



# **Yield Attributing Characters and Yield of Mungbean Crop as Affected by Phosphorus, PSB, and Vermicompost**

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## **Authors' contributions**

*This work was carried out in collaboration among all the authors. Author Shamsurahman designed and conducted the study, performed the statistical analysis. Author SBS wrote the protocol and the first draft of the manuscript, supervised and monitored whole study and author AKS edited the manuscript. Authors JKT and VKS assisted in supervision and writing and editing. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Pulses cover a vast area of the Bundelkhand (UP) and Mungbean is prominent among the pulse crops and it is grown on a larger scale using local varieties entirely in dryland conditions and on residual soil moisture and fertility. In Bundelkhand, farmers grow the crops traditionally and without considering the scientific recommendations. Inorganic fertilizers (synthetic) are an important source of plant nutrients but their continuous and injudicious use posing health and environmental complications. Minimum use of inorganic sources of nutrients and rely on integrated nutrient management is the way to tackle the health and environmental issues due to imbalance and excessive use of inorganic nutrients. Phosphorus, PSB and vermicompost are found to play very important role in boosting the yield of legume crops. This research is, therefore, taken into account to evaluate the response of Mungbean crop to phosphorus, PSB, and vermicompost. The leguminous crops require more phosphorus as it is required for energy transformation in nodules. Phosphate solubilizing bacteria (PSB) is assumed to have greater significance because it helps to

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convert insoluble organic phosphates into simple and soluble forms. Vermicompost is a better and rich source of N, P, K, and micronutrients. Besides, containing a good proportion of exchangeable Ca, Mg, Na, etc., vermicompost enhances organic carbon to the soil and meagerly helps to release of nutrients and in turn uptake is improved. A field experiment was performed during Kharif season, 2019 at Agriculture Farm of Banda University of Agriculture and Technology Banda, Uttar Pradesh, India. Results of the study reveals that the basal applications of 75 kg DAP, 5 t Vermicompost (VC) ha<sup>-1</sup> and seed treated by Phosphate Solubilizing Bacteria (PSB) led to a significant increase in yield attributing characters and yield and gave by 22.57% more yield advantage than 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.

**Keywords:** Mungbean; phosphorus; PSB; vermicompost.

## 1. INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is the foremost crop and grown extensively in India. It is a source of high-quality protein (25%), carbohydrates (60%), fat (1.4%), and rich in vitamin A. Mungbean is consumed in various ways in homes and used as cattle feed. It is also used as green manure crops. It 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 [1]. The important mungbean-growing states are Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan, and Bihar. It can be grown under various soils and climatic conditions [2]. In India, it occupies 3.4-million-hectare area of mung bean with a production of 1.53 million tons and productivity 461 kg ha<sup>-1</sup> that are the average of 2012–13 to 2015–16 [3]. Pulses are hard to drought and play a pivotal role in checking soil erosion owing to their anchorage of deep roots, offer better ground cover, and enrich the soils by fixing the atmospheric nitrogen, having these characters; pulses are called as "Marvel of Nature" [4]. Shifting in crop preferences by farming community has been spotting since the 1990s. The farming community of the Indo Gangetic region was growing pulse formerly but now they are growing wheat crop ensuring high sustainable yield compared to pulses.

Over the past two decades, the production of pulses has largely shifted from the northern parts of India to the central and southern parts of India. Today, 80% of the total pulse production is realized in six states, namely, Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka and Uttar Pradesh [3]. The insufficient supply of pulses, to that of total demand force, the government to bridge the gap of demand-supply, which is met by imports. The pressure on

prices is due to lower domestic availability of these commodities, and thus, the focus should be on managing their supplies through increased production or imports, depending upon India's comparative advantage. Pulses are grown more than 100 countries covering an area of more than 95.72 million-hectare with more than 92.28 million tons annual production and the productivity is 964 kg ha<sup>-1</sup> [5]. The total pulse production in India during 2017–18 was 18.84 million tons from an area of 25.28 million-hectare with the average productivity of 745 kg ha<sup>-1</sup> [6].

In Bundelkhand, farmers grow the crops traditionally and without considering the scientific recommendations. Inorganic fertilizers (synthetic) are an important source of plant nutrients but their continuous and injudicious use posing health and environmental complications. Minimum use of inorganic sources of nutrients and rely on integrated nutrient management is the way to tackle the health and environmental issues due to imbalance and excessive use of inorganic nutrients. Phosphorus, PSB and vermicompost are found to play very important role in boosting the yield of legume crops.

The integrated use of organic manures, chemical fertilizers, bio-fertilizers and their efficient management has found effective in increasing productivity and also in improving the soil health and bring sustainability in system productivity. This research is, therefore, taken into consideration. The chemical fertilizers, no doubt, are the main source that can meet the nutrient requirement but their imbalance and continuous use lead to environmental pollution and deterioration of soil health. Moreover, the availability of fertilizer at economic prices is another problem for farmers. The leguminous crops require more phosphorus as it is required for energy transformation in nodules. Besides,

phosphorus plays a key role in root development, nutrient uptake, and growth of legume crops. However, most of the soils have inadequate amounts of phosphorus (least available to plant) to supply efficient biological nitrogen fixation (*BNF*). Vermicompost is a rich source of N, P, K, and micronutrients. Besides, containing a good proportion of exchangeable Ca, Mg, Na, etc., it adds organic carbon to the soil and helps to slow release of plant nutrients. In vermicompost, some of the secretions of worms and associated microbes act as growth promoters. It is also rich in growth hormones, vitamins, and acts as a powerful biocide against diseases and nematodes besides improving the physical condition of the soil. The poor nutrient economy of light-textured soils necessitates the need for supplementing fertilizer with organic manures. Bio-fertilizers are other 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 [7].

## 2. MATERIALS AND METHODS

To evaluate the response of phosphorus, *PSB*, and vermicompost on growth characters and yield of Mungbean crop, this investigation was conducted during the Kharif, 2019 at Agriculture Farm of Banda University of Agriculture and Technology, Banda (U.P).

### 2.1 Experimental Site

The farm is situated between Latitudes 24° 53' and 25° 55' N and Longitudes 80° 07' and 81° 34' E and having an altitude of 168 m above sea level. Banda's climate is classified as warm and semi-arid. The soil of experimental field was silty clay (Inceptisols) shallow, flat, well drained and moderately fertile, being low in available organic carbon, phosphorus and high in potassium and sulphur. A composite sample from each plot, 0-30 cm of soil depth, was collected and analyzed before sowing.

### 2.2 Experimental Treatments Details

The experiment was conducted in randomized complete block design with 16 treatments

viz., T<sub>1</sub>: Farmer's Practices (FYM -5t + 50 kg DAP); T<sub>2</sub>: 75 kg DAP; T<sub>3</sub>: 100 kg DAP; T<sub>4</sub>: 125 kg DAP; T<sub>5</sub>: *PSB*; T<sub>6</sub>: 75 kg DAP + *PSB*; T<sub>7</sub>: 100 kg DAP + *PSB*; T<sub>8</sub>: 125 kg DAP + *PSB*; T<sub>9</sub>: VC-5t; T<sub>10</sub>: 75 kg DAP + VC- 5t; T<sub>11</sub>:100 kg DAP + VC-5t; T<sub>12</sub>:125 kg DAP + VC-5t; T<sub>13</sub>: *PSB* + VC-5t; T<sub>14</sub>: 75 kg DAP + *PSB* + VC-5t; T<sub>15</sub>: 100 kg DAP + *PSB* + VC-5t and T<sub>16</sub>: 125 kg DAP + *PSB* + VC-5t) and replicated thrice. All the treatments inputs are applied on hectare basis. The notations of treatments can be read as Farmyard manure (FYM), Diammonium phosphate (DAP), Phosphate solubilizing bacteria (*PSB*), and Vermicompost (VC).

The manure used in the study was either prepared or procured from nearby FYM hub. The manure was duly analyzed in laboratory and their content is furnished herewith, FYM had 0.52% N, 0.14% P, 0.49% K and 13.63% Moisture and vermicompost was having 1.6% N, 0.85% P, 1.15% K and 15.78% Moisture, respectively. However, the vermicompost was prepared at University farm in vermicombed. Partial decomposed organic material i.e. chopped crop residue was used as raw materials alongwith cow dung slurry and it filled in vermicombed. Water was sprinkled as and when needed to maintain the moisture in vermicombed and the filled materials were left for one week. A week later, material was churned and rubbed and worms (*Eisenia foetida*) were released in the vermicombed. Vermicombed was covered with jute bags. Sufficient moisture was maintained at all the times for proper functioning of worms and to check overheating. Vermicombed was covered with a thatch roof to provide shade and protect from rain over it. Care had been taken to check the entry of ants, lizards, mouse, snakes, etc. All material had been converted in to the compost in 60 days. Material was taken out and worms were separated by using mesh.

### 2.3 Variety Characteristics

Mungbean variety IPM 2-3 taken for experimentation was developed at ICAR-Indian Institute of Pulses Research, Kalyanpur, Kanpur, U.P., India in 1999. This variety is widely acceptable by farmers of UP which are suitable for kharif and summer for its general cultivation. The maturity period varies from 64 to 73 days according to the prevailing environmental conditions at the maturity period. All the treatments were applied on a hectare basis.

## 2.4 Observations Recorded

### 2.4.1 Number of pods plant<sup>-1</sup>

Three plants randomly selected in each plot and those were used to record the number of pod plant<sup>-1</sup> at harvest and their average was worked out.

### 2.4.2 Number of seeds pod<sup>-1</sup>

Number of seeds pod<sup>-1</sup> was recorded at harvest by counting the number of seeds of ten randomly selected pods from each plot.

### 2.4.3 Length of pod (cm)

Length of pod was recorded by taking average of ten pods from each plot randomly.

### 2.4.4 Test weight (g)

One hundred (100) seeds were counted from the sample drawn randomly from the finally winnowed and cleaned produce of each plot and their weight was recorded so called test weight.

### 2.4.5 Biological yield (kg ha<sup>-1</sup>)

After complete sun drying, picked pods and harvested bundles of each net plot were weighed for biological yield and converted in terms of kg ha<sup>-1</sup>.

### 2.4.6 Seed yield (kg ha<sup>-1</sup>)

The total biomass of each plot was threshed, cleaned and the seeds so obtained were weighed and converted into kg ha<sup>-1</sup>.

### 2.4.7 Straw yield (kg ha<sup>-1</sup>)

Straw yield was calculated by subtracting the seed yield from biological yield (kg ha<sup>-1</sup>).

### 2.4.8 Harvest index (%)

Harvest index was computed by using the formula outlined by [8].

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

## 2.5 Statistical Analysis Applied

For statistical analysis "Analysis of variance" technique was applied to the data recorded for each character. Overall differences were tested by "F" test of significance at 5% level of

significance as suggested by Cochran and Cox [9]. Critical differences at 5% level of probability were worked out for comparing the treatments.

## 3. RESULTS

### 3.1 Yield Attributing Characters

Data on yield attributes viz., Pods plant<sup>-1</sup>, Grains pod<sup>-1</sup>, Length of pod, 100-Seed weight (g), and harvest index influenced by different treatments are being summarized and presented in Table 1.

#### 3.1.1 Pods plant<sup>-1</sup>

Data about the pods plant<sup>-1</sup> (Table 1) shows that the maximum numbers of pods plant<sup>-1</sup> were associated with the application of 75 kg DAP ha<sup>-1</sup> along with VC + PSB (T<sub>14</sub>) and it remained statistically at par with the treatments namely, T<sub>12</sub>, T<sub>13</sub>, T<sub>15</sub> and T<sub>16</sub> but recorded significant response over remaining treatments studied.

#### 3.1.2 Grains pod<sup>-1</sup>

The application of 75 kg DAP ha<sup>-1</sup> along with VC + PSB (T<sub>14</sub>) had ensured the maximum grains setting, though, it differed significantly better over the treatments namely, T<sub>1</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>6</sub>, T<sub>7</sub>, T<sub>10</sub> and T<sub>11</sub> and failed to cause significant variation over treatments namely, T<sub>12</sub>, T<sub>13</sub>, T<sub>15</sub> and T<sub>16</sub> applied (Table 1).

#### 3.1.3 Length of the pod (cm)

The length of the pod increased the maximum in the treatment where 75 kg DAP ha<sup>-1</sup> along with VC + PSB (T<sub>14</sub>) were supplied. The treatment T<sub>4</sub>, T<sub>8</sub>, T<sub>12</sub>, T<sub>14</sub>, T<sub>15</sub> and T<sub>16</sub> have remained statistically at par. However, treatment T<sub>14</sub> produced the tallest pod (6.43 cm) and showed its significant superiority over other treatments (Table 1).

#### 3.1.4 100-Seed weight (g)

Summarized data on 100-Seed weight in the Table 1d reveals that none of the treatments responded significantly among themselves. However, the maximum 100-Seed weight was recorded 4.60 g with the application of 75 kg DAP ha<sup>-1</sup> along with VC + PSB (T<sub>14</sub>).

#### 3.1.5 Harvest index

The data on Harvest Index (Table 1e) reveals that the highest response was recorded with the application of 75 kg DAP ha<sup>-1</sup> along with VC + PSB and it differed its significant superiority over the rest of the treatment studied.

**Table 1. Impact of treatment on yield attributes of mungbean**

Treatments	Pods plant <sup>-1</sup>	Grains pod <sup>-1</sup>	Length of pod (cm)	100-Seed weight (g)	Harvest index (HI)
	(a)	(b)	(c)	(d)	(e)
T <sub>1</sub>	22.22	8.00	6.17	4.27	33.02
T <sub>2</sub>	21.89	7.89	6.16	4.24	33.13
T <sub>3</sub>	22.56	8.22	6.19	4.33	33.39
T <sub>4</sub>	24.22	8.78	6.36	4.47	33.68
T <sub>5</sub>	20.89	7.44	6.13	4.14	29.61
T <sub>6</sub>	22.67	8.33	6.21	4.33	33.46
T <sub>7</sub>	23.33	8.56	6.24	4.40	33.65
T <sub>8</sub>	24.33	9.11	6.39	4.47	33.54
T <sub>9</sub>	21.22	7.56	6.14	4.17	29.74
T <sub>10</sub>	23.00	8.44	6.23	4.37	33.64
T <sub>11</sub>	23.67	8.67	6.27	4.43	33.66
T <sub>12</sub>	25.11	9.11	6.41	4.50	33.56
T <sub>13</sub>	21.67	7.67	6.14	4.20	30.44
T <sub>14</sub>	27.22	9.89	6.49	4.60	35.32
T <sub>15</sub>	26.56	9.78	6.46	4.53	33.19
T <sub>16</sub>	25.56	9.33	6.43	4.50	32.03
SEM	0.95	0.27	0.06	0.15	0.30
C.D.(0.05)	2.76	0.78	0.16	NS	0.88
CV (%)	7.03	5.45	1.57	5.80	1.61

{T<sub>1</sub>: Farmer's Practices (FYM -5t + 50 kg DAP); T<sub>2</sub>: 75 kg DAP; T<sub>3</sub>: 100 kg DAP; T<sub>4</sub>: 125 kg DAP; T<sub>5</sub>: PSB; T<sub>6</sub>: 75 kg DAP + PSB; T<sub>7</sub>: 100 kg DAP + PSB; T<sub>8</sub>: 125 kg DAP + PSB; T<sub>9</sub>: VC-5t; T<sub>10</sub>: 75 kg DAP + VC- 5t; T<sub>11</sub>:100 kg DAP + VC-5t; T<sub>12</sub>:125 kg DAP + VC-5t; T<sub>13</sub>: PSB + VC-5t; T<sub>14</sub>: 75 kg DAP + PSB + VC-5t; T<sub>15</sub>: 100 kg DAP + PSB + VC-5t and T<sub>16</sub>: 125 kg DAP + PSB + VC-5t}

### 3.2 Yield

In Table 2, the grain yield, biological yield, and yield increment/decrement is worked out for different treatments. The study of data reveals that these parameters were significantly influenced by different treatments.

#### 3.2.1 Economic yield (kg ha<sup>-1</sup>)

The perusal of data on seed yield (Table 2a) indicates that the highest yield (1291.58 kg ha<sup>-1</sup>) was produced when applied 75 kg DAP ha<sup>-1</sup> along with 5.0 t VC /ha + PSB. Amongst the treatments applied and further studied their effect on the crop visualize that treatment namely, T<sub>4</sub>, T<sub>8</sub>, T<sub>12</sub>, T<sub>14</sub>, T<sub>15</sub>, and T<sub>16</sub> did not cause any noticeable variation however, T<sub>14</sub> responded significantly over the remaining treatments.

#### 3.2.2 Biological yield (kg ha<sup>-1</sup>)

The data on biological yield reveals that the maximum value was observed with the application of 125 kg DAP ha<sup>-1</sup> accompanied with 5.0 t VC + PSB (T<sub>16</sub>). Though the differences among treatments, T<sub>12</sub>, T<sub>14</sub>, T<sub>15</sub>, and T<sub>16</sub> have remained statistically at par. However, T<sub>16</sub>

showed a significant response over other treatments studied (Table 2b).

#### 3.2.3 Yield increment/decrement (%) over farmer's practice

The study of data on yield increment/decrement presented in Table 2c reveals that the highest yield increment (22.57%) was associated with the application of 75 kg DAP accompanied with 5.0 t VC + PSB (T<sub>14</sub>) whereas the lowest was associated in the plots where seed treated with PSB followed by plots received by 5.0 t of vermicompost, respectively.

## 4. DISCUSSION

### 4.1 Yield Attributing Characters

Application of 75 kg DAP + VC + PSB (T<sub>14</sub>) significantly increased the number of pods plant<sup>-1</sup>, the number of grains pod<sup>-1</sup>, length of the pod, test weight, and harvest index. This might be due to the combined use of DAP, VC, and PSB where phosphorus helps in the photosynthesis and carbohydrate metabolism in leaves which is considered to be one of the major factors limiting plant growth mainly during the reproductive

stage. The level of phosphorus during this period regulates starch/sucrose ratio in the source leaves and the reproductive organs [10] and [11]. Perhaps, this effect of phosphorus on partitioning is responsible in part for the insufficient photosynthetic supply to the nodulated roots of legumes grown on phosphorus-deficient soils. Phosphorus deficiency limits N fixation mainly by reducing the growth of the host plant. Thus, application of phosphorus might have resulted in increased carbohydrate accumulation and their remobilization to reproductive parts of the plant, being the closest sink and hence, resulted in increased flowering, fruiting and seed formation [12]. A significant increase in yield and yield attributes was recorded with the application of 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>) as compared to other treatments. This might be due to the increase in the availability of all the essential nutrients (macro and micro) and particular nitrogen through vermicompost rich in nitrogen. Phosphorus solubilizing bacteria helped in increasing the availability of native as well as applied phosphorus through their solubilizing effect. Phosphorus increased the underground growth i.e. root growth (positively geotropic) which lead to better utilization of nutrients and water and in turn improved the growth attributes.

The improvement in growth yielded more of dry matter for the further manifestation of yield attributes.

The number of pods increased significantly for 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>). It was a single factor in yield attributes that decided the final yield. The 100-grain weight being more of genetic character in nature showed non-significant differences among the treatments. However, applications of 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>) gave the maximum value of 100 seed weight. Concomitant to improvements in yield attributes and grain yield were found significant for 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>). A significant response was also found to harvest index for the same treatment and maximum value (35.32) was recorded. This envisages that rate of DM partitioning was good under 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>). It might be due to partitioning and translocation of photosynthesis. Moreover, applications of 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>) also gave the maximum yield advantage (22.57) over the farmer practice. The applications of 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>) showed significant superiority over the rest of the treatments for yield attributes.

**Table 2. Grain and biological yield of mungbean as affected by treatments**

Treatments	Economic yield (kg ha <sup>-1</sup> )	Biological yield (kg ha <sup>-1</sup> )	Yield Increment /Decrement (%) over Farmer Practice
	(a)	(b)	(c)
T <sub>1</sub>	1053.72	3193.33	0.00
T <sub>2</sub>	1052.40	3176.67	-0.13
T <sub>3</sub>	1085.32	3250.00	3.00
T <sub>4</sub>	1187.75	3526.67	12.72
T <sub>5</sub>	897.83	3033.33	-14.79
T <sub>6</sub>	1112.78	3326.67	5.60
T <sub>7</sub>	1129.03	3353.33	7.15
T <sub>8</sub>	1186.05	3536.67	12.56
T <sub>9</sub>	927.05	3116.67	-12.02
T <sub>10</sub>	1126.97	3350.00	6.95
T <sub>11</sub>	1151.44	3420.00	9.27
T <sub>12</sub>	1194.71	3560.00	13.38
T <sub>13</sub>	962.32	3160.00	-8.67
T <sub>14</sub>	1291.58	3663.33	22.57
T <sub>15</sub>	1258.71	3796.67	19.45
T <sub>16</sub>	1264.92	3953.33	20.04
SEM	43.82	142.91	
C.D.(0.05)	126.56	412.76	
CV (%)	6.79	7.28	

{T<sub>1</sub>: Farmer's Practices (FYM -5t + 50 kg DAP); T<sub>2</sub>: 75 kg DAP; T<sub>3</sub>: 100 kg DAP; T<sub>4</sub>: 125 kg DAP; T<sub>5</sub>: PSB; T<sub>6</sub>: 75 kg DAP + PSB; T<sub>7</sub>: 100 kg DAP + PSB; T<sub>8</sub>: 125 kg DAP + PSB; T<sub>9</sub>: VC-5t; T<sub>10</sub>: 75 kg DAP + VC- 5t; T<sub>11</sub>:100 kg DAP + VC-5t; T<sub>12</sub>:125 kg DAP + VC-5t; T<sub>13</sub>: PSB + VC-5t; T<sub>14</sub>: 75 kg DAP + PSB + VC-5t; T<sub>15</sub>: 100 kg DAP + PSB + VC-5t and T<sub>16</sub>: 125 kg DAP + PSB + VC-5t}

In support of our results observed in present investigation, Ardeshta et al. [13] and Deka and Kakati [14] reported that the application of 60 kg P ha<sup>-1</sup> significantly increased the pods per plant, 100-seed weight and grain yield of mungbean over control and 20 kg P ha<sup>-1</sup> but remained at par with 40 kg P ha<sup>-1</sup>, El-Nagar [15] found that PSB (*B. polymyxa*) exhibited a significant effect on all traits and seed yield feddan<sup>-1</sup> increased by 12.7 % compared with the control, Asewar et al. [16] also found that the application of vermicompost increased the yield attributing characters, pods plant<sup>-1</sup>, grain yield and straw yield compared to control. The increased in yield was higher with vermicompost at 3 t ha<sup>-1</sup>. It is concluded that the application of vermicompost at 2 t ha<sup>-1</sup> was promising for achieving a higher productivity of chickpea, Jat and Ahlawat [17] found that the application of vermicompost 3 t ha<sup>-1</sup> and seed inoculation with *Rhizohium* and phosphate solubilizing bacteria resulted in higher dry matter (19.78 g plant<sup>-1</sup>) and leaf area index (1.57), and pods plant<sup>-1</sup> (27.38) of chickpea. Application of RDF + @ 5.0 ton/ha VC + *Rhizobium* + PSB significantly increased growth and yield attributes of chickpea over control. Dhakal et al. [18] reported that significant improvement in number of pods plant<sup>-1</sup> (32.49), seeds pod<sup>-1</sup> (13.06), and hundred seed weight (3.71 g) was observed in 75% RDF+2.5 t ha<sup>-1</sup> VC+ *rhizobium* + PSB, Singh et al. [19] found that the application of RDF+VC 5t ha<sup>-1</sup> registered maximum yield attributes, Karnavat et al. [20] reported that the basal application of 10 t FYM ha<sup>-1</sup> and 40 kg P ha<sup>-1</sup> + PSB gave the maximum values of all the yield attributes (pod length, pods plant<sup>-1</sup>, 1000 grain weight) of greengram and exerted better response over no FYM and PSB alone, respectively, and Yadav et al. [21] reported that the significantly higher number of pods plant<sup>-1</sup>, number of seeds pod<sup>-1</sup> and test weight obtained in summer mungbean when applied 40 kg P and PSB + *Aspergillus awamori*.

#### 4.2 Yield

The maximum yield was recorded with the application of 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>) and it differed significantly over the rest of the treatments. However, an increase in the dose of DAP further increased the vegetative growth resultant higher biological yield was recorded. Application of 75 kg DAP + 5.0 t VC + PSB (T<sub>14</sub>) delivered adequate nutrients that 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 + 5.0 t VC + PSB (T<sub>16</sub>). 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 + 5.0 t VC + PSB (T<sub>14</sub>) also gave the maximum yield advantage (22.57) over the farmer practice. The treatment T<sub>14</sub> showed significant superiority over the rest of the treatments for grain yield. In backing of our findings in present studies, Choudhary et al. [22] found that the grain yield of greengram was 19.5, 28.7 and 31.3 per cent higher as compared to control with the application of 20, 40 and 60 kg P ha<sup>-1</sup>, respectively, Gendy and Derar [23] reported that the FYM application increased the yield of seed and straw of lentil, Chandra and Pareek [24] found that PSB inoculation increased grain yield by 12.4 % over uninoculation control, Jat and Ahlawat [17] also found that the seed inoculated with *Rhizohium* and phosphate solubilizing bacteria accompanied with application of vermicompost 3 t ha<sup>-1</sup> resulted in higher seed (2.35 t ha<sup>-1</sup>) and straw yield (3.81 t ha<sup>-1</sup>) of chickpea, Dhakal et al. [18] reported that significant improvement in biological yield (43.49 q ha<sup>-1</sup>) was observed in 75%RDF + 2.5 t ha<sup>-1</sup> VC+ *rhizobium* + PSB, Singh et al [19] found that the application of RDF+VC 5t ha<sup>-1</sup> registered maximum yield, Karnavat et al. [20] observed that significantly higher seed and stover yield was recorded with 10 t FYM ha<sup>-1</sup> and 40 kg P ha<sup>-1</sup> application when compared to either no FYM or PSB only, Venkatarao et al. [21] indicated that seed inoculation with the *PSB* and *Aspergillus awamori* significantly increased grain yield (1260 kg ha<sup>-1</sup>) and straw yield (3140 kg ha<sup>-1</sup>) over the rest of the treatments, and Yadav et al. [25] reported that the application of (40 kg P + PSB + *A. awamori*) recorded significantly higher seed yield and straw yield (48.68, 1583kg ha<sup>-1</sup> and 3655kg ha<sup>-1</sup>), respectively.

#### 5. CONCLUSION

Based on the above results it can conclude that treated seed with PSB coupled with basal application of 75 kg DAP and vermicompost 5.0 t ha<sup>-1</sup> incorporated had delivered the highest grain yield (1291.58 kg) and had yield advantage by 22.6% over the farmer's practice (5 t FYM + 50 kg DAP per hectare). However, the application of

higher inputs (100-125 kg DAP with 5.0 t VC and PSB gave the luxuriant growth to the crop rather increased seed yield.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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