The Bioscan 10(3): 1317-1320, 2015 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF PHOSPHORUS LEVELS AND PSB ON GROWTH INDICES AND YIELD OF GREEN GRAM [*VIGNA RADIATA* (L.) WILCZEK] UNDER CUSTARD APPLE (*ANNONA SQUAMOSA*) BASED ON AGRI-HORTI SYSTEM

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KEYWORDS
Green gram
PSB
Phosphorous level
Growth indices and Yield

Received on :
10.05.2015

Accepted on :
18.08.2015

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ABSTRACT
A field experiment was conducted during *Kharif* season of 2011-12 at the Instructional Farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur to evaluate the "effect of phosphorus levels and PSB on growth indices and yield of green gram [*Vigna radiata* (L) Wilczek] under Custard apple (*Annona squamosa*) based on agri-horti system". Treatments consisted of green gram Control, 20, 30, 40 Kg P_2O_5 ha^{-1}, PSB (S1) + 20, 30, 40Kg P_2O_5 ha^{-1}, PSB (S2) + 20,30, 40 Kg P_2O_5 ha^{-1}, PSB(S1) + PSB(S2) + 20, 30, 40 Kg P_2O_5 ha^{-1} during *Kharif* 2011-12. The mean maximum plant height, dry matter accumulation and number of trifoliate leaves of green gram under dual inoculation of PSB (S1) + PSB (S2) along with 40 kg P_2O_5 ha^{-1} at all successive stage which were significantly superior to control, 20 kg P_2O_5 ha^{-1} and 30 kg P_2O_5 ha^{-1} during the experimentation. The seed inoculation with PSB (S1) + PSB (S2) under the application of 40 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) recorded the maximum grain yield at par with 40 kg P_2O_5 ha^{-1} either under PSB (S2), 40 kg P_2O_5 ha^{-1} + PSB (S1) and 30 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) significantly superior over rest of treatment.

INTRODUCTION

Pulses production is very low and become challenging problem against the requirement of increasing population of our country. The pulses availability per capita was 69.9g in 1951, by increasing in 1971, it comes to 50g and in 1982 remained only 40g and in 2005, it was 27g. The availability of pulses is very negligible at present as against required 85g day-1capita-1 for balanced diet to recover this deficit of production. It is high time to cultivate pulses crops scientifically with increasing area (*Patel et al.,* 2013).

In India, shrinking land resources coupled with burgeoning population exerting huge pressure on the farmers, researchers and agricultural policy makers to meet the food grain requirement of nation. This enforces to search out for newer vistas. Agro forestry system with judicious mixing of crop, tree and grasses meet all basic requirements of mankind and his livestock.

Pulses are consumed all over the world; their consumption is higher in those parts of the world where animal proteins are scarce and expensive (Ofuya and Akhidue, 2005). Greengram commonly known as 'Moongbean' or 'Moong'. It contains 24.3 per cent protein fairly rich in carbohydrates and also contains small amount of riboflavin and thiamine, also rich in phosphorus and iron (Patel *et al.,* 2013). Pulses are the world's major source of plant protein. The productivity of pulses is declined due to inadequate plant stand, heavy flower drop and immature pod abscission leading to poor seed setting besides unfavorable environment, water and nutrient deficiencies at critical periods (Dwivedi *et al.*, 2014).

The important greengram growing states are Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar. Though India is the largest producer of pulses in the world, the per capita consumption over the years has come down from 61 g day^{-1} in 1951 to 30 g day^{-1} in 2008 (Reddy, 2009). In India pulses are grown in nearly 23.28 million hectare area with production status of nearly 14.66 million tonnes at an average productivity level of 630 kg ha^{-1} (Economic Survey, 2010-11).

Agri-horti system markedly increases the return per unit of land mainly during early stage of horticultural fruit trees. Fruit tree based agroforestry involves intentional and simultaneous association of annual or perennial crops with perennial fruit-producing trees on the same land unit. In India, green gram occupies 3.7 million hectares and contributes to 1.57 million tonnes in pulse production. Custard apple (*Annona squamosa* L.) is distributed throughout the tropics and is pre eminently a desert fruit, normally eaten fresh. The vitamin C content is appreciable (35-42 mg/100 g) and slightly higher than in grape fruit. Nitrogen requirement of pulse crops is very low than other crops because nitrogen needed only for establishment of plant, after that plant fulfill their requirement through symbiotic nitrogen fixation.

It is a well established fact that phosphorus is one of the most important substances such as phosphate and protein. It also takes part in energy fixing and releasing process in plant. It also induces root proliferation and nodulation. It is essential that green gram should not suffer due to inadequate mineral nutrient especially phosphorus. Since chemical fertilizers are scarce and costly, it is necessary to use them economically in combination with phosphorus and PSB, as green gram shows high response to high phosphorus level and PSB.

Keeping these facts into consideration the present investigation was conducted to study the effect of phosphorus and PSB levels on growth and yield of green gram under custard apple based agri-horti system.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2011-12 at the Instructional Farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur which is situated in Vindhyan region of district Mirzapur (25º 10' latitude, 82º 37' longitude and at an altitude of 427 meters above mean sea level) occupying over an area of more than 1000 ha where variety of crops like agricultural, horticultural, medicinal and aromatic plants are grown. Vindhyan soil comes under rainfed and invariably of poor fertility status. This region comes under agro-climatic zone III A (semi-arid eastern plain zone). The annual rainfall was 267.94 mm with maximum and minimum temperatures ranged between 39.65 °C and 8.12 °C, respectively during *Kharif*, 2011. The total rainfall during the crop season was 1080 mm, maximum and minimum temperature fluctuated between 34.7ºC and 16ºC and relative humidity between 94 and 33 per cent. The soil of the experimental field was sandy loam-silt in texture with low drainage *i.e.* having pH 6.5. It was moderately fertile, being low in available organic carbon (0.23%), available nitrogen (175.50 kg ha^{-1}), and medium in available phosphorus (11.25 kg ha^{-1}) and potassium (185.7 kg ha^{-1}).

The experiment was laid out in Randomized Block Design with Agri-horti system (fruit based on Agroforestry system) *viz.*, custard apple based Agri-horti system. Treatments were replicated thrice. The experiment compared 13 treatments *viz.* uninoculation of seed (Control) each under , 20 kg P_2O_5, 30 kg P_2O_5, and 40 kg P_2O_5 ha^{-1} single inoculation of PSB strain BHU JY-01 each under 20 kg P_2O_5, 30 kg P_2O_5 and 40 kg P_2O_5 ha^{-1} and single inoculation of PSB strain BHU JY-13 each under 20 kg P_2O_5, 30 kg P_2O_5 and 40 kg P_2O_5 ha^{-1} and dual inoculation of PSB BHU JY-01and BHU JY-13 each under 20 kg P_2O_5, 30 kg P_2O_5 and 40 kg P_2O_5 ha^{-1} fertility levels. The requisite quantity of seed at the rate of 15 kg for green gram was sown. The seed were sown with help of *Kudal* directly in rows 30 x 10 cm apart. The experiment was carried out with six years old custard apple trees planted at 5 x 5 meter spacing. Total quantity of nitrogen, phosphorus and single super phosphate as per treatments in the form of Urea (46% N), Di-ammonium Phosphate (18% N and 46% P_2O_5) and Single Super Phosphate (16% SSP) respectively were applied below the seeds at the time of sowing of crop. Seed was treated with PSB as per treatment. Different parameters were evaluated following the standard procedure.

RESULTS AND DISCUSSION

Growth Indices

The maximum plant height, number of trifoliate leaves (Table 1) and dry matter accumulation $plant^{-1}$ (Table 2) of green gram under dual inoculation of PSB (S1) + PSB (S2) along with 40 kg P_2O_5 ha^{-1} at all successive stage which were significantly superior to control with 20 kg P_2O_5 ha^{-1} and 30 P_2O_5 kg ha^{-1} during the experimentation. Plant growth parameters like shoot and root length, number of leaves and dry matter content of green gram at 45 DAS were significantly increased due to inoculation of PSB strains along with RP application as compared to RP control. The inoculation of PSBV-12, PSBV-14, PSBV-15, PSBV-7, PSBV-13, PSBV-5 and PSBV-8 recorded an increase of 25.1, 24.89, 24.49, 24.49, 23.06, 23.06 and 23.06 per cent respectively over RP control with regard to shoot length of green gram. Increase in shoot and root length of several crop plants due to inoculation of P Solubilizing microorganisms have been reported in a number of studies. Increased cell elongation and multiplication due to enhanced nutrient uptake by plants following inoculation of P Solubilizing

Table 1: Effects of Phosphorus levels and PSB on number of Trifoliate leaves $plant^{-1}$, number of branches $plant^{-1}$ and plant height of green gram

Treatment	number of Trifoliate leaves $plant^{-1}$			Number of Branches $plant^{-1}$		Plant height (cm)		
	20 DAS	40 DAS	At harvest	40 DAS	At harvest	20 DAS	40 DAS	At harvest
$T_{1\ (Control)}$	2.13	6.07	4.20	2.33	3.03	17.16	30.11	38.53
T_2 (20Kg P_2O_5 ha^{-1})	2.33	6.53	5.73	2.40	3.20	18.99	32.98	39.40
T_3 (30 Kg P_2O_5 ha^{-1})	2.33	6.93	6.93	2.53	3.37	21.67	34.56	40.73
T_4 (40 Kg P_2O_5 ha^{-1})	2.60	8.33	8.53	2.93	4.07	23.54	40.67	46.67
T_5 (PSB(S1)+20Kg P_2O_5 ha^{-1})	2.53	7.53	7.40	2.67	3.67	22.29	37.63	41.67
T_6 (PSB(S1)+30Kg P_2O_5 ha^{-1})	2.67	8.67	8.73	3.13	4.17	24.26	42.03	47.27
T_7 (PSB(S1)+40Kg P_2O_5 ha^{-1})	2.87	9.13	10.13	3.60	4.63	25.29	46.81	50.00
T_8 (PSB(S2)+20Kg P_2O_5 ha^{-1})	2.60	7.80	7.67	2.73	3.80	22.61	38.54	42.73
T_9 (PSB(S2)+30Kg P_2O_5 ha^{-1})	2.80	8.80	9.07	3.27	4.33	24.46	43.61	47.80
T_{10} (PSB(S2)+40Kg P_2O_5 ha^{-1})	2.67	9.73	10.67	3.80	5.00	26.87	48.36	51.73
T_{11} (PSB(S1)+PSB(S2)+20Kg P_2O_5 ha^{-1})	2.60	8.00	8.27	2.83	3.97	22.85	39.01	45.00
T_{12} (PSB(S1)+PSB(S2)+30Kg P_2O_5 ha^{-1})	2.80	9.00	9.70	3.43	4.50	25.13	44.95	49.00
T_{13} (PSB(S1)+PSB(S2)+40Kg P_2O_5 ha^{-1})	3.13	10.60	12.00	4.67	5.10	27.19	49.66	52.67
SEm ±	0.16	0.51	0.72	0.43	0.18	1.38	2.06	1.49
CD (p=0.05)	0.46	1.48	2.09	1.26	0.53	4.03	6.00	4.35

Table 2: Effects of Phosphorus levels and PSB on number of root nodules plant-1, dry matter accumulation plant^{-1} and yield of green gram

Treatment	Number of root nodules plant^{-1}			Dry matter accumulation (g plant^{-1})			Yield (Kg ha^{-1})	
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	Grain	Straw
$T_{1\ (Control)}$	7.40	15.13	3	1.47	4.10	17.80	711.89	2189.75
T_2 (20Kg P_20_5 ha^{-1})	8.80	17.60	3.6	1.69	4.17	20.42	772.17	2305.02
T_3 (30 Kg P_20_5 ha^{-1})	10.07	21.47	4	1.83	4.37	20.92	799.81	2392.40
T_4 (40 Kg P_20_5 ha^{-1})	11.07	22.47	5.8	2.14	4.98	22.16	826.66	2462.70
T_5 (PSB(S1)+20Kg P_2O_5 ha^{-1})	10.60	21.87	4.6	1.97	4.52	21.15	823.08	2440.06
T_6 (PSB(S1)+30Kg P_2O_5 ha^{-1})	11.33	23.00	6.03	2.38	5.16	22.64	846.87	2537.49
T_7 (PSB(S1)+40Kg P_2O_5 ha^{-1})	12.33	24.67	6.7	2.49	5.70	23.62	918.14	2758.57
T_8 (PSB(S2)+20Kg P_2O_5 ha^{-1})	10.80	22.20	4.9	2.23	4.66	21.64	839.11	2423.33
T_9 (PSB(S2)+30Kg P_2O_5 ha^{-1})	11.53	23.20	6.23	2.43	5.30	22.98	858.71	2557.40
T_{10} (PSB(S2)+40Kg P_2O_5 ha^{-1})	12.80	25.73	6.83	2.55	5.87	23.93	942.26	2786.32
T_{11} (PSB(S1)+PSB(S2)+20Kg P_2O_5 ha^{-1})	10.93	22.33	5.33	2.35	4.87	21.94	843.42	2481.38
T_{12} (PSB(S1)+PSB(S2)+30Kg P_2O_5 ha^{-1})	11.80	24.07	6.6	2.43	5.45	23.16	902.06	2713.36
T_{13} (PSB(S1)+PSB(S2)+40Kg P_2O_5 ha^{-1})	13.20	26.53	7	2.59	5.96	24.05	959.34	2860.87
SEm±	1.04	1.29	0.21	0.10	0.18	1.09	31.37	48.48
CD (p=0.05)	3.03	3.77	0.63	0.28	0.52	3.18	91.55	141.51

microorganisms may have caused the increased plant height (Dubey, 1996 and Dey *et al.*, 2004). Dry matter accumulation increased markedly with dual inoculation of PSB (S1) and PSB (S2) under the medium level of fertility. This influence of treatment may be attributed to higher microbial population favoring more N contents (%) and its association with increased chlorophyll formation due to *Rhizobium* inoculation and increased phosphatase activity (that increased phosphorus supply to plants) and the beneficial effects of production of growth regulators due to PSB inoculation. The similar reasons were also proposed by Prasad and Ram (1984) and Tarafdar *et al.,* (1992).

Similarly this work is also confirm with (Prasad *et al.,* 2014) the result that the effect of rhizobium inoculations and phosphorus levels had significant influence on growth and yield attributing characters and consequently the significant increased yield.

The maximum number of branches plant^{-1} was recorded with application of 40 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) remained at par with 40 kg P_2O_5 ha^{-1} + PSB (S2) and 40 kg P_2O_5 ha^{-1} + PSB (S1) at 40 DAS and at harvest but significantly superior over the control with 20 kg P_2O_5 ha^{-1}, 30 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} + PSB (S1) at all the dates of observation (Table 1). Application of 40 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) remained at par with of 40 kg P_2O_5 ha^{-1} + PSB (S2) and 30 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) while produced significantly higher number of root nodules plant^{-1} over control 56.06 and 57.02 per cent at 20 and 40 DAS respectively (Table 2). The root nodules plant^{-1} was observed significantly enhanced with the medium and higher fertility levels under dual inoculation of PSB (S1) and PSB (S2) as compared to their uninoculation during all the observation periods. It was due to higher number of bacteria present under inoculated condition than uninoculated plots. PSB inoculation showed more available phosphorus in soil, which favored better root growth and resulted in a beneficial effect of nodulation and increased PSB bacterial activity. The results were in close conformity with the observations recorded by Tarafdar *et al.,* (1992).

Yield

The seed inoculation with PSB (S1) + PSB (S2) under the application of 40 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) recorded the maximum grain and straw yield at par with 40 kg P_2O_5 ha^{-1} either under PSB (S2), 40 kg P_2O_5 ha^{-1} + PSB (S1) and 30 kg P_2O_5 ha^{-1} + PSB (S1) + PSB (S2) which was significantly higher over rest treatment combination. With increase in dry matter and photosynthetic products, coupled with efficient translocation, plant produced more pods plant^{-1} with more number of grains pods^{-1}. The significant increase in grain and straw yields appeared to be on account of the beneficial effects of nitrogen, phosphorus and sulphur under dual inoculation of *Rhizobium* and PSB on growth and yield attributes which finally reflected in higher yield of green gram. Phosphate Solubilizing Bacteria (PSB) in solubilizing fixed form of soil P and making it available to plants is very well known. These bacteria have been shown to enhance the growth, increase the yield when applied to crop plants Gaind and Gaur (1991) and Abd-Alla (1994). Inoculation of seed with PSB culture increase the production and productivity of mungbean crops as reported by Shrivastava and Ahlawat (1995).

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