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EFFECT OF PHOSPHORUS, PSB AND VERMICOMPOST ON GROWTH AND YIELD OF MUNGBEAN (*VIGNA RADIATA L.*)

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ABSTRACT

The Bundelkhand is known as the Pulse bowl of Uttar Pradesh as it is covered by large acreage of cultivation and among the pulses, the Mungbean is occupied the vast acreage and considerable production. However, the cultivation of the Mungbean crop is entirely dependent on the availability of farmers' variety (local) and poor & residual resourced conditions (soil moisture and fertility). Nowadays, farmers tend that the reliance on synthetic fertilizers is necessary for higher yields and often the chief source of plant nutrients. Therefore, the increase in biomass productivity in Mungbean at present is often related to the use of chemical fertilizers in geometric rates along with other ways and means of nutrient management. This research is, therefore, taken into account to evaluate the response of phosphorus, PSB, and vermicompost on the growth and yield of Mungbean. Results of a field experiment conducted at BUAT Banda, Uttar Pradesh, India during Kharif season, 2019 reveals that the basal applications of 125 kg DAP and 5 t Vermicompost (VC) per hectare and seed treated by Phosphate Solubilizing Bacteria (PSB) gave the better growth that reflected in terms of the maximum values of growth-characters studied. However, sowing of treated seed by PSB and applied 75 kg DAP and 5 t VC per hectare before sowing directed a significant increase in yield and gave by 22.57% more yield advantage than the farmers' practice.

Keywords: Growth, Mungbean, Phosphorus, Phosphate Solubilizing Bacteria, Yield, and Vermicompost

INTRODUCTION

Pulses are grown in more than 100 countries covering an area of more than 95.72 mha with more than 92.28 mt annual productions and the productivity is lying around 964 kg ha^{-1} (FAO, Stat. 2018). During the year, 2017–18, the total pulse production in India was 18.84 mt from the area of 25.28 mha with average productivity of 745 kg ha^{-1} (Agricultural Statistics at a Glance, 2018).

Mungbean (*Vigna radiata* L.) is the foremost pulse crop and is grown extensively in India in general and Bundelkhand (Uttar Pradesh) in particular. It provides high-quality protein (25%), carbohydrates (60%), fat (1.4%), and vitamin A. Mungbean is primarily a rainy season crop but with the development of early maturing varieties, it has proved to be an ideal crop for spring and summer (*Chaudhary et al, 2010*) under various soils and climatic conditions (*Kumawat et al, 2009*). In India, the predominant growing states for Mungbean are Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan, and Bihar. Altogether, it occupies 3.4 m ha of the area with a total production of 1.53 mt and average productivity of 461 kg ha^{-1} (*Tiwari and Shivhare, 2016*). Mungbean is a hardy crop and thrives well under drought-prone areas and the Bundelkhand suits well to this very crop as it frequently coincides with prolonged dry-spells during the rainy season. In Bundelkhand, crop cultivation is done traditionally and without considering the scientific recommendations.

The Mungbean growers have the dint that the reliance on chemical fertilizers is necessary for higher yields. Synthetic (chemical) fertilizers are the chief source of plant nutrients but their constant and imprudent use posing health and environmental complications. Consequently, it is imperious to determine substitutes to reduce the use of chemical fertilizers applied to Mungbean crops and improve the efficiency of applied fertilizers without causing risks of environmental pollution. Nowadays, the shortage of some other nutrients has become a major concern due to the over-exploitation of natural resources and the high use of chemical fertilizers. It is, therefore, desirable to adopt an integrated approach in meeting the nutrient demand of the crop beside it partly addresses the current burning problems too. Thus, efficient utilization of existing land and available resources (nutrients) besides the practical application of organic and mineral fertilizers helps in attaining yield sustainability in Mungbean and the system's productivity too.

The leguminous crops required more phosphorus and phosphorus is essential for energy transformation in nodules. The soils of Bundelkhand are frequently deficient in phosphorus that restricts biological nitrogen fixation (BNF) in the leguminous crop. Vermicompost is a rich source of major and minor nutrients and adds organic carbon to the soil. It is also rich in growth hormones, vitamins, and acts as a powerful biocide against diseases and nematodes. The poor nutrient economy of lighttextured soils necessitates the need for supplementing fertilizer with organic manures. Bio-fertilizers are other organic sources that play an important role in meeting the nutrient requirements of crops through biological nitrogen fixation (BNF), solubilization of insoluble phosphorus sources, stimulating plant growth, and accelerating the decomposition of plant residues. Inoculation of seeds with phosphate-solubilizing bacteria (PSB) increases nodulation, crop growth, nutrient availability, their uptake, and crop yield of field pea (Srivastava and Ahlawat, 1993). Thus, integrated use of organic manures, chemical fertilizers, and bio-fertilizers and their efficient management has been found effective. Phosphorus, PSB, and vermicompost are found to play a very important role in boosting the growth and yield of legume crops. This approach involves the application of chemical fertilizers, organic sources, and bio-fertilizers to bridge the gap between nutrient demand and supply to improve the grain yield. This research is, therefore, taken into account to evaluate the response of phosphorus, *PSB*, and vermicompost on the growth and yield of the Mungbean crop.

MATERIALS AND METHODS

To evaluate the response of phosphorus, *phosphate solubilizing bacteria (PSB)*, and vermicompost on growth and yield of Mungbean crop**,** the present investigation was conducted during the Kharif, 2019 at Agriculture Farm of Banda University of Agriculture and Technology, Banda (U.P). The farm is situated between Latitudes 24º 53′ and 25º 55′ N and Longitudes 80º 07′ and 81º 34′ E and having an altitude of 168m above sea level. Banda's climate is classified as warm and semi-arid.

The experiment was conducted in randomized complete block design with 16 treatments viz., T_1: Farmer's Practices (FYM -5t + 50 kg DAP); T_2: 75 kg dia ammonium phosphate (DAP); T_3: 100 kg DAP; T_4: 125 kg DAP; T_5: *Phosphate Solubilizing Bacteria* (*PSB*); T_6: 75kg DAP + *PSB*; T_7: 100 kg DAP + *PSB*; T_8: 125 kg DAP + *PSB*; T_9**:** Vermicompost (VC)-5t; T_{10}: 75 kg DAP + VC- 5t; T_{11}:100 kg DAP + VC-5t; T_{12}**:**125 kg DAP + VC-5t; T_{13}: *PSB* + VC-5t; T_{14}: 75 kg DAP + *PSB* + VC-5t; T_{15}: 100 kg DAP + *PSB* + VC-5t and T_{16}: 125 kg DAP + *PSB* + VC-5t) and three replications. The variety taken in the field study was *IPM 2-3*. All the treatments were applied on a hectare basis.

The observations were recorded matching the peak crop growth stages like plant height, branching, dry-matter production (DMP), leaf chlorophyll content, leaf area index (LAI), nodule count, anthesis, maturity, and at harvest to assess the crop growth impacts. Five observation plants were tagged and periodical observations were recorded from the same plants and expressed as the mean of five plants. However, the destructive samplings were done to record dry matter production.

RESULTS AND DISCUSSION

The data on growth characters viz., plant height; branches; dry matter production (DMP); chlorophyll content; leaf area index (LAI); nodule count, grain yield, biological yield, and yield increment/decrement in mungbean were recorded and summarized in the Table-1, 2, and 3.

Growth characters and yield

Plant height (cm) at harvest: Data on plant height shows that increasing application of DAP alone or accompanied with VC / PSB / VC + PSB correspondingly recorded taller plant height. However, T_{16} produced the tallest plant height, and though remained statistically at par with T_{15}, T_{14}, T_{12}, T_{11}, T_8, T_7, and T_4 but recorded significant superiority over the rest of the treatments during kharif 2019.

Branches plant^{-1}: It is obvious from the data denoting branches plant^{-1} that an increasing application of DAP alone or accompanied with VC / PSB / VC + PSB correspondingly increased the branches plant^{-1}. Treatments, T_8, T_{12}, T_{14}, T_{15}, and T_{16} though remained statistically at par. However, maximum branches plant^{-1} (6.44) was noted in T_{16} and also showed its significant superiority over the other treatment.

Dry matter accumulation (g) m^{-1} row length: At 30 DAS, data pertaining to dry matter accumulation revealed that increased dry matter accumulation was recorded with the application of increasing doses of either DAP alone or accompanied with VC / PSB / VC + PSB. Treatments, T_1, T_2, T_3, T_4, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}, and T_{14} did not touch the level of significance on dry matter production and therefore, T_{16} followed by T_{15} imparting significant variation over treatments mentioned earlier.

It is apparent from the data on DMA at 45 DAS, the highest DMA (96.4g) was observed when 125 kg DAP with VC+PSB applied though failed to cause notable variation over T_{15}, T_{14}, T_{12}, T_8, and T_4 but differed its remarkable variation over the rest of the treatments. At harvest, 116.7g DMA was observed in farmer's practice and it kept statistically on par with the application of DAP doses along with combinations of PSB and/or VC. However, T_1 produced markedly lesser DMA than the treatments, T_8, T_{12}, T_{14}, T_{15}, and T_{16} during the study.

Chlorophyll content (mg g^{-1}): At 30 DAS, it is obvious from the data summarized and is being presented in table-2 which itself reveals that the application of swelling doses of DAP alone or accompanied with VC / PSB / VC + PSB correspondingly increases the chlorophyll content. But, statistically, none of the treatments exert significant variation in chlorophyll content. However, a maximum of 2 mg g^{-1} chlorophyll content was recorded under T_{16} treatment followed by 1.93 mg g^{-1} under T_{15} treatment. At 45 DAS, data about chlorophyll content exist in the table are scrutinized which reveals that the application of 125 kg DAP along with VC + PSB gave the maximum 2.85 mg g^{-1} chlorophyll content followed by 1.93 mg g^{-1} by application of 100 kg DAP accompanied with VC + PSB. And it is also noted that none of the treatments exert its significant difference over others.

Leaf area index (LAI): At 30 DAS, scrutiny of data pertaining to LAI reveals that none of the treatment exerts its significant difference regarding LAI. However, the maximum (0.554) value of the leaf area index was recorded under application 125 kg DAP along with VC + PSB (T_{16}), and minimum (0.472) LAI was recorded in the treatment (T_5) where only PSB used. At 45 DAS, an increasing trend in data pertaining to LAI was recorded with the swelling dose of DAP alone or accompanied with VC / PSB / VC + PSB. A non-significant difference regarding LAI is observed. However, the maximum (2.309) LAI was recorded with the application 125 kg DAP along with VC + PSB (T_{16}).

Nodule count plant^{-1}: At 30 DAS, data reveals that increasing doses of DAP alone or accompanied with VC / PSB / VC + PSB correspondingly increases nodule count. Treatments, T_{16}, T_{15}, T_{14} and T_{12} though remained statistically at par. However, maximum nodule count was recorded under T_{16} and that was significantly superior over the rest of the treatments. At 45 DAS, it is obvious from the data that an increasing application dose of DAP alone or accompanied with VC / PSB / VC + PSB application correspondingly increases nodule count. However, T_{16} and T_{15} though remained statistically at par. However, the maximum nodule count was recorded with the application of 125 kg DAP along with PSB + VC (T_{16}) and also imparted significant superiority over the other treatments.

Economic yield (kg ha^{-1}): The perusal of data indicates that the highest response was recorded with the application of 75 kg DAP ha^{-1} along with VC + PSB. Though, the treatments, T_4, T_8, T_{12}, T_{14}, T_{15}, and T_{16} remained statistically equal among themselves. However, T_{14} responded significantly over other treatments, and 1291.58 kg ha^{-1} yield was recorded and that was highest among the treatments.

Biological yield (kg ha^{-1}): Scrutiny of data on biological yield reveals that the maximum value was recorded with the application of 125 kg DAP ha^{-1} accompanied with VC + PSB (T_{16}). Though the T_{12}, T_{14}, T_{15}, and T_{16} have remained at par and statistically insignificant differences were observed. However, T_{16} showed a significant response over other treatments.

Yield increment /decrement (%) over farmer's practice: The study of data on yield increment/decrement in the table reveals that the highest yield increment (22.57%) was recorded with the application of 75 kg DAP accompanied with VC + PSB (T_{14})

Discussion

Results on plant height, branches plant^{-1}, dry matter accumulation m^{-1} row length, and nodule count reveals that the maximum values were noted with the application of 125 kg DAP + VC + PSB (T_{16}) and proved a significant upsurge in major growth characters. The synergistic effect of phosphorus, vermicompost, and PSB application might have enhanced root activities and root nodulation of plants resulting in higher uptake of plant nutrients in adequate quantities and thereby increasing the vegetative growth of the crop. Phosphorus has long been considering an essential element of all living organisms, which plays a crucial role in the conservation and transfer of energy in metabolic reactions of living cells including biological energy transformations (*Rajaq et al., 2017*). Phosphorus plays not only key role in root development and proliferation but also improves nodulation and N fixation by supplying assimilates to the roots. It is the chief constituent of co-enzymes, ATP, and ADP which act as "energy currency" within plants. Almost every metabolic reaction of any significance proceeds via phosphate derivatives. Thus, phosphorus influenced photosynthesis, biosynthesis of protein and phospholipids, nucleic acid synthesis, membrane transport, and cytoplasmic streaming (*Vance et al., 2003*). Vermicompost not only supplies nutrients to plants but also, adds organic matter to the soil that is the food for microorganisms. Whereas, PSB makes the available insoluble form of phosphorus to plants by their solubilizing and mobilizing effects. The combined use of DAP, phosphate solubilizing microorganisms, and vermicompost altered the rhizosphere population affecting positively the plant growth. Phosphorus is known to influence the rate of photosynthesis favorably since it is directly involved in increase energy transfer reaction and essential for nitrogen-fixing bacteria. Thus, the combined use of DAP accompanied with VC + PSB improved phosphorus nutrition coupled with greater N-fixation could have contributed to better plant growth.

Data on yield has recorded the maximum with the 75 kg DAP + VC + PSB (T_{14}) and it showed a significant difference over the rest of the treatments. However, a further increase in the dose of DAP increased the vegetative growth resultant higher biological yield was recorded. Application of 75 kg DAP + VC + PSB (T_{14}) delivered adequate nutrients which provide dynamic adjustment to the crop in terms of temporal and spatial arrangement which led to harvest enhanced solar radiation which ultimately aggravated more production of photosynthesis at the source and translocated from the source to sink (Partitioning of dry matter), thereby, higher grain yield was recorded. However, Maximum biological yield was recorded with the application of 125 kg DAP + VC + PSB (T_{16}). It might be due to heavy nutrition and luxury consumption of nutrients resultant vigorous vegetative growth was occurred and leaving undeveloped sink areas. Moreover, applications of 75 kg DAP + VC + PSB (T_{14}) also gave the maximum yield advantage (22.57) over the farmer practice. The applications of 75 kg DAP + VC + PSB (T_{14}) showed significant superiority over the rest of the treatments for grain yield.

The findings of the present study are well supported by *Dhakal et al., (2016)* who also reported that a significant improvement in straw yield, biological yield and harvest index was observed with 75% RDF + 2.5 t ha^{-1} VC + *Rhizobium + PSB. Singh et al., (2017)* found that the application of RDF + VC 5 t ha^{-1} registered maximum yield attributes. They also reported that the Mungbean produced maximum response with biofertilizer + Mo 1.0 +Co 1.0 kg ha^{-1} in respect to growth, yield attributes, nodule number, nodule weight and 41.2% higher grain yield, *Karnavat et*

Table- 1: Plant height, Branches Plant and Dry matter accumulation as influenced by treatment variables

Treatments	Plant height (cm) at harvest	Branches Plant^{-1}	Dry matter accumulation (g) m^{-1} row length at 30	Dry matter accumulation (g) m^{-1} row length at 45	Dry matter accumulation (g) m^{-1} row length at harvest
T_1	58.67	4.44	61.25	84.67	116.72
T_2	58.33	4.22	61.11	84.25	116.48
T_3	59.00	4.52	62.00	85.08	119.17
T_4	60.83	5.44	64.17	89.00	126.01
T_5	56.00	3.56	58.56	80.92	112.77
T_6	59.17	4.67	62.50	86.50	120.51
T_7	59.50	5.11	63.19	87.75	122.96
T_8	62.17	5.78	64.86	89.67	128.58
T_9	56.83	3.89	60.42	81.00	114.28
T_{10}	59.33	4.89	63.19	86.58	122.83
T_{11}	60.67	5.22	63.47	87.92	125.03
T_{12}	62.00	5.89	64.89	90.08	128.70
T_{13}	58.00	4.00	60.97	82.25	115.87
T_{14}	63.33	6.11	66.94	91.75	133.22
T_{15}	63.67	6.22	68.36	92.00	137.38
T_{16}	64.00	6.44	72.67	96.42	140.19
SEM	1.62	0.24	2.21	2.83	4.04
C.D.(0.05)	4.67	0.71	6.39	8.17	11.68
CV (%)	4.66	8.42	6.02	5.62	5.66

Table- 2: Effect of treatment on chlorophyll content, leaf area index and nodule count of mungbean crop

Treatments	Chlorophyll content (mg g-1) at 30 DAS	Chlorophyll content (mg g-1) at 45 DAS	Leaf area index at 30	Leaf area index at 45	Nodule count at 30 DAS Plant-1	Nodule count at 45 DAS Plant-1
T_1	1.66	2.50	0.503	2.050	54.44	39.00
T_2	1.63	2.49	0.501	2.027	53.22	37.22
T_3	1.73	2.50	0.508	2.054	55.33	40.33
T_4	1.80	2.58	0.523	2.116	69.00	45.89
T_5	1.55	2.40	0.472	1.939	39.78	23.67
T_6	1.74	2.53	0.509	2.060	59.11	42.89
T_7	1.77	2.55	0.514	2.083	62.00	43.89
T_8	1.85	2.65	0.527	2.123	70.33	46.33
T_9	1.56	2.45	0.493	1.987	43.44	26.22
T_{10}	1.75	2.54	0.509	2.074	60.11	43.45
T_{11}	1.78	2.56	0.521	2.108	63.44	44.67
T_{12}	1.87	2.67	0.536	2.151	73.67	49.55
T_{13}	1.61	2.49	0.497	2.012	49.89	36.67
T_{14}	1.89	2.68	0.545	2.194	79.00	51.00
T_{15}	1.93	2.79	0.553	2.275	81.67	53.67
T_{16}	2.00	2.85	0.554	2.309	84.78	57.78
SEM	0.11	0.16	0.031	0.097	4.17	2.29
C.D.(0.05)	NS	NS	NS	NS	12.05	6.61
CV (%)	10.57	10.66	10.486	7.999	11.57	9.30

Table 3: Grain and biological yield of mungbean as affected by treatments

Treatments	Economic yield (kg ha-1)	Biological yield (kg ha-1)	Yield Increment /Decrement (%) over Farmer Practice
T_1	1053.72	3193.33	0.00
T_2	1052.40	3176.67	-0.13
T_3	1085.32	3250.00	3.00
T_4	1187.75	3526.67	12.72
T_5	897.83	3033.33	-14.79
T_6	1112.78	3326.67	5.60
T_7	1129.03	3353.33	7.15
T_8	1186.05	3536.67	12.56
T_9	927.05	3116.67	-12.02
T_{10}	1126.97	3350.00	6.95
T_{11}	1151.44	3420.00	9.27
T_{12}	1194.71	3560.00	13.38
T_{13}	962.32	3160.00	-8.67
T_{14}	1291.58	3663.33	22.57
T_{15}	1258.71	3796.67	19.45
T_{16}	1264.92	3953.33	20.04
SEM	43.82	142.91	
C.D.(0.05)	126.56	412.76	
CV (%)	6.79	7.28	

al., (2017) found that the application of 10 t FYM ha^{-1} gave maximum values of all the yield attributes of green gram. Application of 40 kg P ha^{-1} + *PSB* resulted in significant increase in all attributes over *PSB* only, *Venkatarao et al., (2017)* found that application 40 kg P ha^{-1} recorded the highest grain yield and straw yield. Results further indicated that seed inoculation with the *PSB* and *Aspergillus awamori* significantly increased the highest number of the total and effective number of nodules $plant^{-1}$, plant height, leaf area index, total chlorophyll content, grain yield and straw yield over the rest of the treatments. Muhammad *et al., (2016)* reported that application of vermicompost (2 t ha^{-1}) with a full dose of phosphorus (75 kg P ha^{-1}) fertilization markedly influenced the yield over control in mung bean. The economically significant yield was observed from the treatment where a half dose of fertilizer (37.5 kg P ha^{-1}) with 2 t ha^{-1} vermicompost over control, and *Yadav et al., (2017)* reported that the higher number of seeds pod^{-1} and test weight in Summer mungbean with the application of 40 kg P and PSB + *Aspergillus awamori*. Among the interactions of phosphorus and bio-inoculants, application of 40 kg P and PSB + *Aspergillus awamori*, recorded significantly higher seed yield and straw yield and the treatment combination 40 kg P2O5 + *A. awamori* and 40 kg P + *PSB* found at par with each other.

CONCLUSION

Basal application of 57.50 kg phosphorus (125 kg DAP) + VC + PSB (T_{16}) resulted in a significant increase in growth characters. Application of 34.5 kg phosphorus (75 kg DAP) + VC + PSB (T_{14}) delivered the highest grain yield and more yield advantage (22.57%) over the farmer's practice. However, the application of higher doses of DAP with VC and PSB gave luxuriant growth to the crop rather than increased yield. The maximum biological yield was recorded with the application of 57.50 Kg phosphorus (125 kg DAP) + VC + PSB (T_{16}).

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