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Effect of farm yard manure, phosphorus and sulphur on yield parameters, yield, nodulation, nutrient uptake and quality of chickpea (*Cicer arietinum* L.)

S. K. Das*, B. Biswas and K. Jana

Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani-741235 Nadia (West Bengal), INDIA
*Corresponding author. E-mail: sanjibag@gmail.com

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Abstract: Field experiments were conducted for three years at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal, India during *rabi* 2010-11, 2011-12 and 2012-13 to study the effects of farm yard manure (FYM), phosphorus and sulphur on yield parameters, yield, nodulation, nutrient uptake and quality of chickpea. The experiment was laid out in a factorial randomized block design with three replications having twelve treatment combinations *viz.* two levels of FYM (F_0 -0 t ha^{-1}, F_1 -5 t ha^{-1}) as factor A , three levels of phosphorus (P_0 -0 kg ha^{-1}, P_{30} -30 kg ha^{-1}, P_{60} -60 kg ha^{-1}) as factor B and two levels of sulphur (S_0 -0 kg ha^{-1}, S_{20} -20 kg ha^{-1}) as factor C. Experimental results revealed that yield attributing characters, yield and protein content of chickpea were significantly influenced by FYM, phosphorus, sulphur and interaction effects of these three factors. Significantly higher seed yield (2458.03 kg ha^{-1}) was obtained with the application of FYM 5 t ha^{-1}over it's non application. Application of 60 kg ha^{-1} phosphorus recorded significantly higher seed yield (2735.50 kg ha^{-1}) of chickpea cultivar Anuradha. Application of 20 kg ha^{-1}sulphur recorded significantly higher seed yield (2532.32 kg ha^{-1}) over it's non application in a sulphur deficient soil. Among the interaction effects application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1}sulphur in Farm yard manure(5 t ha^{-1}) treated plot recorded highest seed yield (2979.3 kg ha^{-1}) . Application of sulphur 20 kg ha^{-1} increased the nodule no. by 14.4 %. Application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1} sulphur in Farm yard manure treated plot (5 t ha^{-1}) increased the nodule no. by 62.3%. Varying levels of phosphorus along with sulphur and FYM significantly improved the nutrient uptake by chickpea in a sulphur deficient soil. Application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1} sulphur in Farm yard manure treated plot (5 t ha^{-1}) along with recommended dose of nitrogen and potassium proved to be the best treatment combination for increasing the productivity of chickpea and thereby increasing the pulse production of the country.

Keywords: Chickpea, FYM, Nodulation, Nutrient uptake, Phosphorus, Seed yield, Sulphur

INTRODUCTION

With the growing population of the world in general and the developing countries in particular, demands are overwhelmed for enhanced food production. Various pulses play an important role to satisfy the growing human food demands and nutritional security. Among many others, chickpea is an important source of protein rich food for the people especially in the subcontinent. Chickpea is the second most important pulse crop in the world. Productivity of this crop is much below than the national average, and the prime factor is the non-judicious use of fertilizers. Legumes generally require higher amount of phosphorus as the process of symbiotic nitrogen fixation consumes a lot of energy (Schulze *et al*., 2006). Apart from being a constituent of certain malic acids, phosphorus stimulates root, seed and fruit development as well as aids in vital metabolic functions (Singh *et al*., 2012). Now-a-days soil health has become a cause of concern for sustainable agricultural production in the new millennium. Use of high analysis fertilizers, less use of organic manures, heavy sulphur (S) removal by the crops under intensive cultivation & neglect of S replenishment contributed to widespread S deficiencies in India. Sulphur deficiencies have been reported from 72 countries in the world (Morris, 1998). Over 27000 soil samples from twelve states of India were analysed of which 40% were found deficient & another 35% were potentially deficient in available sulphur (Biswas *et al*., 2004). More than 70% soil samples taken from U.P., M.P., Maharastra, Orissa, Jharkhand, West Bengal, Andhra Pradesh and Karnataka were found low to medium in available sulphur. In West Bengal sulphur deficiency has been observed in 67% samples in red & lateritic soils of Midnapur & 63% in Gangetic alluviums of Nadia district (Biswas *et al*., 2004). Three soil series which were non deficient in sulphur are located in rainfed, monocropped coastal saline zone of W.B. (Ghosh *et al*., 2002). Sulphur has a great role in N-fixation by influencing active nodulation in legume. It is a part of nitrogenase enzyme, promotes nodulation in legumes, which enhances biological N-fixation (BNF) and the productivity of pulses may drastically

be reduced by an inadequate supply of sulphur. It is also necessary for chlorophyll formation and helps in biosynthesis of oil and metabolism of carbohydrates, proteins and fats and thus now-a-days sulphur is being considered as the fourth major nutrient element after NPK. An adequate supply of mineral nutrients to legumes enhances nitrogen fixation (Ganeshamurthy and Reddy, 2000). For example, starter N stimulated early seedling growth and nodulation (Daramola *et al.,* 1982); Phosphorus and sulphur improve nodulation activity (Olivera *et al.,* 2004; Scherer *et al.,* 2008). Sulphur deficiency decreases the concentration of N in the shoots and seeds of many legumes (Claro–Cortes *et al.,* 2002). There is direct involvement of sulfur in the process of nitrogen fixation whereas effect of phosphorus on nitrogen fixation is indirect mainly through enhanced growth and dry matter production. Keeping the above information in view, the present investigation was proposed to be conducted to study the effect of FYM (Farm yard manure) sulphur and phosphorus in chickpea under new alluvial zone of West Bengal.

MATERIALS AND METHODS

Field experiments were conducted at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal, India situated at $24^0$60'N latitude, $88^0$15' E longitude at an elevation of 19.0 meters above the mean sea level (MSL) during *rabi* 2010-11, 2011-12 and 2012-13. The soil of the experimental field was sandy loam in texture and slightly alkaline in reaction (pH 7.5) having an organic carbon content of 0.31%, 71 kg available P_2O_5 ha^{-1} , 113 kg available K_2O ha^{-1} and 8.1 kg available S ha^{-1}. The experiment was laid out in a factorial randomized block design with three replications having twelve treatment combinations *viz.,* two levels of FYM (F_0 -0 t ha^{-1}, F_1 -5 t ha^{-1}) as factor A , three levels of phosphorus(P_0 -0 kg ha^{-1}, P_{30} -30 kg ha^{-1}, P_{60} -60 kg ha^{-1}) as factor B and two levels of sulphur(S_0 -0 kg ha^{-1}, S_{20} -20 kg ha^{-1}) as factor C with a plot size of 4 m X 3 m. The crop was sown on first week of December, 2010-11, 2011-12 and 2012-13 respectively. The chickpea variety used was *Anuradha* (B-39-2) and the seed rate was 50 kg per ha. with a spacing of 30 cm X 10 cm. Nitrogen was applied at the rate 23.5 kg ha^{-1} and potassium was applied at the rate 20 kg ha^{-1} to all the treatments. Nitrogen was applied through Urea, phosphorus through di- ammonium phosphate, potassium through muriate of potash and S through elemental sulphur [Field grade 90% pure] and were applied as basal. Hand weeding was done twice at 20 and 40 days after sowing. Nodulation was studied at 50% flowering stage. Only active nodules were considered. The nodules with the pink colour of leghaemoglobin were considered active nodules. Nutrient uptake was calculated by multiplying the yield with the concentration of particular nutrient.

Data on yield attributes and seed yield (kg ha^{-1}) were recorded at harvest. Analysis of variance of the data in the experimental design and comparison of means at $p \leq 0.05$ were carried out, using MSTAT-C software.

RESULTS AND DISCUSSION

Effect on yield attributing characters and seed yield: Experimental results revealed that yield attributing characters such as primary branches $plant^{-1}$, pods $plant^{-1}$, 100 seed weight of chickpea were significantly influenced by application of FYM, phosphorus (P), sulphur (S) and interaction of FYM , P and S (Tables 1-4). Application of FYM @ 5 t ha^{-1} recorded significantly higher seed yield (2458.06 kg ha^{-1}) mainly attributed to significantly higher no. of primary branches $plant^{-1}$ (7.6 nos.), pods $plant^{-1}$(30.6 nos.), and 100 seed weight (12.8 g) of chickpea. It improved the seed yield by 8.9 % over it's non application. Patil *et al.* (2011) also reported that application of FYM @ 5 t ha^{-1} along with rock phosphate significantly increased the yield of chickpea. Application of phosphorus 60 kg ha^{-1} recorded significantly higher seed yield (2735.50 kg ha^{-1}) mainly due to significantly higher no. of primary branches $plant^{-1}$ (8.1 nos.), pods $plant^{-1}$ (33.6 nos.), and 100 seed weight (13.1 g). It improved the seed yield by 6.8 % over application of phosphorus 30 kg $ha^{-1}$and 53.9 % over it's non application. Basir *et al.* (2008), Dotania *et al.* (2014) and Das *et al.* (2015) also reported that grain yield of chickpea increased significantly with increase in phosphorus dose and was recorded maximum at 60 kg P ha^{-1}. Application of sulphur 20 kg ha^{-1} recorded significantly higher seed yield (2532.33 kg ha^{-1}) mainly attributed to significantly higher no. of primary branches $plant^{-1}$ (7.9 nos.), pods $plant^{-1}$(31.4 nos.), and 100 seed weight (12.9 g) of chickpea. It improved the seed yield by 16 % over it's non application. Increase in yield due to S application may be due to the fact that S is related to photosynthesis of plants. Sulphur application increased rate of photosynthesis due to an increment in protein synthesis and maintenance of high chlorophyll content (Ahmad and Abedin, 2000). Similar results of increased seed yield due to application of 20 kg S ha^{-1} were found by Srinivasarao *et al.*(2004) and Patel *et al.*(2014). In case of interaction effect, application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1} sulphur in Farm yard manure treated plot (5 t ha^{-1}) recorded highest yield (2979.3 kg ha^{-1}) mainly attributed to the highest no. of primary branches $plant^{-1}$ (8.9 nos.), pods $plant^{-1}$ (36.5 nos.), and 100 seed weight(13.4 g) followed by application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1}sulphur without Farm yard manure (2834.0 kg ha^{-1}). The lowest seed yield (1487.3 kg ha^{-1}) was recorded in control plot. Similarly Patel *et al.* (2014) also reported that application of 20 kg S ha^{-1} and 25kg P ha^{-1} along with PSB recorded highest seed yield of chickpea. Singh *et al.* (2012) also reported that application of FYM @ 5 t ha^{-1} along with 40 kg P ha^{-1} gave nhighest yield of kabuli chickpea .

Effect on Protein content: Protein content of chickpea seed was also significantly influenced by application of phosphorus (P), sulphur (S) and interaction of FYM, P and S (Tables 1-4). Irrespective of FYM and sulphur, application of 60 kg ha^{-1} phosphorus significantly

Table 1. Effect of FYM on yield attributing characters, seed yield (kgha^{-1}), protein content and nodulation in chickpea (Pooled data of 3 years).

Treatment	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Number of seeds pod^{-1}	100 seed weight (g)	Nodule no. plant^{-1} (at 50% flowering)	Protein content in seed (%)	Seed yield (kg ha^{-1})
F_0	7.3	28.2	1.6	12.5	67.4	20.1	2258.10
F_1	7.6	30.6	1.7	12.8	71.1	20.3	2458.06
SEm(±)	0.1	0.7	0.2	0.1	1.2	0.2	33.3
CD(P= 0.05)	0.3	2.0	NS	0.3	3.5	NS	99.9

Table 2. Effect of phosphorus on yield attributing characters, seed yield (kgha^{-1}), protein content and nodulation in chickpea (Pooled data of 3 years).

Treatment	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Number of seeds pod^{-1}	100 seed weight (g)	Nodule no. plant^{-1} (at 50% flowering)	Protein content in seed (%)	Seed yield (kg ha^{-1})
P_0	6.7	23.2	1.5	11.9	57.4	19.6	1777.58
P_{30}	7.7	31.4	1.7	13.0	72.9	20.4	2561.17
P_{60}	8.1	33.6	1.8	13.1	77.4	20.7	2735.50
SEm(±)	0.2	0.7	0.2	0.1	1.5	0.3	40.8
CD(P= 0.05)	0.5	2.1	NS	0.3	4.2	0.8	122.3

Table 3. Effect of sulphur on yield attributing characters, seed yield (kgha^{-1}), protein content and nodulation in chickpea (Pooled data of 3 years).

Treatment	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Number of seeds pod^{-1}	100 seed weight (g)	Nodule no. plant^{-1} (at 50% flowering)	Protein content in seed (%)	Seed yield (kg ha^{-1})
S_0	7.0	27.3	1.6	12.5	64.6	19.9	2183.83
S_{20}	7.9	31.4	1.7	12.9	73.9	20.5	2532.33
SEm(±)	0.1	0.7	0.2	0.1	1.2	0.2	33.3
CD(P= 0.05)	0.3	2.0	NS	0.3	3.5	0.5	99.9

Table 4. Interaction effect of FYM, phosphorus and sulphur on yield attributing characters, seed yield (kgha^{-1}), protein content and nodulation in chickpea (Pooled data of 3 years).

Treatment	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Number of seeds pod^{-1}	100 seed weight (g)	Nodule no. plant^{-1} (at 50% flowering)	Protein content in seed (%)	Seed yield (kg ha^{-1})
$F_0P_0S_0$	6.3	20.2	1.5	11.3	51.2	19.1	1487.3
$F_0P_{30}S_0$	7.1	28.1	1.6	12.8	65.5	20.0	2305.0
$F_0P_{60}S_0$	7.4	30.8	1.7	12.9	70.1	20.3	2528.0
$F_0P_0S_{20}$	6.8	23.0	1.5	12.0	59.3	19.8	1786.0
$F_0P_{30}S_{20}$	7.9	32.1	1.7	13.0	76.6	20.6	2608.3
$F_0P_{60}S_{20}$	8.3	34.9	1.8	13.2	81.6	20.9	2834.0
$F_1P_0S_0$	6.5	22.3	1.5	11.8	56.5	19.5	1666.0
$F_1P_{30}S_0$	7.3	30.6	1.7	12.9	69.3	20.2	2516.0
$F_1P_{60}S_0$	7.6	32.0	1.7	13.0	75.0	20.4	2600.7
$F_1P_0S_{20}$	7.0	27.2	1.6	12.6	62.6	19.9	2171.0
$F_1P_{30}S_{20}$	8.4	34.7	1.8	13.1	80.3	20.8	2815.3
$F_1P_{60}S_{20}$	8.9	36.5	1.8	13.4	83.1	21.1	2979.3
SEm(±)	0.3	1.6	0.4	0.2	3.1	0.3	83.4
CD (P= 0.05)	0.9	4.5	NS	0.6	9.2	0.9	244.6

improved the protein content by 5.6% and application of 20 kg ha^{-1} sulphur significantly improved the protein content by 3% irrespective of FYM and phosphorus. Application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1} sulphur in Farm yard manure treated plot (5 t ha^{-1}) increased the protein content of chickpea seed by 10.5% over control. This result was in conformity with the findings of Patel *et al.* (2014). They also found that S and P management in chickpea had significant influence on protein content of grain as increasing protein content in respective treatment was mainly on account of significant increase in nitrogen content and also more absorption of sulphur by chickpea grain. Since, both nutrients are closely linked with protein metabolism

Table 5. Effect of FYM on nutrient uptake in chickpea (Pooled data of 3 years).

Treatment	Total N Uptake (kg ha^{-1})	Available P Uptake (kg ha^{-1})	Available K Uptake (kg ha^{-1})	Available S Uptake (kg ha^{-1})
F_0	73.2	19.5	52.9	10.6
F_1	80.2	21.4	57.9	11.7
SEm(±)	0.9	0.1	0.4	0.1
CD(P= 0.05)	2.5	0.3	1.2	0.2

Table 6. Effect of phosphorus on nutrient uptake in chickpea (Pooled data of 3 years).

Treatment	Total N Uptake (kg ha^{-1})	Available P Uptake (kg ha^{-1})	Available K Uptake (kg ha^{-1})	Available S Uptake (kg ha^{-1})
P_0	55.7	15.2	39.8	8.3
P_{30}	83.7	22.2	60.6	12.1
P_{60}	90.6	24.0	65.8	13.0
SEm(±)	1.2	0.1	0.5	0.1
CD(P= 0.05)	3.6	0.4	1.6	0.3

Table 7. Effect of sulphur on nutrient uptake in chickpea (Pooled data of 3 years).

Treatment	Total N Uptake (kg ha^{-1})	Available P Uptake (kg ha^{-1})	Available K Uptake (kg ha^{-1})	Available S Uptake (kg ha^{-1})
S_0	69.9	18.8	50.3	10.1
S_{20}	83.4	22.1	60.5	12.1
SEm(±)	0.9	0.1	0.4	0.1
CD(P= 0.05)	2.5	0.3	1.2	0.2

Table 8. Interaction effect of FYM, phosphorus and sulphur on nutrient uptake in chickpea (Pooled data of 3 years).

Treatment	Total N Uptake (kg ha^{-1})	Available P Uptake (kg ha^{-1})	Available K Uptake (kg ha^{-1})	Available S Uptake (kg ha^{-1})
$F_0P_0S_0$	45.5	12.6	32.7	6.8
$F_0P_{30}S_0$	73.8	19.8	53.0	10.6
$F_0P_{60}S_0$	82.2	21.9	59.4	11.6
$F_0P_0S_{20}$	56.4	15.2	40.2	8.4
$F_0P_{30}S_{20}$	86.1	22.7	62.6	12.5
$F_0P_{60}S_{20}$	94.9	24.9	69.4	13.6
$F_1P_0S_0$	51.9	14.2	36.9	7.7
$F_1P_{30}S_0$	81.3	21.6	58.4	11.8
$F_1P_{60}S_0$	84.8	22.6	61.4	12.2
$F_1P_0S_{20}$	69.0	18.7	49.5	10.2
$F_1P_{30}S_{20}$	93.5	24.5	68.4	13.5
$F_1P_{60}S_{20}$	100.4	26.5	72.9	14.6
S.Em (±)	1.7	0.2	0.8	0.1
CD(P=0.05)	5.0	0.6	2.3	0.4

and their relationship was synergistic.

Effect on nodulation: Active nodule number at 50% flowering stage of crop growth was significantly influenced by different levels of FYM, phosphorus, sulphur and interaction effect of FYM, P and S (Tables 1-4). Application of FYM @ 5 t ha^{-1} increased the nodule no. by 5.5%. Application of phosphorus 60 kg ha^{-1} increased the nodule no. by 6.2% over application of phosphorus 30 kg ha^{-1}and 34.8 % over it's non application. These results corroborated with the findings of Singh *et al*. (2010). They reported that FYM improved dry weight of nodules significantly by 14.1% over no FYM application. Application of 20 kg P ha^{-1} and 40 kg P ha^{-1} improved nodulation significantly over no application of phosphorus. Similarly Basir *et al.* (2008) noted maximum number of nodules per plant in those treatments which received nutrition at the rate of 15 t FYM ha^{-1} and 60 kg P ha^{-1} while minimum number of nodules per plant was recorded from plots where no FYM and phosphorus was applied. Application of sulphur 20 kg ha^{-1} increased the nodule no. by 14.4 %. Similar results were also reported by Ganeshamurthy and Reddy (2000). In case of interaction effect application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1}sulphur in Farm yard manure treated plot (5 t ha^{-1}) recorded highest nodule number (83.1 nos.) and it increased the nodule no. by 62.3% over control plot. Similarly Islam and Ali (2009) reported that application of P (40 and 80 kg ha^{-1}) increased N fixation by 26 % and 40 %, similarly, an increase of 15 % and 19 % was recorded with S application (15 and 30 kg ha^{-1}).Ganeshamurthy *et al*. (2005) also recorded significantly higher nodule number in green gram due to combined application of phosphorus and sulphur.

Effect on nutrient uptake: Experimental results revealed that the higher uptake of nutrients (N, P, K & S) by chickpea was the resultant of higher yield (Tables 5-8). Nutrient uptake of chickpea was significantly influenced by FYM, P, S and interaction of these three factors. Application of 5 t ha^{-1} FYM increased the

uptake of N by 9.6%, P by 9.7%, K by 9.5% and S by 10.4%. Phosphorus application with higher rate significantly improved the nutrient uptake (N, P, K and S) by chickpea crop. Application of phosphorus 60 kg ha^{-1} increased the uptake of N by 8.2%, P by 8.1%, K by 8.6% and S by 7.4%.over application of phosphorus 30 kg $ha^{-1}$and increased the uptake of N by 62.7%, P by 57.9%, K by 65.3% and S by 56.6%.over it's non application. Nutrient uptake (N, P, K and S) were significantly improved with S application 20 kg ha^{-1}. Application of sulphur 20 kg ha^{-1} increased the uptake of N by 19.3%, P by 17.6%, K by 20.3% and S by 19.8%. In case of interaction effects application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1}sulphur in Farm yard manure treated plot (5 t ha^{-1}) recorded highest nutrient uptake (100.4 kg N ha^{-1}, 26.5 kg $P_2 0_5$ ha^{-1} ,72.9 kg $K_2 0$ ha^{-1} and 14.6 kg S ha^{-1}) and lowest uptake was found with control plot. Similar findings were also reported by Islam and Ali (2009). They reported that nutrient uptake (N, P and S) in chick pea increased significantly with the application of both P and S. Singh *et al.* (2004) also recorded highest uptake of N,P,K and S with 60 kg P ha^{-1} and 40 kg S ha^{-1}.

Conclusion

It can be concluded that application of 60 kg ha^{-1} phosphorus and 20 kg ha^{-1} sulphur in Farm yard manure treated plot (5 t ha^{-1}) along with recommended dose of nitrogen and potassium proved to be the best treatment combination for chickpea in enhancing the productivity, protein content, nodulation and nutrient uptake by the crop in a sulphur deficient soil of new alluvial zone of West Bengal.

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