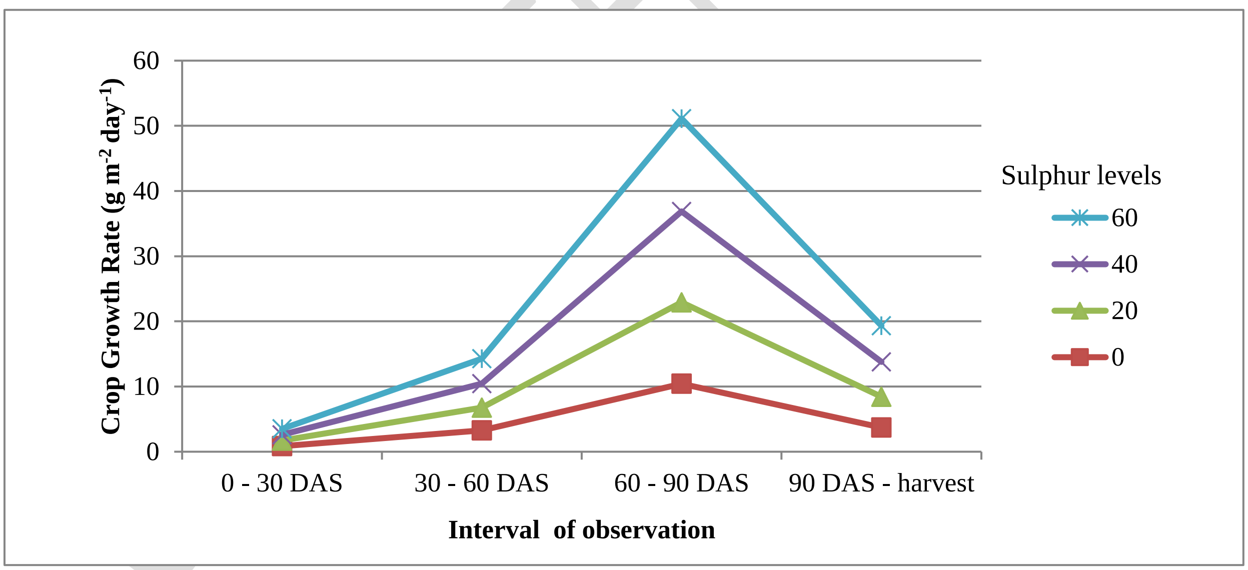

Fig 2: Crop growth rate as influenced by different levels of sulphur

Relative growth rate

Effect of sources of phosphorus: The results depicted in fig.3, showed that phosphorus sources significantly influenced the relative growth rate at 30-60 DAS, 60-90 DAS and at harvest.

Among the sources, application of 32 kg P_2O_5 ha^{-1} through PROM significantly increased relative growth rate over 32 kg P_2O_5 ha^{-1} through DAP and SSP with the magnitude of 4.78, 2.25% at 30-60 DAS and 7.60, 2.61% at 60-90 DAS and 10.41, 4.13% at harvest, respectively.

These findings could be the consequence of increased sulphur availability, which raised photosynthetic activity and plant metabolism and thus led to improved growth. It is also evident from the fact that applying sulphur has been shown to increase the availability of sulphur and other nutrients, all of which are thought to be crucial for the growth and development of plants. The current study's results are consistent with those of Prajapat *et al.* (2011) and Kumawat *et al.* (2014).

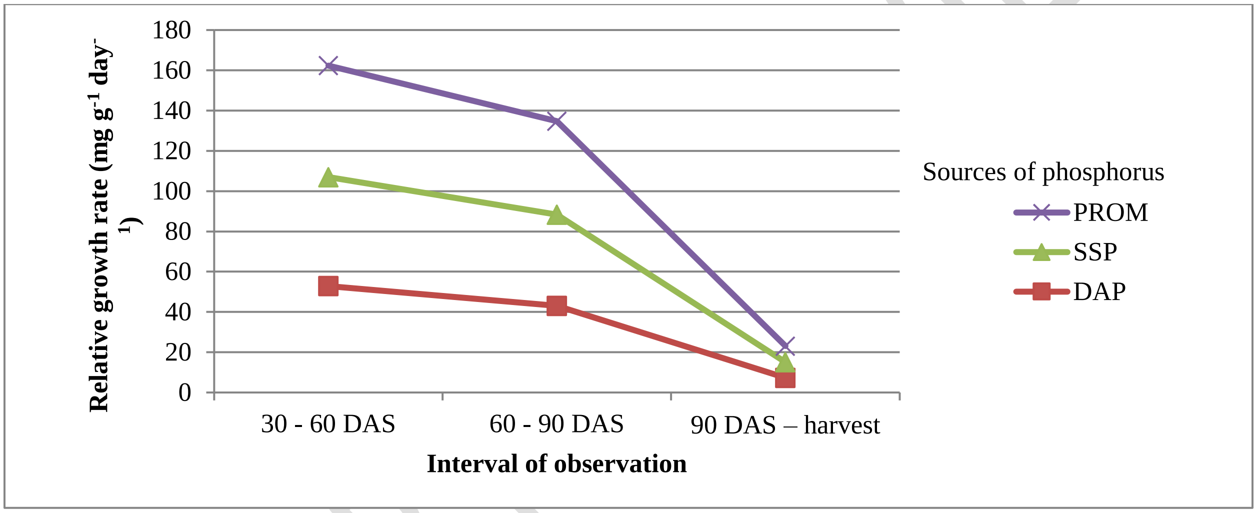

Fig 3: Relative growth rate as influenced by different sources of phosphorus

Effect of levels of sulphur: Fig. 4 illustrates that significantly higher relative growth rate was recorded by the application of 40 kg S ha^{-1} which was superior over control and 20 kg S ha^{-1} by 4.07, 2.21% at 30-60 DAS and 11.00, 3.38% at 60-90 DAS and 12.69, 3.63% at harvest, respectively.

Addition of PROM enhances the activity and population of *Rhizobium* bacteria in roots and thus increased the availability of nitrogen for plant growth. Similar result was found with Bairwa *et al.* (2019) who observed the dry matter accumulation increased significantly with the application of PROM as a source of phosphorus which also indicate growth rate.

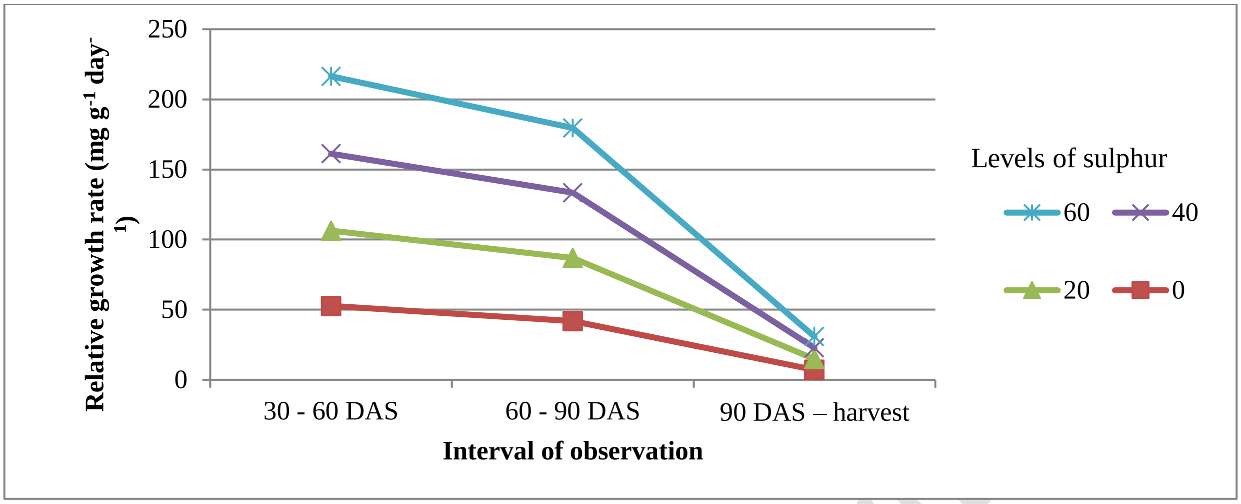

Fig 4: Relative growth rate as influenced by different levels of sulphur

Pods plant^{-1}

Effect of sources of phosphorus: The information in Table 1, shows that higher pods plant^{-1} were recorded by the application of PROM as a source of phosphorus and it was significantly superior over DAP and SSP. Applying 32 kg of P_2O_5 ha^{-1} using PROM resulted in 13.76 and 7.51% more pods plant^{-1} than applying 32 kg of P_2O_5 ha^{-1} through DAP and SSP, respectively.

Effect of levels of sulphur: Significantly increase in number of pods plant^{-1} was recorded by the application of 40 kg S ha^{-1} over control and 20 kg S ha^{-1} which was statistically at par with 60 kg S ha^{-1}, according to data reported in Table 1. The% increase in number of pods plant^{-1} due to 40 kg S ha^{-1} over control and 20 kg S ha^{-1} was 7.20 and 20.19%, respectively.

Seeds pod^{-1}: Data presented in Table 1 revealed that number of seeds pod^{-1} of chickpea did not influenced due to different sources of phosphorus and levels of sulphur.

Test weight

Effect of sources of phosphorus: Test weight was significantly impacted by the application of various phosphorus sources, as evidenced by the data in Table 1. The test weight was considerably raised by 6.43 and 2.27%, respectively, when 32 kg P_2O_5 ha^{-1} through PROM was applied as opposed to 32 kg P_2O_5 ha^{-1} through DAP and 32 kg P_2O_5 ha^{-1} through SSP.

Effect of levels of sulphur: Application of 40 kg S ha^{-1} recorded a considerable increase in test weight and it was significantly superior over control and 20 kg S ha^{-1}, but remained at par with

60 kg S ha^{-1}. The% increase in test weight due to 40 kg S ha^{-1} over control and 20 kg S ha^{-1} with the magnitude of 11.11 and 5.53%, respectively.

Seed yield

Effect of sources of phosphorus: Data presented in table 2 showed that application of different sources of phosphorus had significant effect on seed yield of chickpea. Significantly higher seed yield was recorded by the application of 32 kg P_2O_5 ha^{-1} through PROM over 32 kg P_2O_5 ha^{-1} through DAP and SSP by 27.23 and 14.73%, respectively.

Effect of levels of sulphur: Data presented in table 2 revealed that 40 kg S ha^{-1} found significant enhancement in seed yield of chickpea over control and 20 kg S ha^{-1} but it remains statistically at par with 60 kg S ha^{-1}. The% increase due to 40 kg S ha^{-1} was 33.34 and 12.99% over control and 20 kg S ha^{-1}, respectively.

Straw yield

Effect of sources of phosphorus: The information in table 2 demonstrated that application of 32 kg P_2O_5 ha^{-1} through PROM resulted in a considerable increase in straw yield compared to 32 kg P_2O_5 ha^{-1} through DAP and SSP with the magnitude of 18.52 and 11.29%, respectively.

Effect of levels of sulphur: Maximum straw yield was obtained by the application of 40 kg S ha^{-1} over control and 20 kg S ha^{-1} by 28.87 and 8.62%, respectively. However, it was still comparable to 60 kg S ha^{-1} (Table 2).

Biological yield

Effect of sources of phosphorus: A thorough examination of the information in Table 2 showed that the application of various phosphorus sources significantly affected the biological yield of chickpeas. Maximum biological yield was recorded by the application of 32 kg P_2O_5 ha^{-1} through PROM and it was significantly superior over 32 kg P_2O_5 ha^{-1} through DAP and SSP, by 21.62 and 12.52%, respectively.

This increase in yield and yield attributes by PROM may be due to an organic source of nutrition which contains organic matter and several essential nutrients with phosphorus and provide food for beneficial microorganism in field. Similar results were found with Yadav *et al.* (2017) and Bairwa *et al.* (2019).

Effect of levels of sulphur: Significantly higher biological yield was obtained by the application of 40 kg S ha^{-1} which was statistically at par with 60 kg S ha^{-1} and significantly superior over control and 20 kg S ha^{-1} with the tune of 30.64 and 10.20%, respectively.

Overall yield attributes appear to have improved as a result of a balanced nutritional environment, effective and increased metabolite partitioning and sufficient nutrient translocation towards the development of reproductive structures or sinks. In order to improve plant growth and development, sulphur improves root growth, encourages nodule formation and stimulates seed formation. These actions may have increased chickpea yield. Similar findings were also reported by Baviskar *et al.* 2010; Yadav et al., 2023.

Harvest index (%)

Results showed that harvest index of chickpea remained unaffected due to different sources of phosphorus and levels of sulphur.

CONCLUSION

The application of 32 kg P_2O_5 ha^{-1} through phosphorus rich organic manure significantly increase the crop growth rate, relative growth rate, yield attributes like seeds $pods^{-1}$, pods $plant^{-1}$, seed, straw and biological yield. Among the sulphur levels application of 40 kg S ha^{-1} significantly increased the crop growth rate, relative growth rate, yield attributes, seed, straw and biological yield.

Table 1: Effect of different sources of phosphorus and levels of sulphur on yield attributes of chickpea

Treatments	Pods plant^{-1}	Seeds pod^{-1}	Test weight (g)
Sources of phosphorus (32 kg ha^{-1})			
DAP	32.19	1.63	146.75
SSP	34.06	1.66	152.72
PROM	36.62	1.72	156.18
SEm±	0.71	0.03	2.37
CD (p = 0.05%)	2.09	NS	6.95
Levels of sulphur (kg ha^{-1})			
0	30.21	1.64	141.68
20	33.87	1.67	149.17
40	36.31	1.69	157.43
60	36.77	1.70	159.26
SEm±	0.82	0.04	2.73
CD (p = 0.05%)	2.41	NS	8.02

Table 2: Effect of different sources of phosphorus and levels of sulphur on yields and harvest index of chickpea

Treatments	Yields (kg ha^{-1})			Harvest index (%)
	Seed	Straw	Biological	
Sources of phosphorus (32 kg ha^{-1})				
DAP	1744	3168	4912	35.63
SSP	1934	3374	5309	36.34
PROM	2219	3755	5974	37.08
SEm±	48	79	107	0.66
CD (p = 0.05%)	142	231	315	NS
Levels of sulphur (kg ha^{-1})				
0	1606	2864	4470	36.00
20	1901	3398	5299	35.97
40	2148	3691	5840	36.69
60	2208	3777	5985	36.73
SEm±	56	91	124	0.77
CD (p = 0.05%)	164	267	364	NS

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