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Effect of organic manures, bio-fertilizers, levels of nitrogen and phosphorus on growth and yield of soybean

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Abstract
An expriment entitled "Effect of organic manures, bio-fertilizers, levels of nitrogen and phosphorus on soybean [*Glycine max* (L.) Merrill]" was conducted during 2014-15 at Tribal Research cum Training Centre, Anand Agricultural University, Devagadh Baria, Dist. Dahod, Gujarat. The soil of the experimental site was sandy loam in texture, free from any kind of salinity or sodicity hazards, having low in organic carbon and nitrogen, medium in available phosphorus and high in potassium. The experiment consisted of sixteen treatment combinations each of two organic manures (vermicompost @ 2.5 t ha^{-1} and FYM @10 t ha^{-1}), levels of nitrogen (22.5 and 45 kg N ha^{-1}), levels of phosphorus (30 and 60 kg P_2O_5 ha^{-1}) and biofertilizers (No biofertilizer and *Rhizobium* + PSB). The experiment was laid out in randomized block design with factorial concept. The soybean variety NRC-37 was used in the experiment as a test crop. Significantly the highest seed yield (1760 kg ha^{-1}, 1809 kg ha^{-1} and 1843 kg ha^{-1}) of soybean was found with the application of vermicompost @ 2.5 t ha^{-1}, 60 kg P_2O_5 and seed treatment of *Rhizobium* + PSB, respectively.

Keywords: Organic manures, bio-fertilizers, nitrogen, phosphorus, growth, yield, soybean

Introduction

Soybean [*Glycine max* (L.) Merrill] is also known as "Chinese pea" or "Manchurian bean". Madhya Pradesh, Maharashtra, Rajasthan, Gujarat and Uttar Pradesh are the leading producers of soybean. In Gujarat, the total area under cultivation was 0.742 lakh ha with the production and the productivity of 0.701 lakh tonne and 945 kg ha^{-1}, respectively (SOPA, 2014). There is an increasing interest in the use of organic manures as a source of nutrient supply to crop production for sustainable soil productivity, ecological stability and to minimize the requirement for chemical fertilizers. Amongst the different sources of organic manures, FYM and vermicompost are easily available in the market. Integration of inorganic and organic manures not only sustain the crop production but also effective in improving soil health and enhancing the nutrient use efficiency (Verma *et al.*, 2005) [16]. However, inadequate use of fertilizer is one of the most important reason for low productivity. In 2012, the area of soybean in Madhya Pradesh and Gujarat was 58.12 lakh ha and 0.83 lakh ha, respectively and productivity of soybean in Madhya Pradesh and Gujarat was 1150 kg ha^{-1} and 1103 kg ha^{-1}, respectively. While in 2013, the area of soybean in Madhya Pradesh and Gujarat was increased (62.60 lakh ha and 0.930 lakh ha, respectively) but productivity of soybean in Madhya Pradesh and Gujarat was decreased (950 kg ha^{-1} and 1050 kg ha^{-1}, respectively). It might be due to farmers of Madhya Pradesh and border area of Gujarat like Dahod and Panchmahal have started using urea instead of diammonium phosphate (DAP) in its cultivation due to rising prices of fertilizers (Dainikjagran, 2013). The price urea is comparatively less hence farmers are using it more often as compared to other fertilizers. Urea is a source of nitrogen only. So use of urea instead of DAP in soybean fields is scientifically improper practices because it may lead to a chemical imbalance in the fields and decreasing in crop production. During *Kharif* seasons of last couple of years, we are finding difficulties for buying fertilizers because of rises in prices. In 2011, a 50 kg sack of DAP cost was Rs 860 but at present, it is available at a cost of Rs 1,450. In the year 2012, as per Dainik jagran, the consumption of DAP and super phosphate was 30-40 percent less as of the normal because of rises in prices. As we all know, for having good harvest, right time and right mixing of fertilizers is very much necessary. So in this context rock phosphate is use as a source of phosphorus under this study which contains 28-30 per cent P_2O_5.

Material and Method

A field experiment was conducted at Tribal Research cum Training Center, Anand Agricultural University, Devgadhbaria, District:-Dahod, Gujarat during the *kharif* season of the year 2014 on sandy loam soil having pH 6.0, low in organic carbon (0.33 %) and available nitrogen (241.50 kg ha^{-1}), while medium in available phosphorus (34.52 kg ha^{-1}) and high in potassium (260.50 kg ha^{-1}). The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. There were four factor each have two level [Organic Manures (O_1 - Vermicompost @ 2.5 t ha^{-1}) and O_2 – Farm Yard Manure @ 10.0 t ha^{-1}), Levels of Nitrogen (N_1 - 22.5 kg N ha^{-1} and N_2 - 45 kg N ha^{-1}), Levels of Phosphorus (P_1 - 30 kg P_2O_5 ha^{-1} and P_2 - 60 kg P_2O_5 ha^{-1}) and Bio-fertilizers [B_1 - No biofertilizer and B_2 - Rhizobium + PSB (Seed treatment)] total sixteen treatment combinations applied on preceding *kharif* soybean. Nitrogen was applied through urea. Phosphorus was applied through rock phosphate. *Rhizobium japonicum* @ 5 ml kg^{-1} seed and *Bacillus coagulans* @ 5 ml kg^{-1} seed was applied through seed treatment.

Result

1. Effect of organic manures

Generally, economic yield depends on fruiting organs produced by plant. The major factors of total seasonal yields of paramount importance are number of pods plant^{-1} and pod size. In the present study, number of pod plant^{-1}, pod length and seed index were taken as a component related with the seed yield, straw yield as well as harvest index. Based on results, it can be concluded that number of pods plant^{-1} were significantly influenced due to organic manures application. In the present study, highest number of pods plant^{-1} were produced in the vermicompost @ 2.5 t ha^{-1} because most nutrients are found continuously available in vermicompost such as nitrates, phosphates, soluble potassium as well as micronutrients. This finding is in close conformity with the findings of Thanunathan *et al.* (2002) [15] and Maheshbabu *et al.* (2008) [8]. The increase in pod length due to effect of vermicompost improves soil physical properties by decreasing bulk density and increasing the soil water holding capacity. Similar results were also reported by Laharia *et al*. (2013) [7]. Dry weight of root nodules plant^{-1} was found significant in treatment FYM @ 10 t ha^{-1}. It might be due to higher microbial activity in root nodules. Similar results were also reported by Paradkar and Deshmukh (2004) [11]. Significantly the highest seed yield of soybean was found with the application of vermicompost @ 2.5 t ha^{-1}. It might be due to soil physical properties by increasing water holding capacity with greater increase in soil organic carbon and plant nutrients which are in available forms. It increases cation exchange capacity and improve soil structure, bacterial population and biological activity. Vermicompost also increase the yield attributes which reflected in yield. These findings are in close conformity with the findings of Maheshbabu *et al.* (2008) [8], Laharia *et al.* (2013) [7] and Konthoujam *et al.* (2013) [6].

2. Effects of nitrogen

In the present investigation, application of different levels of nitrogen was significantly increase the plant height at 60 days and at harvest. This might be due to adequate supply of nitrogen with application of 45 kg N ha^{-1} treatment. Nitrogen being on essential constituent of essential metabolites including protein and amino acids as well as structural constituents of the plant cell which might have influenced different physiological process such as cell division and elongation which ultimately reflected on plant height. Similar results are also reported by the Kaisi and David (2007). The data on seed and straw yield of soybean presented in Table 1 revealed that the highest value of seed yield (1702 kg ha^{-1}) and straw yield (1745 kg ha^{-1}) obtained with the application of 45 kg N ha^{-1}. It might be due to higher plant height due to better utilization of plant nutrients and phased release of nutrients as per requirement of crop. These results are in close conformity with the results of Morshed *et al.* (2008) [9].

3. Effect of phosphorus

Phosphorus is major plant nutrient needed for increasing seed yield for soybean crop. Phosphorus is called key of life and nitrogen governs the above earth growth whereas ‘P’ governs the root growth i.e. below earth growth (Rotaru, 2010) [12]. Significantly the highest pods plant^{-1} (131) was recorded under treatment 60 kg P_2O_5 ha^{-1}. This might be due to higher quantity of phosphorus application, created favourable conditions for supplying more nutrients by developing congenial conditions for development of higher number of pods plant^{-1}. These findings are in close agreement with the results of Gupta *et al*. (2006) [3]. Significantly the highest pod length (3.75 cm) was recorded in treatment 60 kg P_2O_5 ha^{-1} as compared to 30 kg P_2O_5 ha^{-1}. It might be due to more congenial conditions for plant growth and better absorption of plant nutrients from soil results greater dry matter production from photosynthesis and consequently large effective pod length. Similar results are also reported by Ijgude and kadam (2008) [4]. The increase in soybean yield might be due to the effect of phosphorus availability and enhanced growth, yield attributes and ultimately higher seed yield. These are supported by Gupta *et al.* (2006) [3] and Paliwal *et al.* (2009) [10]. The data on straw yield are presented in Table 1 revealed that the highest straw yield of 1742 kg ha^{-1} was found with application of 60 kg P_2O_5 ha^{-1}. The better vegetative growth might have obviously resulted into superior straw yield. Sufficient soil moisture in the soil profile under higher application of plant nutrients were more available and translocated to produce more green matter is one of the reason for the same. These findings were confirmed by Ijgude and Kadam (2008) [4], Gupta *et al.* (2006) [3] and Paliwal *et al*. (2009) [10].

4. Effect of biofertilizers

In recent years, bio-fertilizers have been emerged as a supplement to mineral fertilizers and hold a promise to improve the crop production in several crops. The bio-fertilizers were found to have positive impact on soil fertility, resulting in an increase in crop yield without causing any environment and water on soil hazards (Shubhangi *et al.*, 2010) [14]. The increase in the dry weight of root nodule might be due to more number of nodules per plant. Phosphorus has a specific role in nodule initiation, growth and function in addition to its role in host plant growth. Microorganisms with phosphate solubilizing potentially increase the availability of soluble phosphate and enhance the plant growth by improving biological nitrogen fixation. Phosphorus deficiency has been shown to restrict the nodulation process severely in soybean (Konthoujam *et al.,* 2013) [6].

5. Interaction effect

In the present study, several interactions were found significant in respect of growth and yield parameters. In case of pod length, O × P, N x P and N × P × B was found significant. Interaction effect of phosphorus and bio fertilizer was found significant in case of seed yield of soybean. It may be due to bio-fertilizers are improve soil structure, texture, chemical properties, cation exchange capacity and also made phosphorus available from near root zone which can easily available to plant. Same trends are also observed by Morshed *et al.* (2008) [9], Sawarkar *et al.* (2009) [13] and Maheshbabu *et al.* (2012).

Table 1: Growth parameters and yield of soybean as influenced by different treatments

Treatment	Plant height (cm)			Number of branches plant^{-1}	Number of pods plant^{-1}	Pod length (cm)	Dry weight of root nodules plant^{-1} (mg)	Seed index (g)	Seed Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
	30 DAS	60 DAS	At harvest							
O_1= Vermicompost @ 2.5 t ha^{-1}	31.78	48.36	61.47	3.93	133	3.71	124.20	13.05	1760	1680
O_2= FYM @ 10 t ha^{-1}	31.59	47.36	60.55	3.79	122	3.52	134.25	12.50	1606	1648
S.Em$\pm$	0.60	0.74	1.13	0.093	2.27	0.06	3.43	0.18	38.77	50.00
CD (P=0.05)	NS	NS	NS	NS	6.56	0.17	9.92	0.51	112	NS
N_1= 22.5 kg N ha^{-1}	31.12	45.84	57.58	3.81	126	3.61	128.79	12.79	1663	1583
N_2= 45 kg N ha^{-1}	32.24	49.88	64.43	3.91	129	3.62	129.67	12.81	1702	1745
S.Em$\pm$	0.60	0.74	1.13	0.093	2.27	0.06	3.43	0.18	38.77	50.00
CD (P=0.05)	NS	2.14	3.27	NS	NS	NS	NS	NS	NS	144
P_1= 30 kg P_2O_5 ha^{-1}	32.05	47.65	60.89	3.80	124	3.49	126.96	12.64	1557	1586
P_2= 60 kg P_2O_5 ha^{-1}	31.31	48.06	61.12	3.92	131	3.75	131.50	12.91	1809	1742
S.Em$\pm$	0.60	0.74	1.13	0.093	2.27	0.06	3.43	0.18	38.77	50.00
CD (P=0.05)	NS	NS	NS	NS	6.56	0.17	NS	NS	112	144
B_1= No Biofertilizer	31.96	47.25	59.73	3.79	124	3.55	105.29	12.69	1522	1620
B_2= *Rhizobium* + PSB (Seed Treatment)	31.40	48.47	62.98	3.93	131	3.68	153.17	12.85	1843	1708
S.Em$\pm$	0.60	0.74	1.13	0.093	2.27	0.06	3.43	0.18	38.77	50.00
CD (P=0.05)	NS	NS	NS	NS	6.56	NS	9.92	NS	112	NS
C.V. %	9.36	7.61	9.08	11.76	8.71	7.98	13.02	6.77	11.29	14.72
Interaction	NS	PxB, OxPxB	NS	NS	NS	O x P, N x P, NxPxB	NS	O x P	P x B	NS

Table 2: Plant height of soybean at 60 DAS as influenced by P x B interaction

Plant height (cm) at 60 DAS		
Treatments	**B_1= No Biofertilizer**	**B_2= *Rhizobium* + PSB (Seed Treatment)**
P_1= 30 kg P_2O_5 ha^{-1}	46.35	47.16
P_2= 60 kg P_2O_5 ha^{-1}	48.15	49.78
S.Em$\pm$	1.05	
CD (P=0.05)	3.03	

Table 3: Plant height of soybean at 60 DAS as influenced by O x P x B interaction

Plant height (cm) at 60 DAS			
Treatments		**B_1= No Biofertilizer**	**B_2= *Rhizobium* + PSB (Seed Treatment)**
O_1= Vermicompost @ 2.5 t ha^{-1}	P_1= 30 kg P_2O_5 ha^{-1}	47.77	47.83
	P_2= 60 kg P_2O_5 ha^{-1}	48.87	48.97
O_2= FYM @ 10 t ha^{-1}	P_1= 30 kg P_2O_5 ha^{-1}	43.73	48.47
	P_2= 60 kg P_2O_5 ha^{-1}	46.55	50.70
S.Em$\pm$		1.49	
CD (P=0.05)		4.29	

Table 4: Pod length as influenced by O x P interaction

Pod length (cm)		
Treatment	**P_1= 30 kg P_2O_5 ha^{-1}**	**P_2= 60 kg P_2O_5 ha^{-1}**
O_1= Vermicompost @ 2.5 t ha^{-1}	3.49	3.94
O_2= FYM @ 10 t ha^{-1}	3.48	3.55
S.Em$\pm$	0.08	
CD (P=0.05)	0.24	

Table 5: Pod length as influenced by N x P interaction

Pod length (cm)		
Treatment	**P_1= 30 kg P_2O_5 ha^{-1}**	**P_2= 60 kg P_2O_5 ha^{-1}**
N_1= 22.5 kg N ha^{-1}	3.57	3.65
N_2= 45 kg N ha^{-1}	3.40	3.84
S.Em$\pm$	0.08	
CD (P=0.05)	0.24	

Table 6: Pod length as influenced by N x P x B interaction

Pod length (cm)			
Treatment		B_1= No Biofertilizer	B_2= *Rhizobium* + PSB (Seed Treatment)
N_1= 22.5 kg N ha^{-1}	P_1= 30 kg P_2O_5 ha^{-1}	3.47	3.67
	P_2= 60 kg P_2O_5 ha^{-1}	3.70	3.60
N_2= 45 kg N ha^{-1}	P_1= 30 kg P_2O_5 ha^{-1}	3.46	3.35
	P_2= 60 kg P_2O_5 ha^{-1}	3.59	4.10
S.Em$\pm$		0.118	
CD (P=0.05)		0.34	

Table 7: Seed index as influenced by O x P interaction

Seed index (g)		
Treatment	P_1= 30 kg P_2O_5 ha^{-1}	P_2= 60 kg P_2O_5 ha^{-1}
O_1= Vermicompost @ 2.5 t ha^{-1}	11.76	11.99
O_2= FYM @ 10 t ha^{-1}	12.24	12.66
S.Em$\pm$	0.25	
CD (P=0.05)	0.72	

Table 8: Seed yield of soybean as influenced by P x B interaction

Seed yield (kg ha^{-1})		
Treatment	B_1= No Biofertilizer	B_2= *Rhizobium* + PSB (Seed Treatment)
P_1= 30 kg P_2O_5 ha^{-1}	1463	1651
P_2= 60 kg P_2O_5 ha^{-1}	1582	2035
S.Em$\pm$	54.82	
CD (P=0.05)	158	

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