Agropedology 2017, 27 (02), 201 - 206

Short Communication

Effect of Fertilizers and Microbial Inoculants on Yield and Quality of Soybean (*Glycine max*. L. Merrill)

Aliho Shikhu[1], A. K. Singh[1], Sanjay Kumar Singh[2] and Engrala A. O.[*3]

[1]*Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland-797106, India*
[2]*Department of Soil Science, Tirhut College of Agriculture, Dholi Campus, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar- 848 125, India*
[3]*AICRP on Soybean, Medziphema Campus, Nagaland University, Nagaland-797106, India*

A field experiment was carried out during *Kharif*, 2015 at the experimental farm of the School of Agricultural Sciences and Rural Development, Medziphema campus, Nagaland to study the effect of fertilizers and microbial inoculants on yield and quality of soybean. There were twelve treatments replicated thrice in randomized block design. Results showed that 100% RDF, *Rhizobium* @ 20 g kg^{-1} seed + *Phosphatica* @ 20 g kg^{-1} seed and their combinations recorded the highest plant height, nodule number $plant^{-1}$ and dry weight of nodule (g $plant^{-1}$). The maximum seed (2201.65kg ha^{-1}) and stover yield (2785.89 kg ha^{-1}) of soybean was found with the use of 100% RDF followed by treatment comprising of *Rhizobium* @ 20 g kg^{-1} seed + *Phosphatica* @ 20 g kg^{-1} seed .The maximum protein (40.43%) and oil (19.99%) contents were associated with treatment of 100% RDF. The highest nutrient utilization of nitrogen (209.34 kg ha^{-1}), phosphorus (24.41 kg ha^{-1}), potassium (85.72 kg ha^{-1}) and sulphur (19.80 kg ha^{-1}) was recorded in the treatment combination of 100% RDF + *Rhizobium* @ 20 g kg^{-1} seed + *Phosphatica* @ 20 g kg^{-1} seed.

Among the essential nutrients, nitrogen, phosphorus, potassium and sulphur play a crucial role in soybean crop growth and yield (Amanullah *et al*. 2011). The long term use of high analysis chemical fertilizers leads to secondary and micronutrient deficiency, decline in crop yields and soil fertility in soybean cultivated area and hence, application of bio-fertilizers along with inorganic fertilizers to the soil leads to increase in productivity of the crop and sustain the soil health for longer period (Manna *et al*. 2007). Soybean depends on its symbionts *Bradyrhizobium japonicum* for effective growth and dry matter production. Phosphate solubilizing bacteria (PSB) improved nodulation, root and shoot biomass, straw and grain yield, P and N uptake of the soybean crop (Linu *et al*. 2009). It was reported that co-inoculation of *Bradyrhizobium* and phosphate solubilizing bacteria significantly improved soybean growth and its yield components than sole application of inoculant (Menaria and Singh 2004). Mishra *et al.* (2010) observed significant increase in root biomass and nodule numbers of pea and lentil under single or double inoculation with *Bradyrhizobium* and *Bacillus*. The research was thus carried out to study the effect of combined use of fertilizers and microbial inoculants (*Rhizobium* and PSB) on growth, yield and quality of soybean under agro-climatic condition of Nagaland.

A field experiment was carried out during *Kharif*, 2015 at the experimental farm of the School of Agricultural Sciences and Rural Development, Medziphema campus. The area falls under sub-humid climate receiving annual rainfall of about 2000 to 2500

*Corresponding author (Email: engraao@yahoo.in)

mm per annum and about 85% of the total rainfall is concentrated in July to November. The initial soil sample collected from the experimental site was processed and analyzed following standard procedures (Jackson 1973). The experimental soil was sandy loam in texture, acidic in reaction (pH 4.3) and had 15.0 g kg^{-1} organic carbon, 238.34 kg ha^{-1} available N , 11.2 kg ha^{-1} available phosphorus, 178.4 kg ha^{-1} available potassium and 10.64 kg ha^{-1} available sulphur There were twelve treatments comprising of four levels of RDF *viz.* 0 %, 50 %, 75 % and 100 % and 2 sources of microbial inoculants in 3 different combinations *viz.,* $M_{1=}$ *Rhizobium,* $M_{2=}$ Metallic Phosphatica, $M_{3=}$ *Rhizobium* + Metallic Phosphatica replicated three times in factorial randomized block design. The seeds were innoculated with carrier based culture @ 20 g kg^{-1} seed. Nitrogen, phosphorus, potassium and sulphur were applied @ 20, 60, 40, 40 kg ha^{-1} as 100% RDF and other levels accordingly. Soybean variety RKS-18 was sown on 25th June, 2015. The growth characters were recorded at 60 days of sowing (DAS) and yield and yield attributing traits were observed at harvesting stage. The seed and stover samples collected from each plot were ground in a Wiley mill and analyzed for N, P, K and S content. Nitrogen was estimated by Kjeldhal method (Jackson 1973) and di-acid mixture (HNO_3: $HClO_4$, 3:1) digested samples were used for determination of P and K by colorimetrically using vanado-molybdate yellow colour method and flame photometer, respectively. Sulphur was estimated by Turbidimetric method. Protein content in seed was calculated by multiplying the nitrogen content with a factor of 6.25 per cent. Seed oil content was estimated by Soxhlet extraction as described by A.O.A.C (1990). Transesterification of fatty acids to fatty acid melty esters (FAMEs) and further quantification and identification of FAMEs was carried out using gas chromatography-flame ionization detector (GC- FID).

The treatment having 100 % RDF had highest plant height (72.42 cm), number of nodules $plant^{-1}$ (45.25) and dry weight of nodules (0.37 g $plant^{-1}$) followed by 75 % RDF. The combined inoculation of *Rhizobium and* Metallic Phosphatica recorded the highest plant height (68.49 cm), number of nodules $plant^{-1}$ (43.97) and dry weight of nodules (0.35 g $plant^{-1}$) than the seed inoculation with *Rhizobium* or Phosphatica separately. These findings are in conformity with the finding of Govindan and Thirumurugan 2003 and Lanje *et al.* (2005). The treatment receiving 100% RDF + *Rhizobium* Phosphatica recorded the highest plant height (73.42 cm) and maximum dry weight of nodules (0.39 g $plant^{-1}$) while, maximum number of nodules $plant^{-1}$ (48.52) was recorded in 75% RDF with co-inoculation of *Rhizobium* and Phosphatica (Table1). Menaria and Singh (2004) also reported similar findings. The maximum seed (2201.65 kg ha^{-1}) and stover yield (2785.89 kg ha^{-1}) of soybean was found with the use of 100% RDF, while, *Rhizobium* + Phosphatica inoculation produced highest seed yield (2139 kg ha^{-1}) and stover yield (2721.46 kg ha^{-1}). The interaction effect of fertilizers and microbial inoculants had significant influence on grain and stover yield (Table 1).

The higher protein (40.42%) and oil content (19.99%) was recorded in treatment receiving 100% RDF (Table 2). The combined use of *Rhizobium* and Phosphatica had protein (38.93%) and oil content (19.11%) of seed than seed inoculation either with *Rhizobium* or Phosphatica and the results are in conformity with the findings of Lanje *et.al.* (2005). Highest protein and oil content were associated with 100% RDF + *Rhizobium* + Phosphatica. The main and interaction effects of treatment could not influence palmatic acid significantly. The mean content of stearic acid in soybean ranged from 1.44 to 1.63 per cent in different treatments. Mohammadi (2015) reported highest stearic acid (1.84 %) in treatment having 100% RDF + *Rhizobium.* The mean value of oleic acid was 41.42, 40.79, 40.34 and 40.5 per cent in 0, 50, 75 and 100 % RDF treatments, respectively. The linoleic acid content ranged from 37.42 to 43.40 per cent in different treatments. The maximum amount (5.63%) of linoleic acid was found in Mzx100% RDF treatment.

The highest total N, P, K and S uptake was recorded in 100 % RDF (184.46, 21.07, 75.27 and

17.45 kg ha^{-1}, respectively) and seed inoculation with *Rhizobium* + Phosphatica (172.63, 19.22, 63.46 and 16.14 kg ha^{-1}, respectively) (Table 3). The highest (209.34 kg ha^{-1}), phosphorus (24.41 kg ha^{-1}), potassium (85.72 kg ha^{-1}) and sulphur (19.80 kg ha^{-1}) uptake was recorded in the treatment having 100% RDF+ *Rhizobium*+Phosphatica. These findings are in agreement with the findings of Devi *et al*. (2013).

Table 1. Effect of fertilizers and microbial inoculants on growth and yield attributes of soybean

Microbial inoculants @ 20 g kg^{-1} seed	Fertilizer levels (% RDF)				Mean
	0	50	75	100	
			Plant height (cm)		
M_1	51.81	63.05	66.56	71.75	63.34
M_2	53.20	65.81	69.32	71.89	65.06
M_3	62.81	67.42	70.29	73.42	68.49
Mean	55.94	65.43	68.72	72.42	
CD at 5 %	F = 2.80		M = 2.42	F × M = 4.84	
			Number of nodules plant^{-1}		
M_1	28.33	40.67	41.08	45.08	38.79
M_2	33.50	39.17	45.33	44.67	40.67
M_3	38.67	42.67	48.52	46.00	43.97
Mean	33.50	40.84	44.98	45.25	
CD at 5 %	F = 2.78		M = 2.41	F × M = 4.81	
			Dry weight of nodules (g plant^{-1})		
M_1	0.31	0.34	0.34	0.36	0.34
M_2	0.28	0.36	0.35	0.37	0.34
M_3	0.35	0.29	0.38	0.39	0.35
Mean	0.31	0.33	0.37	0.37	
CD at 5 %	F = 0.04		M = 0.03	F × M = 0.06	
			Seed yield (kg ha^{-1})		
M_1	1706.17	2012.10	1999.63	2019.75	1934.41
M_2	1646.91	1949.38	2029.01	2098.73	1931.01
M_3	1929.38	2023.95	2116.86	2486.47	2139.17
Mean	1760.82	1995.14	2048.50	2201.65	
CD at 5 %	F = 124.53		M = 107.85	F × M = 215.69	
			Stover yield (kg ha^{-1})		
M_1	2247.63	2765.31	2701.24	2678.52	2598.18
M_2	2253.09	2658.02	2646.91	2676.54	2585.64
M_3	2573.75	2633.32	2676.14	3002.62	2721.46
Mean	2358.16	2685.55	2674.76	2785.89	
CD at 5 %	F = 144.58		M = 125.41	F × M = 250.43	

Table 2. Effect of fertilizers and microbial inoculants on quality attributes of soybean

Microbial inoculants @ 20 g kg^{-1} seed	Fertilizer levels (% RDF)				Mean
	0	50	75	100	
			Protein content (%)		
M_1	36.25	37.15	39.79	40.35	38.39
M_2	35.90	37.12	39.67	40.25	38.24
M_3	36.44	38.21	40.40	40.67	38.93
Mean	36.20	37.48	39.95	40.42	
CD at 5 %	F = 0.75	M = 0.65	F × M = NS		
			Oil content (%)		
M_1	17.74	18.54	18.79	19.96	18.76
M_2	17.59	18.46	18.67	19.84	18.64
M_3	17.92	18.57	19.80	20.16	19.11
Mean	17.75	18.52	19.09	19.99	
CD at 5 %	F = 0.25	M = 0.22	F × M = 0.44		
			Palmitic acid (%)		
M_1	10.85	12.21	11.62	11.16	11.46
M_2	10.68	11.46	12.43	11.76	11.58
M_3	11.06	11.68	10.89	10.86	11.12
Mean	10.86	11.78	11.64	11.26	
CD at 5 %	F = NS	M = NS	F × M = NS		
			Stearic acid (%)		
M_1	1.31	1.56	1.72	1.84	1.60
M_2	1.52	1.42	1.61	1.63	1.54
M_3	1.68	1.34	1.44	1.42	1.47
Mean	1.50	1.44	1.59	1.63	
CD at 5 %	F = 0.14	M = 0.11	F × M = NS		
			Oleic acid (%)		
M_1	42.20	39.62	40.34	38.68	40.21
M_2	40.38	42.12	41.02	40.72	41.06
M_3	41.68	40.64	39.68	42.12	41.03
Mean	41.42	40.79	40.34	40.50	
CD at 5 %	F = 0.56	M = 0.92	F × M = 5.60		
			Linoleic acid (%)		
M_1	39.12	40.12	41.26	39.86	40.09
M_2	40.90	40.68	43.40	38.16	40.78
M_3	37.42	43.34	42.38	41.34	41.12
Mean	39.14	41.38	42.34	39.78	
CD at 5 %	F = 0.98	M = 0.42	F × M = 6.20		
			Linolenic acid (%)		
M_1	4.32	4.62	4.93	5.63	4.87
M_2	4.82	5.10	5.01	4.72	4.91
M_3	3.98	4.62	4.80	5.02	4.86
Mean	4.37	5.11	4.91	5.12	
CD at 5 %	F = NS	M = NS	F × M = NS		

Table 3. Effect of fertilizers and microbial inoculants on nutrient uptake (kg ha^{-1}) by soybean

Microbial inoculants @ 20 g kg^{-1} seed	Fertilizer levels (% RDF)				Mean
	0	50	75	100	
			Nitrogen uptake (kg ha^{-1})		
M_1	124.87	147.38	159.74	171.10	150.77
M_2	119.01	150.57	159.20	172.95	150.43
M_3	145.84	163.68	172.25	209.34	172.63
Mean	129.91	153.68	163.73	184.46	
CD at 5 %	F = 11.60	M = 10.05		F × M = 20.10	
			Phosphorus uptake (kg ha^{-1})		
M_1	13.07	16.36	17.99	19.54	16.74
M_2	12.89	16.64	17.40	19.27	16.55
M_3	15.60	18.33	18.53	24.41	19.22
Mean	13.85	17.11	17.97	21.07	
CD at 5 %	F = 1.63	M = 1.44		F × M = 2.82	
			Potassium uptake (kg ha^{-1})		
M_1	39.18	53.09	56.04	70.15	54.62
M_2	37.73	50.01	62.60	69.95	55.07
M_3	46.68	55.73	65.72	85.72	63.42
Mean	41.20	52.94	61.45	75.27	
CD at 5 %	F = 4.19	M = 3.63		F × M = 7.25	
			Sulphur uptake (kg ha^{-1})		
M_1	10.31	13.13	16.29	16.40	14.03
M_2	9.67	14.15	14.91	16.14	13.72
M_3	12.33	15.74	16.70	19.80	16.14
Mean	10.77	14.34	15.20	17.45	
CD at 5 %	F = 1.15	M = 1.00		F × M = NS	

References

A.O.A.C. (1990). Official Methods of analysis (18th ed.) Association of Official Agricultural Chemists, Washington.

Amanullah M. M., Ananthi T., Subramanian K.S. and Muthukrishnan P. (2011). Influence of mycorrhiza, nitrogen and phosphorus on growth, yield and economics of hybrid maize. *The Madras Agriculture Journal* **98**, 62-66.

Devi K.N., Singh B.T., Singh H.A., Singh N.B. and Diana S. (2013). Influence of inorganic, biological and organic manures on nodulation and yield of soybean (*Glycine max* L. Merrill) and soil properties. *Australian Journal of Crop Science* **7**, 1407-1415.

Govindan K. and Thirumurugan V. (2003). Effect of *Rhizobium* and PSB in soybean. *Journal of Maharashtra Agricultural Universities* **28**, 54-60

Jackson M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Lanje P.W., Buldeo A.N., Zade S.R. and Gulhane V.G. (2005). Effect of Rhizobium and phosphorus solubilizers on growth and yield of soybean. *Journal of Soils and Crops* **15**,132-135.

Linu M.S., Stephen J. and Jisha M.S. (2009). Phosphate Solubilizing *Gluconacetobacter* sp., *Burkholderia* sp. and their potential interaction with cowpea (*Vigna unguiculata* (L.). *International Journal of Agricultural Research* **4**, 79-87.

Manna M.C., Swarup A.,Wanjari R.H., Mishra B. and Shahi D.K. (2007). Long term fertilization, manure and liming effects on soil organic matter and crop yields. *Soil and Tillage Research* **94**, 397-409.

Menaria B.L. and Singh P. (2004). Effect of chemical and biofertilizer on yield attributing character and

yield of soybeans (*Glycine max* L. Merrill). *Legume Research* **27,** 231-232.

Mishra A., Prasad K. and Rai G. (2010). Effect of bio-fertilizer inoculations on growth and yield of dwarf field pea in conjunction with different doses of chemical fertilizers. *Journal of Agronomy* **9**, 163-168.

Mohammadi K. (2015). Grain oil and fatty acids composition of soybean affected by nano-iron chelate, chemical fertilizers and farmyard manure. *Journal Archive of Agronomy and Soil Science* **61**, 1593-1600.

Received : May , 2017 *Accepted : October, 2017*