Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 2554-2557
Received: 15-09-2019
Accepted: 18-10-2019

Sonal Kumari
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

P Mahapatra
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

DK Shahi
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

AK Singh
Department of Agronomy, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Corresponding Author:
Sonal Kumari
Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Effect of P, S and *Bradyrhizobium* on yield, nutrient content and uptake by soybean (*Glycine max*) under rainfed condition

Sonal Kumari, P Mahapatra, DK Shahi and AK Singh

Abstract
Experiment was conducted in the *Kharif* season, 2016 under rainfed conditions at experimental farm of Birsa Agricultural University, Kanke, Ranchi, Jharkhand to investigate the Effect of P, S and *Bradyrhizobium* on yield, nutrient content and uptake by soybean (*Glycine max*) under rainfed condition. The experiment was laid in a split-split plot design with 18 treatment combinations and three replications comprising two levels of inoculation (I_0 and I_1), three levels of phosphorus (P_{40}, P_{60} and P_{80} kg ha^{-1}) and three levels of sulphur (S_0, S_{15} and S_{30} kg ha^{-1}). Parameters measured were grain yield, N, P and S nutrient content and its uptake by dry matter of soybean. The results indicate that grain yield (23.91 q ha^{-1}) of soybean was highest with 80 kg P_2O_5 ha^{-1} which was significantly superior over 60 kg and 40 kg P_2O_5 ha^{-1}. Soybean responded to applied sulphur but there was no significant difference between two levels of sulphur for grain yield (23.62 q ha^{-1} @ 30 kg S ha^{-1} and 22.31 q ha^{-1} @ 15 kg S ha^{-1}). *Rhizobium* inoculation significantly increased the grain yield (23.36 q ha^{-1}) of soybean. Application of different levels of P, S and *Rhizobium* inoculation did not have significant influence on nitrogen, phosphorus and sulphur content in grain and straw of soybean. Total nitrogen and sulphur uptake by soybean significantly increased from 160.44 to 185.66 kg ha^{-1} and 13.34 to 15.43 kg ha^{-1} respectively, with increasing levels of phosphorus from 40 to 80 kg P_2O_5 ha^{-1} while, in case of total phosphorus uptake, application of phosphorus @ 80 kg P_2O_5 ha^{-1}(16.34 kg ha^{-1}) was found to be significant over 40 kg P_2O_5 ha^{-1} which was at par with 60 kg P_2O_5 ha^{-1} (15.36 kg ha^{-1}). Application of 30 kg S ha^{-1} retained significantly higher total uptake of nitrogen (183.36 kg ha^{-1}), phosphorus (16.09 kg ha^{-1}) and sulphur (15.43 kg ha^{-1}) compared to 0 kg S ha^{-1} (164.50, 14.12 and 13.53 kg ha^{-1} for total uptake of N, P and S respectively). *Rhizobium* inoculated treatment had significantly higher total uptake of nitrogen (180.97 kg ha^{-1}), phosphorus (15.98 kg ha^{-1}) and sulphur (15.10 kg ha^{-1}) as compared to uninoculated (166.12, 14.09 and 13.80 kg ha^{-1} for total uptake of N, P and S respectively).

Keywords: Soybean, Phosphorus, Sulphur, *Bradyrhizobium* Yield, Nutrient content and uptake

Introduction

Soybean is one of the most resilient rainfed crop. Area and production of soybean in Jharkhand are 0.01 lakh ha and 12.5 q ha^{-1} respectively. Soybean productivity ranges from 1.6 to 1.9 t ha^{-1} in general except for Jharkhand where productivity is as low as of 1.26 t ha^{-1} (DFI, committee estimates, 2015). Jharkhand has good potential of soybean but due to certain limitations like erratic behavior of monsoon, high temperature stress at critical growth stage, low base exchange capacity, low to very low in available phosphorus and sulphur, medium in available nitrogen & potassium status, deficient in available boron, low water holding capacity and high permeability. To overcome limitations and increase the production of soybean by adequate supply of nutrients especially nitrogen, phosphorus and sulphur to the crops. Soybean being leguminous crop, P, S and *Bradyrhizobium* play a significant role - phosphorus stimulates rhizobial activity, nodule formation and thus helps in N_2-fixation. It increases the water use effciency, improves taste, storage quality and skin hardness of the bean. As phosphorus plays a role in photosynthesis, respiration, energy storage and transfer, cell division and enlargement, it has been shown to be important for growth, development and yield of soybean (Kakar *et al.*, 2002) [7]. Sulphur aids in stabilization of protein structure, involve in metabolic activities of vitamins, helps in synthesis of sulphur containing essential amino acids, chlorophyll formation, takes part in N-metabolism and promotes nodulation for N_2-fixation in legumes. It also gives rise to bold seeds in oil seeds. (Rao and Ganeshmurthy, 1994) [14]. Soybean crop has ability to fix atmospheric nitrogen in symbiosis with the bacteria *Bradyrhizobium japonicum*. (Mallarino, 2005) [11]. However, most of the Jharkhand soils are low to very low in available phosphorus and sulphur, medium in available nitrogen & potassium status and deficient in available boron. Thus, with a view to generate information and out the optimum doses of P, S with inoculation are needed for proper growth, development, yield and quality of soybean.

Materials and Methods

In order to study the Effect of P, S and *Bradyrhizobium* on yield, nutrient content and uptake by soybean (*Glycine max*) under rainfed condition, an experiment was conducted at experimental farm of Birsa Agricultural University, Kanke, Ranchi, Jharkhand, during the *kharif* season, 2016. Geographically, Birsa Agricultural University, Kanke, Ranchi is situated at 23^0 - 19' N latitude, 83^0 - 17' E longitude at an altitude of about 625 meter above the mean sea level. Weather condition prevailing during course of investigation from June to October, 2016 were 1308.6 mm total rainfall, temperature varied from 14.5^{0C} to 37.7^{0C} and average relative humidity varied from 46.9% to 71.7% recorded at 2:00 pm and 79.9% to 87.3% at 7:00 am. The surface soil (0-15 cm) of the experimental site was sandy clay loam in texture with pH (5.2), EC (0.08dS m^{-1}), low in organic carbon (2.6 g kg^{-1}),CEC (8.5 c mol (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. The experiment was laid out in split-split plot design with three replications and 18 treatment combinations comprising two levels of inoculation (I_0 and I_1), three levels of phosphorus (P_{40}, P_{60} and P_{80} kg ha^{-1}) and three levels of sulphur (S_0, S_{15} and S_{30} kg ha^{-1}). Soybean (var. JS-335) was taken as a test crop during the *Kharif* season, 2016. The data on nutrient uptake by soybean was calculated by following formula –

$$\text{Nutrient uptake (kg ha}^{-1}\text{) in grain or straw } \frac{\text{Nutrient content (\%) either in grain or straw} \times \text{dry matter of grain or straw (kg ha}^{-1}\text{)}}{100}$$

Total nutrient uptake was calculated by addition of nutrient uptake by grain and nutrient uptake by straw and analyzed statistically to find out the treatment difference and the mean differences as outlined by Snedecor and Cochren (1967) [7].

Results and Discussion

Yield

Critical examination of data given in table 1 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_20_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 (Kumar *et al.*, 2012; Wu *et al.*, 2012; Dhage *et al.*, 2014) [8, 20, 5]. Different doses of sulphur influenced significantly the grain yield of soybean and 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 1 that apparently the straw yield of soybean was found non significant with different doses of sulphur application.

Table 1: 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 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 (Parakhia *et al.*, 2016; Longkumer *et al.*, 2017) [13, 10]. 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 (Solomon *et al.*, 2012; Morad *et al.*, 2013; Adeyeye *et al.*, 2017) [18, 12, 2]. No change in harvest index (HI) of soybean was noticed under the influence of varying levels of phosphorus, sulphur and *Rhizobium* inoculation (Table 1).

Nutrient content

Data pertaining to nutrient content in grain and straw of soybean clearly proved that application of different levels of phosphorus, sulphur and *Rhizobium* inoculation did not have significant influence on nitrogen, phosphorus and sulphur content in grain and straw (Table 2). With increased doses of phosphorus from 40 kg to 80 kg P_2O_5 ha^{-1}, nitrogen content increased from 5.86% to 5.93% in grain and 1.77% to 1.81% in straw and phosphorus content increased from 0.451% to 0.480% in grain and 0.185% to 0.203% in straw while sulphur content from 0.413% to 0.422% in grain and 0.221% to 0.223% in straw. Application of 30 kg S ha^{-1} recorded highest nitrogen content in grain (5.94%) and straw (1.80%), phosphorus content in grain (0.476%) and straw (0.202%) and sulphur content in grain (0.425%) and straw (0.228%) followed by 15 kg S ha^{-1} and 0 kg S ha^{-1}(nitrogen content - 5.85% and 1.78% in grain and straw respectively, phosphorus content – 0.461% in grain and 0.191% in straw and sulphur content in grain 0.411% and straw 0.217% @)0 kg S ha^{-1}). Inoculated plot recorded remarkably the higher nitrogen content in grain (5.92%) and straw (1.81%), phosphorus content in grain (0.480%) and straw (0.203%) and sulphur content in grain (0.422%) and straw (0.224%) as compared to uninoculated plot.

Nutrient uptake

Application of phosphorus and sulphur at varying doses with *Bradyrhizobium* inoculation influenced the nitrogen, phosphorus and sulphur uptake significantly during the study (Table 2). Maximum nitrogen uptake by grain, straw and total nitrogen uptake follow the trend of 80 kg P_2O_5 ha^{-1} (142.11 kg ha^{-1} in grain), (43.55 kg ha^{-1} in straw) and (185.66 kg ha^{-1} total uptake) > 60 kg P_2O_5 ha^{-1} (133.78 kg ha^{-1} in grain), (40.75 kg ha^{-1} in straw) and (174.5kg ha^{-1}total uptake)> 40 kg P_2O_5 ha^{-1} (123.20 kg ha^{-1} in grain), (37.23 kg ha^{-1} in straw) and (160.44 kg ha^{-1} total uptake). The highest dose of phosphorus @ 80 kg P_2O_5 ha^{-1} recorded significantly higher phosphorus uptake by grain (11.47 kg ha^{-1}), straw (4.86 kg ha^{-1}) and total uptake (16.34 kg ha^{-1}) over 40 kg P_2O_5 ha^{-1} which was at par with 60 kg P_2O_5 ha^{-1} in grain (10.79 kg ha^{-1}), straw (4.56 kg ha^{-1}) and total uptake (15.36 kg ha^{-1}). Application of 80 kg P_2O_5 ha^{-1} recorded maximum sulphur uptake by grain (10.09 kg ha^{-1}) which was at par with 60 kg P_2O_5 ha^{-1} (9.50 kg ha^{-1}). Phosphorus application @ 80 and 60 kg P_2O_5 ha^{-1} were found superior to 40 kg P_2O_5 ha^{-1} (8.69 kg ha^{-1}). Sulphur uptake by straw and total uptake follow the trend of 80 kg P_2O_5 ha^{-1} (5.34 kg ha^{-1} by straw and total uptake 15.43 kg ha^{-1}) > 60 kg P_2O_5 ha^{-1} (5.04 kg ha^{-1} by straw and total uptake 14.55 kg ha^{-1}) > 40 kg P_2O_5 ha^{-1} (4.65 kg ha^{-1} by straw and total uptake 13.34 kg ha^{-1}). The increase uptake of nitrogen, phosphorus and sulphur by soybean grain and straw might be due to the added supply and increased availability of phosphorus through inorganic and organic source. These nutrients helped to increase the uptake due to well developed root system and nodulation under balance nutrient application resulting better absorption of water and nutrients, greater photosynthetic efficiency and production of assimilates and their efficient partitioning into sink led to higher content of N, P and S in grain and straw (Abbassi *et al.*, 2012; Dhage *et al.*, 2014; Laharia *et al.*, 2015) [1, 5, 9]. Application of 30 kg S ha^{-1} recorded significantly higher nitrogen uptake by grain (140.60 kg ha^{-1}), straw (42.76 kg ha^{-1}) and total uptake (183.36 kg ha^{-1}) compare to 0 kg S ha^{-1} (125.98 kg ha^{-1} in grain), (38.51 kg ha^{-1}in straw) and (164.50 kg ha^{-1} total uptake). Application of 30 kg S ha^{-1} was significantly superior to 15 kg S ha^{-1}and 0 kg S ha^{-1} and recorded maximum phosphorus uptake by grain (11.29 kg ha^{-1}), straw (4.78 kg ha^{-1}) and total uptake (16.09 kg ha^{-1}) while lowest phosphorus uptake by grain (9.97 kg ha^{-1}), straw (4.14 kg ha^{-1}) and total uptake (14.12 kg ha^{-1}) with 0 kg S ha^{-1}. Sulphur uptake by grain with application of 30 kg S ha^{-1}(10.03 kg ha^{-1}) was significantly superior to 0 kg S ha^{-1} (8.86 kg ha^{-1}) which was however, at par with 15 kg S ha^{-1} (9.39 kg ha^{-1}). Sulphur uptake by straw and total uptake were significantly higher with application of 30 kg S ha^{-1} (5.39 kg ha^{-1} by straw and total uptake15.43 kg ha^{-1}) compare to 15 kg ha^{-1} (4.98 kg ha^{-1} by straw and total uptake 14.37 kg ha^{-1}) and 0 kg S ha^{-1} (4.66 kg ha^{-1} by straw and total uptake 13.53 kg ha^{-1}). The increase in nutrient uptake due to sulphur application might be because of the synergistic effect of added sulphur on the utilization of nutrient by the plant and yield obtained. This is attributed due to application of sulphur might have improved the overall nutrient availability creating favourable environment in the rhizoshere for greater absorption of nutrient by the plant. The increased photosynthesis, production of metabolites and efficient partitioning of these metabolites into different sinks resulted in higher content of nutrients.

Table 2: Effect of P, S and *Bradyrhizobium* on nutrient content and uptake by soybean

Treatment	N Content (%)		N uptake (kg ha^{-1})			P content (%)		P uptake (kg ha^{-1})			S content (%)		S uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total	Grain	Straw	Grain	Straw	Total	Grain	Straw	Grain	Straw	Total
Phosphorus level (kg ha^{-1})															
P_1	5.86	1.77	123.2	37.2	160.4	0.451	0.185	9.50	3.89	13.39	0.413	0.221	8.69	4.65	13.34
P_2	5.92	1.80	133.7	40.7	174.5	0.476	0.201	10.79	4.56	15.36	0.421	0.223	9.50	5.04	14.55
P_3	5.93	1.81	142.1	43.5	185.6	0.480	0.203	11.47	4.86	16.34	0.422	0.223	10.09	5.34	15.43
S.Em (±)	0.02	0.01	2.5	0.72	3.2	0.009	0.005	0.25	0.16	0.39	0.002	0.002	0.19	0.06	0.25
CD(P=0.05)	NS	NS	8.2	2.36	10.4	NS	NS	0.81	0.54	1.27	NS	NS	0.62	0.22	0.97
Sulphur level (kg ha^{-1})															
S_1	5.85	1.78	125.9	38.5	164.5	0.461	0.191	9.97	4.14	14.12	0.411	0.217	8.86	4.66	13.53
S_2	5.92	1.80	132.5	40.2	172.7	0.470	0.196	10.49	4.39	14.89	0.42	0.223	9.39	4.98	14.37
S_3	5.94	1.80	140.6	42.7	183.3	0.476	0.202	11.29	4.78	16.09	0.425	0.228	10.03	5.39	15.43
S.Em (±)	0.03	0.01	3.3	1.0	4.3	0.005	0.003	0.27	0.11	0.36	0.004	0.003	0.24	0.14	0.36
CD(P=0.05)	NS	NS	9.8	3.0	12.8	NS	NS	0.79	0.32	1.05	NS	NS	0.71	0.41	1.07
Inoculation level															
I_0	5.89	1.79	127.4	38.7	166.1	0.459	0.191	9.95	4.14	14.09	0.416	0.222	9.01	4.79	13.80
I_1	5.92	1.81	138.6	42.3	180.9	0.480	0.203	11.23	4.74	15.98	0.422	0.224	9.84	5.24	15.10
S.Em (±)	0.02	0.02	0.53	0.59	1.05	0.008	0.003	0.20	0.03	0.21	0.002	0.002	0.008	0.03	0.06
CD(P=0.05)	NS	NS	3.2	3.6	6.41	NS	NS	1.25	0.21	1.30	NS	NS	0.04	0.21	0.26
C.V. (%)	2.50	2.53	10.79	10.78	10.74	4.69	6.04	10.85	10.60	10.15	3.74	6.04	10.99	11.91	10.75

These findings were in agreement with those reported by Ravi *et al.*, (2008) [15]; Ganie *et al.*, (2014) [6]; Sharma *et al.*, (2014) [16]. Inoculation significantly enhanced the nitrogen uptake by grain (138.65 kg ha^{-1}), straw (42.32 kg ha^{-1}) and total nitrogen uptake (180.97 kg ha^{-1}) over respective uninoculated plots. Application of inoculation to soybean seed significantly influenced the phosphorus uptake by grain (11.23 kg ha^{-1}), straw (4.74 kg ha^{-1}) and total phosphorus uptake (15.98 kg ha^{-1}) compare to uninoculated plot. *Rhizobium* inoculation increased the sulphur uptake by grain (9.84 kg ha^{-1}), straw (5.24 kg ha^{-1}) and total sulphur uptake (15.10 kg ha^{-1}) and were found significantly superior over uninoculated plot. Present result also indicated that nutrient uptake increases due to application of *Rhizobium* culture might be beacause soybean obtains nitrogen directly from the soil and indirectly from symbiotic fixation with *Bradyrhizobium japonicum*. The increase in nutrient uptake by plant due to microbial inoculation was also reported by Son *et al.*, (2006) [19]; Ali and Yadav (2009) [3]; Solomon *et al.*, (2012) [18].

References

1. Abbasi MK, Tahir MM, Azam W, Abbas Z, Rahim N. Soybean yield and chemical composition in response to phosphorus – potassium nutrition in Kashmir. American Society of Agronomy. 2012; 104(5):1476-1484.
2. 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.
3. Ali ASR, Yadav RS. Response of fenugreek (*Trigonella foenum-graecum* L.) to various fertility levels and biofertilizer inoculation. Indian Journal of Agricultural Sciences 2009; 79(2):145-147.
4. DFI, committee estimates, 2015.
5. Dhage SJ, Patil VD, Dhamak AL. Influence of phosphorus and sulphur levels on nodulation, growth parameters and yield of soybean (*Glycine max* L.) grown on Vertisol. An Asian Journal of Soil Science. 2014; 9(2):244-249.
6. Ganie MA, Akhter F, Najar GR, Bhat MA. Influence of sulphur and boron supply on nutrient content and uptake of French bean (*Phaseolus vulgaris* L.) under Inceptisols of North Kashmir. African Journal of Agricultural Research 2014; 9(2):230-239.
7. Kakar KM, Tariq M, Taj FH, Nawab K. Phosphorous use efficiency of Soybean as affected by phosphorous application and inoculation. Pakistan Journal of Agronomy. 2002; 1(1):49-50.
8. Kumar S, Tomar J, Kishore GR, Kumar A, Singh S. Effect of phosphorus and sulphur on growth and yield of pigeon pea (*Cajanus cajan*). Advance Research Journal of Crop Improvement. 2012; 3(1): 50-52.
9. Laharia GS, Hadole SS, Meena SM, Aage AB. Interactive effect of phosphorus and zinc on nutrient uptake and nutrient use efficiency of soybean. International Journal of Tropical Agriculture. 2015; 33(4):0254-8755.
10. Longkumer LT, Singh AK, Jamir Z, Kumar M. Effect of sulphur and boron nutrition on yield and quality of soybean (*Glycine max* L.) grown in an acid soil. Communication in Soil Science and Plant Analysis. 2017; 48(4):405-411.
11. Mallarino AP. Foliar fertilization of soybean: Is it useful to supplement primary fertilization? In: Integrated Crop Management, IC-494, 2005; 15:125-126.
12. Morad M, Sara S, Alireza E, Reza CM, Mohammad D. Effects of seed inoculation by *Rhizobium* strains on yield and yield components in common bean cultivers (*Phaseolus Vulgaris* L.). International Journal of Bioscience. 2013; 3(3):134-141.
13. Parakhia DV, Parmar KB, Vekaria LC, Bunsa PB, Donga SJ. Effect of various sulphur levels on drymatter, yield attributes of soybean (*Glycin max* L.) varieties. The Ecoscan. 2016; 10(1, 2):51-54.
14. Rao AS, Ganeshmurthy AN. Soybean response to applied P and Son Vertic Ustochrepts in relation to available P and S. Journal of Indian Society of Soil Science. 1994; 2:606-610.
15. Ravi S, Channal HT, Hebsur NS, Patil BN, Dharmatti PR. Effect of sulphur, zinc and iron nutrition on growth, yield, nutrient uptake and quality of safflower (*Carthamus tinctorius* L.). Karnataka Journal of Agricultural Sciences 2008; 21(3):382-385.
16. Sharma A, Sharma S, Gill PPS. Influence of nitrogen and sulphur application on nutrient uptake, protein content and yield parameters of soybean. Indian Journal of Plant Science. 2014; 3(2):2319-3824.
17. Snedcor GW, Cochran WG. Statistical method. The IOWA State University Press, IOWA, 1967.
18. Solomon T, Pant LM, Angaro T. Effect of inoculation by *Bradyrhizobium japonicum* strains on nodulation, nitrogen fixation and yield of soybean varieties on Nitisols of Bako, Western Ethiopa, ISRN Agronomy, 2012, 261-475.
19. Son TTN, Diep CN, Giang TTM. Effect of *Bradyrhizobium* and PSB application on soybean in rotational system in the Mekong Delta. Omonrice. 2006; 14:48-57.
20. Wu DT, Xiao-Xue Z, Zhen-Ping G, Chun-Mei MA, Lei Z. Effect of phosphorus nutrition on phosphorus absorption and yields of soybean. *Acta Metallurgica Sinica*. 2012; 18(3):670-677.