Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 2061-2064

Sonal Kumari
Department Of Soil Science & Agricultural Chemistry, Faculty of Agriculture Birsa Agricultural University, Ranchi, Jharkhand, India.

DK Shahi
Department of Soil Science & Agricultural Chemistry, Faculty of Agriculture, Birsa Agricultural University, Ranchi, Jharkhand, India.

P Mahapatra
Department of Soil Science & Agricultural Chemistry, Faculty of Agriculture, Birsa Agricultural University, Ranchi, Jharkhand, India.

AK Singh
Department of Agronomy, Faculty of Agriculture, Birsa Agricultural University, Ranchi, Jharkhand, India.

Aarti Singh
Department of Agroforestry and Siliviculture, Faculty of Forestry, Birsa Agricultural University, Ranchi, Jharkhand, India.

Correspondence
Sonal Kumari
Department of Soil Science & Agricultural Chemistry, Faculty of Agriculture Birsa Agricultural University, Ranchi, Jharkhand, India.

Effect of phosphorus, sulphur and microbial inoculation on yield and quality of soybean in an acid soil of Ranchi

Sonal Kumari, DK Shahi, P Mahapatra, AK Singh and Aarti Singh

Abstract
A field experiment was conducted at experimental farm of Birsa Agricultural University with Soybean (*var.* JS-335) as a test crop during the *Kharif* season, 2016 to study the combined application of Phosphorus and Sulphur along with *Bradyrhizobium* on yield and quality of soybean (*Glycine max* L.). The experiment was laid down with 18 treatment combinations having two levels of inoculation (I_0 and I_1), three levels of phosphorus (40, 60 and 80 kg ha^{-1}) and three levels of sulphur (0, 15 and 30 kg ha^{-1}) in a split-split plot design replicated thrice. The results revealed that different levels of phosphorus and sulphur along with microbial inoculation significantly influenced the yield attribute as well as yield of soybean. The significantly highest number of pods per plant (43.27), grain yield (23.91 q ha^{-1}) and straw yield (27.13 q ha^{-1}) at 80 kg P_2O_5 ha^{-1} which was statistically *at par* with 60 kg P_2O_5 ha^{-1} for number of pods per plant and significantly superior over 60 kg and 40 kg P_2O_5 ha^{-1} for grain and straw yield of soybean. Soybean responded to applied sulphur but there was no significant difference between two levels of sulphur for number of pods per plant and grain yield. Microbial inoculation significantly increased the grain yield (23.36 q ha^{-1}) and straw yield (26.43 q ha^{-1}) of soybean. Application of phosphorus and sulphur significantly enhanced the oil content in soya grain and highest oil content of 19.48 % and 19.44 % with 80 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}, correspondingly and having statistical equivalence with 60 kg P_2O_5 ha^{-1} and 15 kg S ha^{-1}.

Keywords: Soybean, Phosphorus, Sulphur, *Bradyrhizobium*, Yield and Quality.

Introduction

Soybean [*Glycine max* (L.) Merrill] originated in China and known as MIRACLE CROP and it is grown in India as an important oilseed crop occupying area of 10.1 million hectares with annual production of 12.21 million tones (Anonymous, 2013) [4]. At present, India ranks fifth (USDA, 2013) with respect to soybean acreage and production in the globe. Soybean cultivation improves soil health because it is able to fix atmospheric nitrogen in symbiosis with the bacteria *Bradyrhizobium japonicum* and fixes 20% of the atmospheric nitrogen throughout the world annually (Franco, 1978). The enhancement of symbiotic N-fixation by root nodules as a result of phosphorus nutrition is improved due to high phosphorus requirement of the bacteroides and suggested that large quantity of phosphorus fertilizer may be required for successful soybean production (Kuepper, 2003; Mallarino, 2005). Out of several nutrients provided to plants, phosphorus is a major and essential nutrient for better plant growth and yield as this crop is exhaustive in nature and requires more energy. It is involved in wide range of plant processes from permitting cell division to development of good root system. It stimulates pod setting, seed formation and protein synthesis and increases water use efficiency, improves taste, storage quality and skin hardness of the bean (Jaggi, 1998). Phosphorus is a structural component of the membrane system of cell, the chloroplasts and the mitochondria can profoundly influence growth, yield and oil content of oilseed crop (De, 1993) [9]. Sulphur has been recognized as one of the important secondary nutrient and helps in stabilization of protein structure involves in metabolic activity of vitamins, synthesis of sulphur – containing amino acids, co. enzyme A, chlorophyll formation, takes part in nitrogen metabolism and promote nodulation for nitrogen fixation in legumes. Further, without adequate sulphur, crops cannot reach their full potential in terms of yield, quality or protein content nor can they make efficient use of applied nitrogen. It gives rise to bold seeds in oil seeds (Singh and Rathi, 1984). Soybean is sulphur-loving plant and contains large quantity of other organic sulphur compounds such as- glutathione, sulfolipids and secondary sulphur compound which play an important role in physiology and protection against environment stress and pests. Like other oil seed crops, its sulphur requirement is more than that of many other crops for proper growth and yield (Rao and Ganeshamurthy, 1994).

Materials and methods

The experiment was conducted under field condition at experimental farm of Soil Science and Agricultural Chemistry, B.A.U, Ranchi. The soil of the experimental site was sandy clay loam in texture having good drainage and fairly moisture retention capacity with acidic pH (5.2), EC (0.08dS m^{-1}), low in organic carbon (2.6 g kg^{-1}),CEC (8.5 cmol (p^+) kg^{-1}), total nitrogen (0.157 %) and available nitrogen (181.5 kg ha^{-1}), medium in available phosphorus (23.9 kg ha^{-1}) and available sulphur (17.0 ppm) was above the critical range. Soybean (*var.* JS-335) was taken as a test crop during the *Kharif* season, 2016 with 18 treatment combinations comprising two levels of inoculation (I_0 and I_1), three levels of phosphorus (40, 60 and 80 kg ha^{-1}) and three levels of sulphur (0, 15 and 30 kg ha^{-1}) in split-split plot design with three replications. The data on yield and quality parameters were recorded by following standard methods. Grain and straw yield were recorded at harvest and expressed in q ha^{-1}. The harvest index is a ratio of economic yield to the biological yield per hactare. The harvest index for each treatment was calculated by using the following formula.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield (Grain + straw)}} \times 100$$

The protein content in soybean was determined by multiplying total nitrogen content by factor of 6.25 and oil content in soybean seed was estimated by Ether Extraction method using Soxhlet apparatus (AOAC, 2000) [5]. The data obtained from the field and laboratory studies were analyzed following standard statistical procedure as outlined by Snedecor and Cochren (1967). The value of standard error of mean S.Em (±) and critical difference at 5% level of significance were computed among the various parameters which were obtained from field and laboratory experiments.

Results and Discussion

Yield attributes

Data pertaining to yield attributing characters from the table 1 indicated that application of different levels of phosphorus on soybean showed significant effect on number of pods per plant. Application of 80 kg and 60 kg P_20_5 ha^{-1} significantly augmented the number of pods per plant by 43.27 and 42.71 $plant^{-1}$ over 40 kg P_20_5 ha^{-1} (39.27 $plant^{-1}$) while 80 and 60 kg P_20_5 ha^{-1} were at par with each other. This may be due to increased availability of phosphorus and its favorable influence on proper root and shoot development and higher nutrient absorption which ultimately improved the growth and number of branches and resulted in more number of pods per plant (Sharma *et al.*, 2002; Kausandiker *et al.*, 2003; Tomar and Singh 2004; Shahid *et al.*, 2010). The perusal of data from table 1 revealed that the application of graded doses of phosphorus caused a non-significant effect on the number of grains per plant and hundred seed weight of soybean.

Table 1: Effect of Phosphorus, Sulphur and *Bradyrhizobium* on yield attributing characters of soybean

Treatments	Yield attributing characters		
	No. of pods per plant	No. of grain per plant	100-seed weight (g)
Phosphorus level (kg ha^{-1})			
P_1	39.27	127.8	10.09
P_2	42.71	130.8	10.19
P_3	43.27	132.7	10.23
S.Em (±)	0.96	1.87	0.05
CD (P=0.05)	3.13	NS	NS
Sulphur level (kg ha^{-1})			
S_1	39.83	129.7	10.12
S_2	42.21	130.3	10.18
S_3	43.21	131.3	10.21
S.Em (±)	0.92	1.90	0.05
CD (P=0.05)	2.69	NS	NS
Inoculation level			
I_0	41.22	129.0	10.17
I_1	42.30	131.9	10.19
S.Em (±)	1.46	0.63	0.05
CD (P=0.05)	NS	NS	NS
C.V. (%)	9.39	6.16	2.25

The highest number of grains per plant and hundred seed weight 132.7 and10.23 g, respectively were recorded with 80 kg P_20_5 ha^{-1} which was superior to other levels of phosphorus. The different levels of sulphur put forth significant variation on number of pods per plant (Table 1). Application of 30 kg S ha^{-1} produced significantly more number of pods (43.21 $plant^{-1}$) as compared to 0 kg S ha^{-1} (39.83 $plant^{-1}$) which was however, at par with 15 kg S ha^{-1} (42.21 $plant^{-1}$) because sulphur plays a pivotal role in energy transformation, activation of enzymes and also in carbohydrate metabolism. Among the fertilizer elements, sulphur requirement of oilseed crops is quite high as compared to other crops (Das and Das, 1995; Baldev *et al.*, 1999; Chaubey *et al.*, 2000; Khan, 2001; Mohanti *et al.*, 2004) [6, 7, 8]. The data given in table 1 reveals that the number of grains per plant was not found significant due to different levels of sulphur. Number of grains per plant was observed higher under the treatment 30 kg S ha^{-1} (131.3 $plant^{-1}$) as compared to 15 kg S ha^{-1} (130.3 $plant^{-1}$) and 0 kg S ha^{-1} (129.7 $plant^{-1}$). The same trend was also recorded in hundred seed weight with sulphur application from 0 kg (10.12 g) to 30 kg S ha^{-1} (10.21 g). The data presented in table 1 shows that application of *Rhizobium* inoculation did not manifest its significant influence on number of pods per plant, number of grains per plant and hundred seed weight of soybean but marginal increase could be visualized on number and weight of soybean seed.

Critical examination of data given in table 2 reveals that phosphorus levels significantly influenced the grain and straw yield. The application of 80 kg P_20_5 ha^{-1} produced significantly higher grain yield (23.91 q ha^{-1}) and straw yield (27.13 q ha^{-1}) over 40 kg P_20_5 ha^{-1} (20.92 q 23.66 q ha^{-1} for grain and straw yield, respectively). It was also evident that application of 60 kg and 40 kg P_2O_5 ha^{-1} differed significantly with each other. The increase in grain and straw yield of soybean over lower dose of phosphorus might be attributed to the favorable stimulatory effect of phosphorus which play a key role on root development, energy translocation and metabolic processes of plant through which increased translocation of photosynthates towards the sink development might have occurred (Tewari *et al.,* 2005; Kumar *et al.,* 2012; Wu *et al.,* 2012; Dhage *et al.,* 2014).

Table 2: Effect of Phosphorus, Sulphur and *Bradyrhizobium* on yield of soybean

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Phosphorus level (kg ha^{-1})			
P_1	20.92	23.66	46.96
P_2	22.56	25.60	46.82
P_3	23.91	27.13	46.85
S.Em (±)	0.39	0.43	0.14
CD (P=0.05)	1.30	1.42	NS
Sulphur level (kg ha^{-1})			
S_1	21.50	24.47	46.76
S_2	22.31	25.45	46.70
S_3	23.62	26.46	47.15
S.Em (±)	0.53	0.61	0.14
CD (P=0.05)	1.55	NS	NS
Inoculation level			
I_0	21.59	24.50	46.84
I_1	23.36	26.43	46.93
S.Em (±)	0.16	0.10	0.11
CD (P=0.05)	0.99	0.61	NS
CV (%)	10.06	10.28	1.28

The perusal of data presented in table 2 shows that the different doses of sulphur influenced significantly the grain yield of soybean. Significantly higher grain yield (23.62 q ha^{-1}) was recorded with the application of 30 kg S ha^{-1} as compared to 0 kg S ha^{-1} (21.50 q ha^{-1}) which was at par with 15 kg S ha^{-1} (22.31 q ha^{-1}). The results further revealed in table 2 that apparently the straw yield of soybean was found non significant with different doses of sulphur application. The increase in grain yield of soybean by sulphur application might be due to the effect of sulphur in utilizing large quantities of nutrients through their well developed root system, which resulted in better utilization of plant nutrients from soil (Kumar *et al.,* 2009; Singh *et al.,* 2012; Aktar *et al.,* 2013; Layek *et al.,* 2014; Parakhia *et al.,* 2016; Longkumer *et al.,* 2017) [2]. An appraisal of the data given in table 2 reveals that inoculation had pronounced and significantly affected the grain and straw yield of soybean. The inoculation produced significantly higher grain and straw yield 23.36 q and 26.43 q ha^{-1}, respectively as compared to uninoculated plot (21.59 q and 24.50 q ha^{-1} of grain and straw yield, respectively). This might be due proper establishment and greater infection of N-fixers and use of specific rhizobial strain homologous for the test plant may have influenced to develop healthy and efficient nodules supplemented with P and S in adequate number on root biomass, resulting in efficient dinitrogen reduction and its assimilation leading to increased grain and straw yield (Alam *et al.,* 2009; [3] Solomon *et al.,* 2012; Morad *et al.,* 2013; Adeyeye *et al.,* 2017) [1]. No change in harvest index (HI) of soybean was noticed under the influence of varying levels of phosphorus, sulphur and *Rhizobium* inoculation.

Quality

While examining the potentiality of phosphorus, sulphur and the microbial culture (Table 3) it came out that both the nutrient elements had non significant effect on protein accumulation in grains of soybean during investigation. However, there was non significant increase in protein content from 36.68 % to 37.11 % with increasing dose of phosphorus from 40 kg to 80 kg P_2O_5 ha^{-1} whereas addition of P at graded levels had significant impact on oil content in grains of soybean (Table 3). Application of 80 kg P_2O_5 ha^{-1} significantly yields maximum oil content (19.48 %) over 40 kg P_2O_5 ha^{-1} (18.80 %) which was however, *at par* with 60 kg P_2O_5 ha^{-1} (19.37 %). The significantly higher oil content with the increasing levels of phosphorus was due to fact that phosphorus is one of the main constituent of the fatty acids (Kanojia and sharma 2009; Shahid *et al.,* 2010; Sadozai *et al.,* 2013). The different levels of sulphur put forth non-significant variation in protein content as shown in table 3. Application of 30 kg S ha^{-1} has higher protein content (37.16 %) whereas, 0 kg S ha^{-1} produced lowest protein content (36.60%). The data depicted in table 3 shows that application of 30 kg S ha^{-1} significantly increases the oil content (19.44 %) as compared to 0 kg S ha^{-1} (18.92 %). Increase in the oil content of soybean with sulphur application may be due to increase in fatty acids as sulphur is involved in fat metabolism (Reddy and Reddy 2001; Singh *et al.,* 2002; Gokhale *et al.,* 2005; Morshed *et al.,* 2009). The data pertaining to effect of inoculation on protein and oil content is presented in table 3 indicates that inoculated treatment had higher protein content (37.05 %) and oil content (19.34 %) over uninoculated.

Table 3: Effect of Phosphorus, Sulphur and Bradyrhizobium on quality of soybean

Treatment	Protein content (%)	Oil content (%)
Phosphorus level (kg ha^{-1})		
P_1	36.68	18.80
P_2	37.03	19.37
P_3	37.11	19.48
S.Em (±)	0.12	0.15
CD (P=0.05)	NS	0.49
Sulphur level (kg ha^{-1})		
S_1	36.60	18.92
S_2	37.06	19.30
S_3	37.16	19.44
S.Em (±)	0.22	0.13
CD (P=0.05)	NS	0.40
Inoculation level		
I_0	36.84	19.11
I_1	37.05	19.34
S.Em (±)	0.13	0.16
CD (P=0.05)	NS	NS
C.V. (%)	3.75	3.03

References

1. Adeyeye AS, Togun AO, Olaniyan AB, Akanbi WB. Effect of fertilizer and *Rhizobium* inoculation on growth and yield of soybean variety. Advances in Crop Science and Technology, 2017; 5:255.
2. Aktar F, Islam NM, Shamsuddoha ATM, Bhuiyan MSI. Shelpi S. Effect of phosphorus and sulphur on growth and yield of soybean (*Glycine max* L.). International Journal of Bioresource and Stress Management. 2013; 4(4):555-560.
3. Alam MA, Siddique A, Chowdhary MAH, Pradhan, M. Nodulation, yield and quality of soybean as influenced by

integrated nutrient management. Journal of Bangladesh Agricultural University, 2009; 7(2):229-234.
4. Anonymous. (2013). http://*www.icexindia.com*/soybean.html.
5. AOAC. Official Method 999.25 Gas Chromatographic Method, Chapter, 2000, 50-19.
6. Baldev R, Pareek RG, Ram T. Effect of phosphorus, sulphur and PSB on growth and yield of mustard. Agriculture Digest Journal 1999; 19(3):203-206.
7. Chaubey AK, Singh SB, Kaushik MK. Response of groundnut (*Arachis hypogaea*) to source and level of sulphur fertilizer in mid-western plains of Uttar Pradesh. Indian Journal of Agronomy, 2000; 45(1):166-169.
8. Das KN, Das K. Effect of sulphur and nitrogen fertilizer on growth and yield toria (*Brassica campestris sub sp. Oleifera var. toria*). Indian Journal of Agronomy. 1995; 40(2):329-331.
9. De GC. Nutrient Management, Fundamental of Agronomy, Oxford & IBH Publication Co, 1993, 155-156.