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Effect of phosphorus and PSB on yield attributes, quality and economics of summer greengram (*Vigna radiata* L.)

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Abstract
A field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (Uttar Pradesh) during the *zaid* season of 2016. The experiment comprised of nine treatments *viz.* T_1 : Control, T_2 : 20 kg $P_2O_5ha^{-1}$, T_3 : 40 kg $P_2O_5ha^{-1}$,T_4 : 60 kg $P_2O_5ha^{-1}$,T_5 : 80 kg $P_2O_5ha^{-1}$,T_6 : 20 kg $P_2O_5ha^{-1}$+ PSB,T_7 : 40 kg $P_2O_5ha^{-1}$ + PSB,T_8 : 60 kg $P_2O_5ha^{-1}$ + PSB,T_9 : 80 kg $P_2O_5ha^{-1}$ + PSB tested in Randomized Block Design and replication three times. The basic information, on the physico-chemical properties of the soil indicated that the soil of the experimental field was classified as silty loam which was low in organic carbon, nitrogen and phosphorus and medium in potassium. The crop recorded normal recommended cultural practices and plant protection measures. Results revealed that all the growth, yield attributes and quality increased significantly under the integrated treatment (80 kg $P_2O_5ha^{-1}$ + PSB). The growth characters *viz.*, plant height, leaf area index, dry matter accumulation and number of branches plant^{-1} and yield attributes like number of pod plant^{-1}, number of grain pod^1, 1000 - seed weight (g), biological yield, seed yield, stover yield (q ha^{-1}), harvest index (%) and NPK uptake of mung crop. On the basis of economics of different treatment, the maximum gross returns (Rs. 72371.00 ha^{-1}), net returns (Rs. 50873.00 ha^{-1}) and B: C ratio (2.37) was recorded under treatment (P + PSB) for mung crop.

Keywords: phosphorus, attributes, greengram, economics

Introduction
Pulse crops are important source of dietary and calories in food and feed products throughout the world. The production of pulses is not sufficient to ensure per capita per day availability of 80 g, which is the minimum requirement recommended by the World Health Organization (WHO) and FAO. In fact, the availability of pulses declined from >70g in mid- fifties to >35g in 1990's (Singh, 1994).

Pulses are important in agriculture system because their multiple role in dry farming which is well recognized, due to its availability to tap moisture from deeper layers of the soil by virtue of deep penetrating root system. The crop also posses unique quality of fixing atmospheric nitrogen with the help of symbiotic bacteria (Rhizobia) present in their root nodules. The fact that Pulses not only provide high nutritive value to our food and rich feed for cattle but also in some parts of the word (Middle East and West America) due to its religious preference and discourage meat production and consumption. The pulses makes diet balanced by supplying minerals and vitamins besides providing proteins as well as an abundance of food energy (Sajatia, 1997).

In our country the major area of pulses are under rainfed conditions. So that the production figures are often fluctuating because of changing environment. For example the production of pulses increased from 8.4 million tonnes in 1950-51 to 12.7 million tonnes in next decade but it dropped again to only 10.9 million in 1987-88. The production has exceeded 13 million tonnes after 1988 and productivity has increased over 10 % as compared to previous year. Annual production with an average yield of 576 kg ha^{-1} of pulses in India was 14.5 million tonnes and has the distinction of being world's largest producer of grain legumes.

It has been estimated that the Indian demand of total pulses would be around 30.3 MT by 2020 AD on the basis of food characteristics demand system, the demand projections for pulses for the years 2005 and 2010 are 20.0 and to 23.3 Mt, respectively (Chaturvedi and Ali. 2002).

Mungbean or greengram (*Vigna radiata L.*) is one of the important edible pulse crop. It belongs to family Papilionacea. It is the third important pulse crop cultivated throughout India (after chickpea and pigeon pea) for its multipurpose uses as vegetable, pulse, fodder and green manure crop. It contains protein, carbohydrates fat and fibres in the range of 21-25%, 60-65%, 1-1.5% and 3.5-4.5% respectively. Its seed is more palatable, nutritive, digestible and non-

non-flatulent than other pulses grown in country. It occupies as good position due to its high seed protein content and ability to store the soil fertility through symbiotic nitrogen fixation.

Among Pulses Mungbean (*Vigna radiata* (L.) Wilczek) is one of the most important crop in India as it is grown both in summer, as well as rainy season. In India mungbean is grown on 3.38 m ha with an average productivity of 474 kg ha^{-1} (Anonymous, 2001). In Uttar Pradesh mungbean is grown on 25.9 thousand ha with a productivity of 659 kg ha^{-1} (Anonymous 2014). The average yield of mungbean is quite low.

Mungbean grown in summer season gives better yield than grown in rainy season, as summer crop is almost free from infestation of insects, pest and diseases. Still productivity of summer mungbean is low for due to major constraint of nutrient availability.

Phosphorus helps in better nodulation and efficient functioning of nodule bacteria for fixation of N to be utilized by plants during grain- development stage, which in turn led to increase in green yield.

Plants acquire phosphorus from soil solution as phosphate and anion. It is the least mobile element in plant and soil contrary to other macronutrients. It precipitates in soil as orthophosphate or is adsorbed by Fe and AI oxides through legend exchange. Phosphorus solubilizing bacteria play important role in phosphorus nutrition by enhancing its availability to plants through release from inorganic and organic soil P pools by solubilization and mineralization. Principle mechanism in soil for mineral phosphate solubilization is lowering of soil pH by microbial production of organic acids and mineralization of organic Phosphorus by acid phosphatases. Use of phosphorus solubilizing bacteria as inoculants increases phosphorus uptake. These bacteria also increase prospects of using phosphatic rocks in crop production. Greater efficiency of phosphorus solubilizing bacteria has been shown through co-inoculation with other beneficial bacteria and mycorrhiza (Khan *et al*., 2009).

PSB inoculation: some heterotrophic bacteria and fungi have the ability to solubilizing inorganic phosphorus from insoluble sources, such as, tricalcium phosphate, ferric, aluminium and magnesium phosphate, rock phosphate and bone meal. Important phosphate solubilizing bacteria (PSB) are: *Pseudomonas striata, Bacillus polimixa, Aspergillus awamori, Penicillium digitatum* etc. Inoculation of seeds or seedlings with microphosbiofertilizers can provide 30 kg P_2O_5 per hectare equivalent of phosphorus applied at superphosphate (Gaur, 1990).

Keeping facts in view the present study entitled "Effect of phosphorus and PSB on growth, yield and quality of summer greengram (*Vigna radiata* L.)" will be under taken with the following objectives:

1. To study the effect of phosphorous, PSB on growth and yield of summer greengram.
2. To study the effect of phosphorous and PSB on quality of summer greengram.
3. To study the economics of various treatments.

Materials and Methods

The field experiment was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Faizabad (U.P.) during *Zaid* season of 2016. The experimental sites falls under sub-tropical zone in Indo-gangetic plains and lies between 26.47º North latitude, 82.12º East longitudes, at an altitude of about 113.0 meter from mean sea level. The soil of experimental field was low in available nitrogen (210 kg/ha) and organic carbon (0.42%), medium in available phosphorus (11.71 kg/ha) and high in potassium (216.80 kg/ha). The reaction of the soil was slightly alkaline. The total rainfall during course of experimentation was 12.10 mm in the month of May 2016. During the crop season, the maximum temperature was recorded 41.6^0C in the month of April 2016 while lowest minimum temperature was recorded 14.1^0C in the month of March 2016. The experiment was laid out in randomized block design with four phosphorus levels (20 kg P ha^{-1}, 40 kg P ha^{-1}, 60 kg P ha^{-1} and 80 kg P ha^{-1}). After receiving a pre-sowing irrigation the field was ploughed once with tractor drawn soil turning plough followed by subsequent two harrowing by cultivator. The fine seed bed was prepared by harrowing followed by planking. A uniform dose of 20 kg N and 40 kg K_2O h^{-1} in the form of urea and murate of potash along with Single super phosphate as per treatment was applied just before sowing in furrow 5 cm below seed. The greengram variety Narendra Mung -1 was sown using seed rate 25 kg ha^{-1} behind desi plough in furrow-spaced at 30cm on 10 March 2016. To have uniform plant population the thinning was done after complete germination (15DAS) to maintain the plant to plant distance of 8-10 cm. Three irrigations including pre sowing irrigation were applied as per need of the crop. Two weeding's were done after 25 and 45 days after sowing by manual. After making net plot harvesting was done manually when the plants turned yellowish brown in colour. The weight of total biological produce of each net plot was recorded after sun drying before threshing. The threshing was done by wooden sticks. The cleaned seed weight of each net plot was recorded. To obtain straw yield the grain yield was subtracted from the total biological yield.

Result and Discussion

Yield attributes

Pod length (cm), number of pods $plant^{-1}$, grains pod^{-1} and test weight (gm)

Yield attributes such as number of pods $plant^{-1}$, pod setting percentage, grains per pod, yield $plant^{-1}$ and 1000-grain weight increased significantly with increasing levels of phosphorus upto 80 kg P_2O_5 ha^{-1}. Phosphorus resulted in higher rate of dry matter accumulation as well as its translocation from sources to sink in the plants which ultimately reflected for higher values of yield attributing characters. This might be due to the increase in vegetative development and reproductive attributes under proper availability of phosphorus and better physical condition of soil. Application of treatments the increase in yield attributes were mainly due to increase photosynthetic activity of leaves. translocation of photosynthates from source to sink and nutrient uptake by the application of bio-fertilizer and phosphorus dose. The minimum values of all the attributes were observed under control plot because plants were unable to receive more nutrients. The results agreement with those of Prakash *et al*. (2002) [30]. Inoculation of Mungbean with PSB increased all the yield attributing characters of Mungbean. The maximum value of all these characters were observed in 80 kg P_2O_5+PSB and minimum values in the control it may be due to fact that the formation of root nodules and atmospheric nitrogen fixation, (Khan *et al*. 2004) reported that the inoculation of seed with PSB increased seed yield in Mungbean.

Yield

Grain yield and straw yield (q ha^{-1})

Application of phosphorus increased grain and straw yield significantly upo 60 kg P_2O_5 $_{ha}^{-1}$ though the maximum yields were obtained with 80 kg P_2O_5 ha^{-1}. Application of 80 kg P_2O_5 increased the grain yield by 12.25 over control. The increase in grain yield with P_2O_5application was due to (i) increase in source capacity viz., plant height, leaves plant^{-1}, branches plant $^{-1}$ and dry matter accumulation as well as sink capacity viz., pods plant^{-1}, grain number and size plant^{-1} (ii) better utilization of photosynthate towards sink. Increase in translocation might have happened due to increase in potassium and phosphorus uptake which are responsible for quick and easy translocation of the photosynthates from source to sink.

Harvest index

Increase in harvest index with phosphorus application is the indication of better translocation of photosynthates from source to sink. These results are in conformity with the findings of Pandey& Singh (2001) [1], Khan *et al*. (2004) also reported increased biological yield of Mungbean with increasing level of P. Various treatments did not reflect the harvest index (HI) significantly although it increased with increasing level of phosphorus alone as well as Similar results in their experiments.

Quality

Protein content

The protein content increased significantly with increasing doses of phosphorus upto 80 kg P_2O_5 ha^{-1}. Increase in protein content with increasing doses of phosphorus. These results are in conformity with those observed by Shahi (2002) [34] and Singh (2004) [39].

Nutrient uptake

Uptake of nutrients followed the patterns of dry matter production as the nutrient content was not influenced by phosphorus levels. Application of phosphorus accelerated the uptake of nutrients (N,P and K) significantly and higher values were recorded with highest levels of phosphorus 80 kg ha^{-1} followed by 60 kg ha^{-1}. It may be ascribed to (i) vigorous root growth which helped in more nutrient absorption (ii) to profuse shoot growth i.e. Higher dry matter production. The results are in agreement with those of Singh *et al.* 2008 [40]. Shahi *et al.* 2003.

Economics

The cost of cultivation, gross return and net return increased with increase in each level of phosphorus. Application of 80 kg P_2O_5 ha^{-1} + PSB recorded highest gross income of Rs. 72371 and net return of Rs. 50873. The net return Re^{-1} investment (B:C) increased uto 80 kg P_2O_5 ha^{-1} + PSB recoding highest values of Rs. 2.37. This was attributed to greater increase in grain and straw yield as compared to cost of cultivation with increasing levels of phosphorus. These results are in conformity with those observed by Mitra *et al.* (2006) [25] who reported increased benefit cost ration and net income with increasing levels of phosphorus.

Table 1: Plant stand at harvest, Pod length(cm), Number of Pods/plant, Grains/pod, Test weight (g) as influenced by the phosphorus and PSB**.**

Treatments	Plant stand at harvest	Pod length (cm)	Pods/plant	Grain/pod	Test weight(g)
T_1 : Control	9.87	6.50	25.20	5.80	37.80
T_2 : 20 kg $P_2O_5ha^{-1}$	10.58	7.20	29.00	6.30	39.10
T_3 : 40 kg $P_2O_5ha^{-1}$	10.70	7.80	31.50	6.80	39.80
T_4 : 60 kg $P_2O_5ha^{-1}$	10.81	8.00	34.90	7.50	40.10
T_5 : 80 kg $P_2O_5ha^{-1}$	11.21	8.10	36.70	7.80	40.20
T_6 : 20 kg $P_2O_5ha^{-1}$+ PSB	11.24	7.90	34.00	6.60	39.70
T_7 : 40 kg $P_2O_5ha^{-1}$ + PSB	11.35	8.00	36.30	7.80	40.50
T_8 : 60 kg $P_2O_5ha^{-1}$ + PSB	11.69	8.30	38.60	8.20	41.20
T_9 : 80 kg $P_2O_5ha^{-1}$ + PSB	11.90	8.40	40.60	8.40	41.40
SEm±	0.07	0.33	1.08	0.09	0.3
C.D. at 5%	0.21	0.71	3.25	0.27	0.9

Table 2: Grain yield (q/ha), Straw yield (q/ha) and harvest index as influenced by the phosphorus and PSB.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index
T_1 : Control	4.65	11.25	29.24
T_2 : 20 kg $P_2O_5ha^{-1}$	6.75	15.55	30.30
T_3 : 40 kg $P_2O_5ha^{-1}$	8.45	19.15	30.61
T_4 : 60 kg $P_2O_5ha^{-1}$	10.37	23.45	30.70
T_5 : 80 kg $P_2O_5ha^{-1}$	11.60	25.86	30.96
T_6 : 20 kg $P_2O_5ha^{-1}$+ PSB	7.93	17.57	30.35
T_7 : 40 kg $P_2O_5ha^{-1}$ + PSB	9.45	21.26	30.77
T_8 : 60 kg $P_2O_5ha^{-1}$ + PSB	11.78	26.45	30.81
T_9 : 80 kg $P_2O_5ha^{-1}$ + PSB	12.25	27.36	30.92
SEm±	0.35	1.06	1.23
C.D. at 5%	1.05	3.19	3.68

Table 3: Protein Content as influenced by the phosphorus and PSB.

Treatments	Protein content
T_1 : Control	19.18
T_2 : 20 kg $P_2O_5ha^{-1}$	21.56
T_3 : 40 kg $P_2O_5ha^{-1}$	22.25
T_4 : 60 kg $P_2O_5ha^{-1}$	22.37
T_5 : 80 kg $P_2O_5ha^{-1}$	22.56
T_6 : 20 kg $P_2O_5ha^{-1}$+ PSB	21.8
T_7 : 40 kg $P_2O_5ha^{-1}$ + PSB	22.86
T_8 : 60 kg $P_2O_5ha^{-1}$ + PSB	23.31
T_9 : 80 kg $P_2O_5ha^{-1}$ + PSB	23.43
SEm±	0.02
C.D. at 5%	0.07

Table 4: N.P.K uptake in grain and straw as influenced by the phosphorus and PSB

Treatments	Nitrogen			Phosphorus			Potassium		
	N up in grain	N up in straw	Total Uptake N	P up in grain	P up in straw	Total uptake P	K up in grain	K up in straw	Total Uptake K
T_1 : Control	14.27	11.73	26	2.51	5.28	7.79	3.53	14.57	18.1
T_2 : 20 kg $P_2O_5ha^{-1}$	23.28	18.66	41.94	4.18	9.64	13.82	7	26.43	33.43
T_3 : 40 kg $P_2O_5ha^{-1}$	31.50	26.68	58.18	5.66	13.34	19	9.6	35.86	45.46
T_4 : 60 kg $P_2O_5ha^{-1}$	37.12	33.08	70.2	6.84	16.79	23.63	11.4	44.53	55.93
T_5 : 80 kg $P_2O_5ha^{-1}$	41.87	47.04	88.91	7.77	21.01	28.78	12.9	56.13	69.09
T_6 : 20 kg $P_2O_5ha^{-1}$+ PSB	27.67	33.27	60.94	5.47	14.9	20.37	8.9	38.91	47.81
T_7 : 40 kg $P_2O_5ha^{-1}$ + PSB	33.35	41.39	74.74	6.61	17.88	24.49	11.15	46.75	57.9
T_8 : 60 kg $P_2O_5ha^{-1}$ + PSB	43.93	53.75	97.68	8.36	23.13	31.49	14.25	60.27	74.52
T_9 : 80 kg $P_2O_5ha^{-1}$ + PSB	45.93	57.55	103.48	8.82	24.09	32.91	14.94	62.57	77.51
SEm±	1.44	1.71	3.12	0.29	0.52	1.13	0.45	2.00	2.32
C.D. at 5%	4.33	5.12	9.35	0.87	1.56	3.39	1.34	5.98	6.96

Table 5: Economics of various treatment combination

Treatments	Total cost of cultivation	Gross Return (Rs.)	Net Return (Rs.)	B:C
T_1 : Control	17650	26741	9091	0.52
T_2 : 20 kg $P_2O_5ha^{-1}$	18607	39156	20549	1.10
T_3 : 40 kg $P_2O_5ha^{-1}$	19563	51454	31891	1.63
T_4 : 60 kg $P_2O_5ha^{-1}$	20521	60546	40025	1.95
T_5 : 80 kg $P_2O_5ha^{-1}$	21478	68450	46972	2.19
T_6 : 20 kg $P_2O_5ha^{-1}$+ PSB	18627	46839	28212	1.51
T_7 : 40 kg $P_2O_5ha^{-1}$ + PSB	19583	55764	36181	1.85
T_8 : 60 kg $P_2O_5ha^{-1}$ + PSB	20541	69696	49155	2.39
T_9 : 80 kg $P_2O_5ha^{-1}$ + PSB	21498	72371	50873	2.37

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