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Effect of PSB Inoculation With and Without P and S Application on Productivity of Mungbean (*Vigna radiata* L.) in Western U.P. India

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A B S T R A C T

A field experiment was conducted during *summer* season, 2018 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to evaluate the effect of PSB inoculation with and without P and S application in mungbean. The experimental results revealed that yield attributing traits *viz.* number of pods plant^{-1}, number of grains plant^{-1}, grain yield plant^{-1}, test weight and biological yield, grain yield, straw yield in mungbean differ significantly among different treatments. Growth parameters were significantly better in the treatment T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}). The highest grain yield was recorded in T_{13} where 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1} were applied with PSB inoculation. From the study it may be concluded that the application of 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1} with PSB inoculation (T_{13}) gave best results (Grain yield increased by 13.2%, 15.2%, 4.7% and 100.2% over T_2, T_4, T_{12} and T_1, respectively) and proved to be beneficial for *summer* mungbean. Application of 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1} with PSB inoculation (T_{12}) also gave better results, besides saving of 15 kg S ha^{-1}.

Introduction

Mungbean (*Vigna radiata* L.) has been grown in India since ancient time and it is also known as green gram and golden gram. It is another important short duration, predominantly rainy season pulse crop grown in many part of India. It is a short duration pulse crop which can be grown as catch crop between *rabi* and *kharif* seasons. During *summer*, it can also be used as a green manure crop. Being a leguminous crop, it has the capacity to fix atmospheric nitrogen. Its green plants are used as fodder after removing the mature pods. It is a short duration crop therefore has less water requirement as compared to other *summer* crops. Moreover, it is drought resistant that can with stand adverse environmental conditions, and hence successfully be grown in rainfed areas (Anjum *et al*., 2006).

Mungbean is an excellent source of protein (25%) with high lysine content (460 mg g^{-1}) and tryptophan (60 mg g^{-1}). It also has remarkable quantity of ascorbic acid when sprouted and also bears riboflavin (0.21 mg 100 g^{-1}) and minerals (3.84 g 100 g^{-1}). However, the per capita consumption of pulses was 43.0 g day^{-1} and 52.9 g day^{-1} in the year 2016 and 2017, respectively. The total area covered under mungbean in India during 2017-18 was 4.26 M ha with a total production of 2.01 Mt and a productivity of 472 kg ha^{-1} (Anonymous, 2018).

There is a lack of information to use of the phosphorus solubilizing micro-organism in mungbean under semi-arid and subtropical zone of western U.P. Thus, towards increasing yield there is need of using phosphate solubilizing microbes with phosphatic fertilizers for optimizing crop yield, maintenance of soil fertility at sustainable level of production. Phosphorus solubilizing micro-organisms (bacteria and fungi) enable P to become available for plant uptake after solubilization. Several soil bacteria, particularly those belonging to the genera *Bacillus* and *Pseudomonas*, and fungi belonging to the genera *Aspergillus* and *Penicillium* possess the ability to bring insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric, and succinic acids. These acids lower the pH and bring about the dissolution of bound forms of phosphates. The Phosphate solubilizing micro-organisms improved phosphorus uptake over control with and without chemical fertilizers. Thus, looking towards increasing higher the importance in view pulses on need of use of bio-inoculants with phosphatic fertilizers for optimizing crop yield, maintenance of soil fertility at sustainable level of production. Inoculation of Phosphorus solublizing or mobilizing microorganisms with legume crops has been found to substitute around 20% P requirement by P solublization (Singh *et al.,* 1998). PSB improve plant growth and yield when supplemented with chemical fertilizers. However, if PSB are used in combination with organic amendments, they could not only enhance the crop yield but also can help in preventing fertilizer runoff, leaching of nutrients, retaining more moisture and improving plant growth (Saxena *et al.,* 2013).

Pulses yield are held back due to deficiencies of sulphur. The demand of sulphur for mungbean like other pulses is higher than cereals because of their high protein content. Heavy sulphur mining through crop removal and extensive use of high analysis fertilizers of nitrogen, phosphorous and potassium free of sulphur with concomitant leaching losses are some of the factors responsible for its improvement in Indian soils.

Sulphur plays pivotal role in synthesis of sulphur containing amino acids like cysteine, cystine and methionine, besides glutathione (Kokani *et al*., 2014). Thus, judicious and balanced use of sulphur is of paramount importance in increasing pulse production and to combat protein calorie malnutrition of people.

Materials and Methods

In order to study the "Effect of PSB Inoculation With and Without P and S Application on Productivity of Mungbean (*Vigna radiata* L.) in Western U.P." a field experiment was conducted at Crop Research Centre (CRC) Chirori of Sardar Vallabhbhai Patel University of Agriculture and

Technology, Meerut (U.P.) during *summer* season of 2018. The details of the procedures followed, criteria used for treatments evaluation and methods adopted are explained as follows:

Yield attributes

Number of pods plant^{-1}

Total numbers of pods on tagged five plants were counted and average number of pods plant^{-1} was worked out and recorded as mean number of pods plant^{-1}.

Number of grains pod^{-1}

Number of grains pod^{-1} was recorded at harvest by counting the number of grains of 10 randomly selected pods from each net plot and average number of grains pod^{-1} was calculated.

Test weight (1000 grains weight)

One thousand randomly selected grains from the grain yield samples of irrespective shape and size was counted from the net plot produce and their weight were recorded on electrical digital balance.

Grain yield plant^{-1}

Pods obtained from five tagged sample plants were threshed and the grains obtained were weighted after winnowing. Average grain yield as g plant^{-1} was recorded.

Yield studies

Grain yield

After threshing, winnowing and cleaning, the product of each plot was weighed separately in kg plot^{-1} and converted in terms of grain yield in q ha^{-1}.

Straw yield

Straw yield was calculated by subtracting the grain yield from biological yield (q ha $^{-1}$).

Biological yield

After complete sun drying harvested produce grains and straw of each plot were recorded separately or individual net plot was weighed with the help of spring balance and weight was recorded in kg plot^{-1}. Later, biological yield plot^{-1} converted in q ha^{-1}.

Harvest index

The harvest index was calculated by dividing the economic (grain) yield by total biological yield (grains + straw) and multiplying the fraction by 100 (Singh and Stoskopf, 1971).

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

Results and Discussion

Yield attributing characters

The yield attributes *viz.*, number of pods plant^{-1}, number of grains pod^{-1}, grains yield plant^{-1} and test weight (1000 grains weight in gram) as affect by PSB inoculation with and without P and S were recorded at harvest stage and data are presented in Table 1 and depicted Figure 1. The improvement in yield and yield attributing character might be attributed to the fact that combined and balanced application of P and S with PSB inoculation increases photosynthetic activity of leaves, translocation of photosynthates from source to sink with consequent improvement, nutrients uptake and better metabolism and increase efficiency of other nutrients by P and S. Yield attributes (Table 1) *viz.* number of pods plant^{-1}, number of grains pod^{-1}, grains yield plant^{-1} and 1000 grains weight significantly differs under the treatment T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}) as well as sole application of P and S levels. The highest number of pods $plant^{-1}$, number of grains pod^{-1}, grains yield $plant^{-1}$ and 1000 grains weight (g) (19.0, 7.2, 5.1 and 38.1, respectively) were found in T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}) while, lowest in control (T_1). The significant increase in yield is a function of yield attributes character *viz.* number of pods $plant^{-1}$, number of grains pod^{-1}, grains yield $plant^{-1}$ and 1000 grains weight. The process of tissue differentiation from somatic to reproductive merismatic activity and development of floral primordial might have increased with increasing sulphur and phosphorus with inoculation of PSB resulting in more flowers and pods and ultimately the higher grain yield. The results of our study are in line with the findings of Singh and Yadav (2004) and Tiwari *et al.*, (2015).

Table.1 Effect of PSB inoculation with and without P and S application on yield attributes in mungbean

Treatments	**Yield attributes**			
	Pods per plant	**Grains per pod**	**Grains yield $plant^{-1}$ (g)**	**1000 grains weight (g)**
T_1 Control	13.6	5.4	2.6	36.1
T_2 60 kg P_2O_5 ha^{-1}	18.0	6.9	4.6	37.8
T_3 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}	17.3	6.6	4.2	37.4
T_4 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}	17.6	6.9	4.5	37.6
T_5 PSB	15.4	5.9	3.4	36.6
T_6 PSB + 20 kg P_2O_5 ha^{-1}	16.4	6.4	3.8	37.0
T_7 PSB + 40 kg P_2O_5 ha^{-1}	17.4	6.7	4.4	37.5
T_8 PSB + 15 kg S ha^{-1}	16.1	6.3	3.7	36.9
T_9 PSB + 30 kg S ha^{-1}	16.7	6.5	4.0	37.2
T_{10} PSB + 20 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}	17.0	6.6	4.2	37.4
T_{11} PSB + 20 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}	17.5	6.8	4.5	37.5
T_{12} PSB + 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}	18.6	7.1	5.0	38.0
T_{13} PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}	19.0	7.2	5.1	38.1
SEm (±)	**0.6**	**0.3**	**0.2**	**1.4**
C.D. (P=0.05)	**1.8**	**0.8**	**0.5**	**NS**

Table.2 Effect of PSB inoculation with and without P and S application on yields (Grains, straw and biological) and harvest index of mungbean

Treatments	Yields(q ha^{-1})			Harvest index
	Grains	Straw	Biological	
T_1 Control	5.61	16.07	21.68	25.88
T_2 60 kg P_2O_5 ha^{-1}	9.92	27.63	37.55	26.42
T_3 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}	9.25	25.76	35.01	26.42
T_4 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}	9.75	26.18	35.93	27.14
T_5 PSB	7.13	21.23	28.36	25.14
T_6 PSB + 20 kg P_2O_5 ha^{-1}	8.21	22.99	31.20	26.31
T_7 PSB + 40 kg P_2O_5 ha^{-1}	9.45	27.21	36.66	25.78
T_8 PSB + 15 kg S ha^{-1}	8.01	21.29	29.30	27.34
T_9 PSB + 30 kg S ha^{-1}	8.50	21.48	29.98	28.35
T_{10} PSB + 20 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}	9.15	23.81	32.96	27.76
T_{11} PSB + 20 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}	9.58	24.71	34.29	27.94
T_{12} PSB + 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}	10.72	27.60	38.32	27.97
T_{13} PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}	11.23	28.07	39.30	28.58
SEm (±)	**0.35**	**0.92**	**1.26**	**1.00**
C.D. (P=0.05)	**1.01**	**2.63**	**3.62**	**NS**

Harvest index express the proportion of economic yield in total biological yield did not differ significantly by the PSB inoculation with and without P and S during the experimentation. Numerically maximum harvest index value (28.6%) was observed in T_{13}.

Fig.1 Effect of PSB inoculation with and without P and S application on yield attributes in mungbean

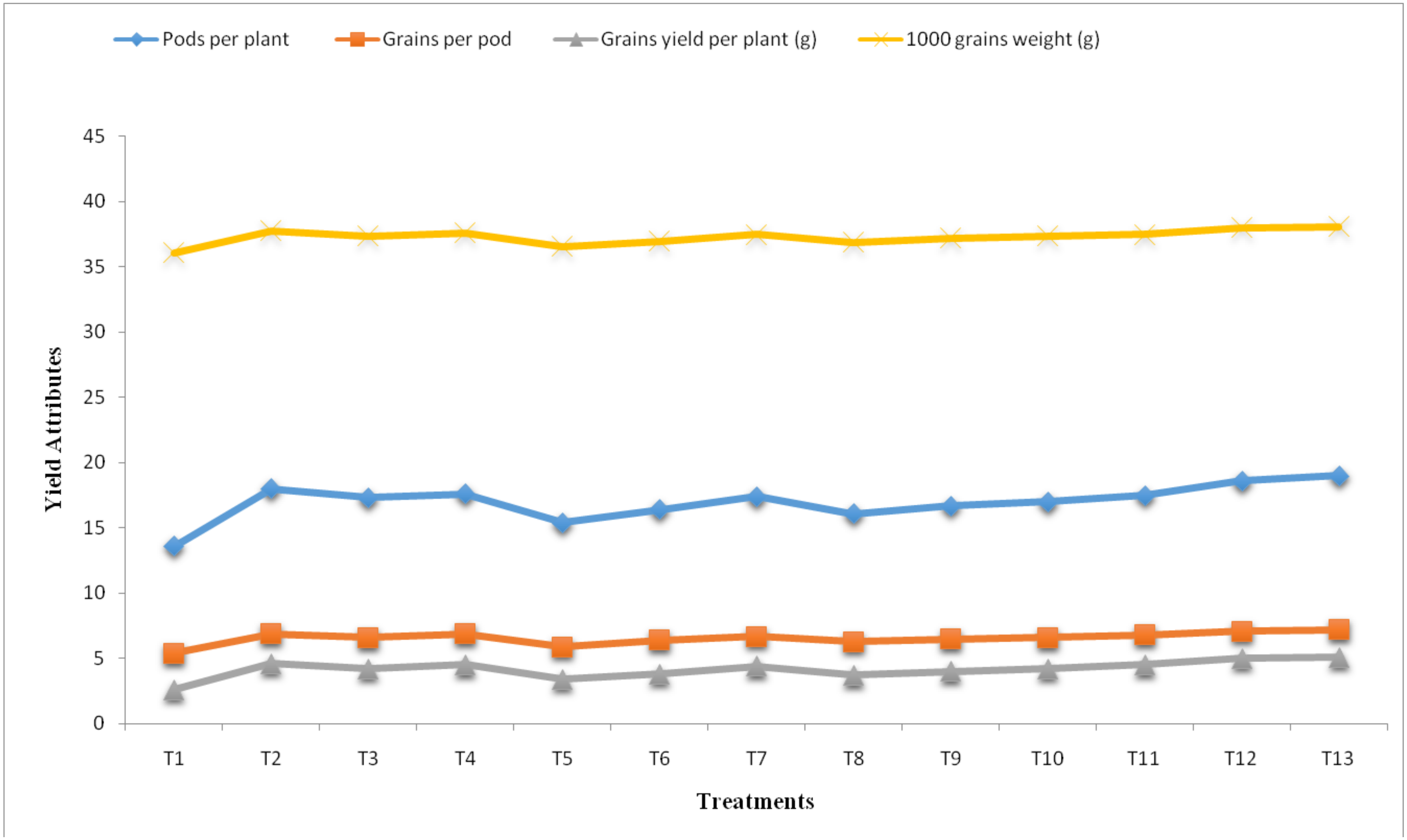
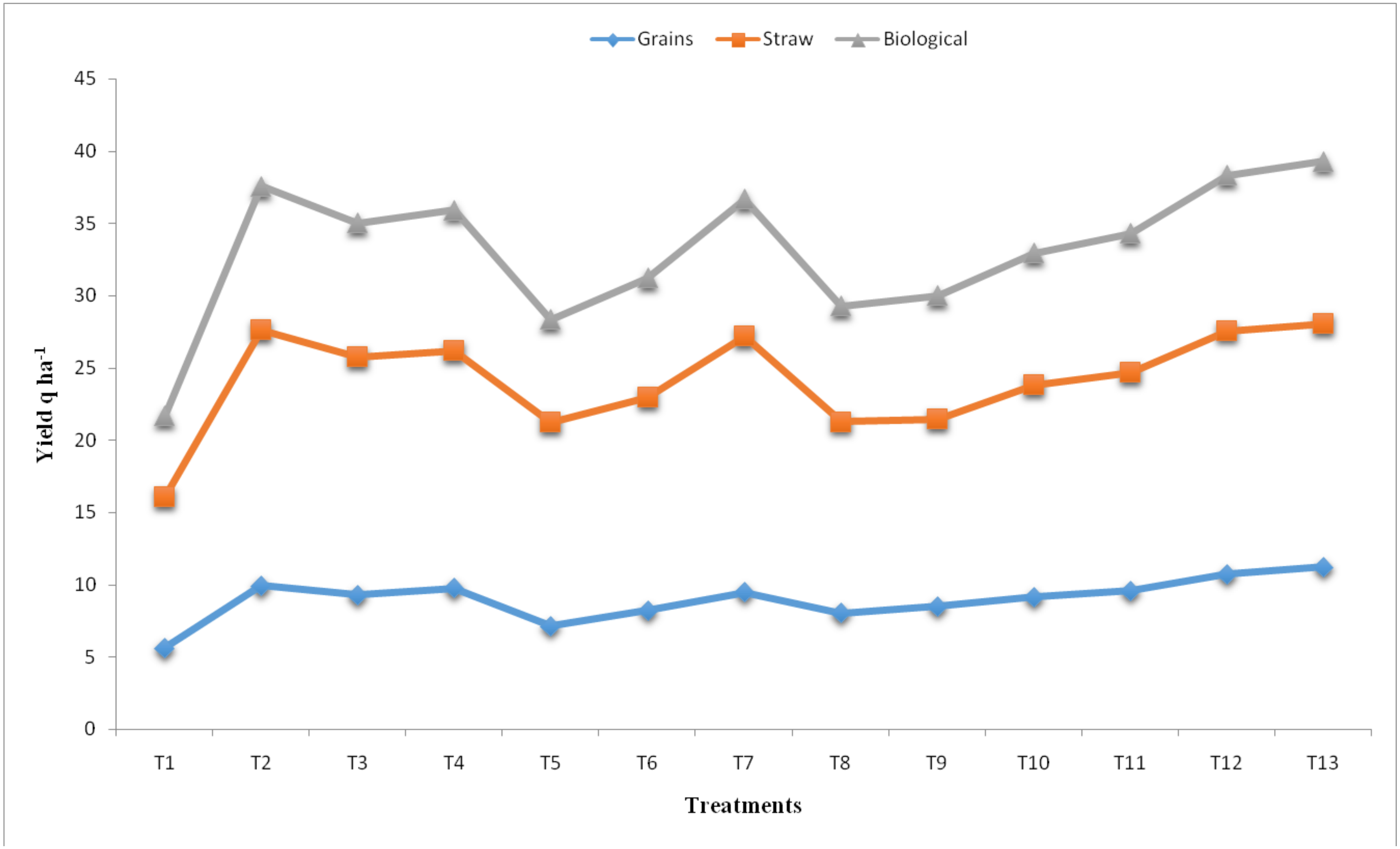


Fig.2 Effect of PSB inoculation with and without P and S application on yields (Grains, straw and biological) of mungbean



Yields

Data regarding the effect of PSB inoculation with and without P and S application on biological, grains, straw yield and harvest index are given Table 2 and depicted in Figure 2. It is clear from the data that the biological, grains and straw yields were significantly affected by different treatments. The maximum grain yield of 11.2 q ha^{-1}, statistically at par to T_{12} (PSB + 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}) and significantly higher than remaining treatments was found in T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}) which were higher over control by 91.1 and 100.2% in T_{12} and T_{13}, respectively. Statistically no effect was found on harvest index. The highest straw and biological yield (28.1 and 39.3 q ha^{-1}) were found in T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}) and 27.6 and 38.3 q ha^{-1} found in T_{12} (PSB + 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}) while, lowest (16.1 and 28.7 q ha^{-1}) found in control (T_1), respectively. The results of study are in line with the findings of Bhatt *et al.*, (2013), Sharma (2014) and Singh *et al.*, (2018).

In conclusion, the application of 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1} with inoculation of PSB significantly increased the values of yield attributes *viz.*, number of pods $plant^{-1}$ (19.0), number of grains pod^{-1} (7.2), grain yield $plant^{-1}$ (5.1 g), test weight (38.1 g), grain yield (11.23 q ha^{-1}), straw yield (28.1 q ha^{-1}) and biological yield (39.3 q ha^{-1}) of mungbean than the control, while harvest index (28.58%) did not differ significantly. The maximum grain yield 11.23 q ha^{-1}, statistically at par with T_{12} (PSB + 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}) and significantly higher than remaining treatments was found in T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}), which was higher over control by 91.1 and 100.2% in T_{12} (PSB + 40 kg P_2O_5 ha^{-1} + 15 kg S ha^{-1}) and T_{13} (PSB + 40 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}), respectively.

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