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\(_2\)O\(_5\) ha\(^{-1}\) + 30 kg S ha\(^{-1}\)). The highest grain yield was recorded in T\(_{13}\) where 40 kg P\(_2\)O\(_5\) 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\(_2\)O\(_5\) 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\(_2\)O\(_5\) 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
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 or mobilizing microorganisms with legume crops has been found to substitute around 20% P requirement by P solubilization (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) Chiri. 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 T13 (PSB + 40 kg P₂O₅ 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 T13 (PSB + 40 kg P₂O₅ ha⁻¹ + 30 kg S ha⁻¹) while, lowest in control (T1). 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               | Pods per plant | Grains per pod | Grains yield plant⁻¹ (g) | 1000 grains weight (g) |
|--------------------------|----------------|----------------|--------------------------|------------------------|
| T1 Control               | 13.6           | 5.4            | 2.6                      | 36.1                   |
| T2 60 kg P₂O₅ ha⁻¹       | 18.0           | 6.9            | 4.6                      | 37.8                   |
| T3 40 kg P₂O₅ ha⁻¹ + 15 kg S ha⁻¹ | 17.3         | 6.6            | 4.2                      | 37.4                   |
| T4 40 kg P₂O₅ ha⁻¹ + 30 kg S ha⁻¹ | 17.6         | 6.9            | 4.5                      | 37.6                   |
| T5 PSB                   | 15.4           | 5.9            | 3.4                      | 36.6                   |
| T6 PSB + 20 kg P₂O₅ ha⁻¹ | 16.4           | 6.4            | 3.8                      | 37.0                   |
| T7 PSB + 40 kg P₂O₅ ha⁻¹ | 17.4           | 6.7            | 4.4                      | 37.5                   |
| T8 PSB + 15 kg S ha⁻¹    | 16.1           | 6.3            | 3.7                      | 36.9                   |
| T9 PSB + 30 kg S ha⁻¹    | 16.7           | 6.5            | 4.0                      | 37.2                   |
| T10 PSB + 20 kg P₂O₅ ha⁻¹ + 15 kg S ha⁻¹ | 17.0        | 6.6            | 4.2                      | 37.4                   |
| T11 PSB + 20 kg P₂O₅ ha⁻¹ + 30 kg S ha⁻¹ | 17.5        | 6.8            | 4.5                      | 37.5                   |
| T12 PSB + 40 kg P₂O₅ ha⁻¹ + 15 kg S ha⁻¹ | 18.6        | 7.1            | 5.0                      | 38.0                   |
| T13 PSB + 40 kg P₂O₅ 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 |               |
| T₁ Control                        | 5.61   | 16.07 | 21.68      | 25.88          |
| T₂ 60 kg P₂O₅ ha⁻¹                | 9.92   | 27.63 | 37.55      | 26.42          |
| T₃ 40 kg P₂O₅ ha⁻¹ + 15 kg S ha⁻¹ | 9.25   | 25.76 | 35.01      | 26.42          |
| T₄ 40 kg P₂O₅ ha⁻¹ + 30 kg S ha⁻¹ | 9.75   | 26.18 | 35.93      | 27.14          |
| T₅ PSB                           | 7.13   | 21.23 | 28.36      | 25.14          |
| T₆ PSB + 20 kg P₂O₅ ha⁻¹          | 8.21   | 22.99 | 31.20      | 26.31          |
| T₇ PSB + 40 kg P₂O₅ ha⁻¹          | 9.45   | 27.21 | 36.66      | 25.78          |
| T₈ PSB + 15 kg S ha⁻¹             | 8.01   | 21.29 | 29.30      | 27.34          |
| T₉ PSB + 30 kg S ha⁻¹             | 8.50   | 21.48 | 29.98      | 28.35          |
| T₁₀ PSB + 20 kg P₂O₅ ha⁻¹ + 15 kg S ha⁻¹ | 9.15 | 23.81 | 32.96      | 27.76          |
| T₁₁ PSB + 20 kg P₂O₅ ha⁻¹ + 30 kg S ha⁻¹ | 9.58 | 24.71 | 34.29      | 27.94          |
| T₁₂ PSB + 40 kg P₂O₅ ha⁻¹ + 15 kg S ha⁻¹ | 10.72 | 27.60 | 38.32      | 27.97          |
| T₁₃ PSB + 40 kg P₂O₅ 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 T₁₃.
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$_2$O$_5$ ha$^{-1}$ + 15 kg S ha$^{-1}$) and significantly higher than remaining treatments was found in T$_{13}$ (PSB + 40 kg P$_2$O$_5$ 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$_2$O$_5$ ha$^{-1}$ + 30 kg S ha$^{-1}$) and 27.6 and 38.3 q ha$^{-1}$ found in T$_{12}$ (PSB + 40 kg P$_2$O$_5$ 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$_2$O$_5$ 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$^{-1}$ (51.1 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$_2$O$_5$ ha$^{-1}$ + 15 kg S ha$^{-1}$) and significantly higher than remaining treatments was found in T$_{13}$ (PSB + 40 kg P$_2$O$_5$ 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$_2$O$_5$ ha$^{-1}$ + 15 kg S ha$^{-1}$) and T$_{13}$ (PSB + 40 kg P$_2$O$_5$ ha$^{-1}$ + 30 kg S ha$^{-1}$), respectively.

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