Effect of *Rhizobium* and PSB inoculation on growth, yield attributes and yield of chickpea (*Cicer arietinum* L.)

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Abstract

A field experiment was conducted during *rabi* season 2017-18 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to evaluate the effect of *Rhizobium* and PSB inoculation with DAP application. The area situated at a latitude of 29° 01’ N and longitudes of 77° 75’ E with an elevation of 228 m above mean sea level. The soil of experimental field was well drained, sandy loam in texture, alkaline in reaction (7.81), low in available nitrogen, organic carbon and medium in available phosphorus and potassium with an electrical conductivity of 0.28 dSm⁻¹. Eight treatments comprising control, inoculation of *Rhizobium* and PSB with DAP application were tested in RBD with three replications. The chickpea crop was grown with recommended package and practices. The data on growth, yield attributes and yield were estimated as per the standard procedures. The experimental results revealed that growth parameters (plant height, number of branches plant⁻¹, number of nodules and their fresh and dry weight plant⁻¹ and dry matter accumulation plant⁻¹), yield attributing traits viz. number of pods plant⁻¹, number of seeds plant⁻¹, test weight and biological yield, grain yield, straw yield in chickpea differ significantly among different treatments. Growth parameters were significantly better in the treatment T₈ (*Rhizobium* + PSB + DAP). The highest grain yield was recorded in T₈ where DAP was applied with inoculation of *Rhizobium* and PSB. This treatment was superior to the other treatments. Growth and yield attributing characters were comparatively higher in T₈. From the study it is concluded that the application of DAP with *Rhizobium* and PSB inoculation (*T₈ Rhizobium* + PSB + DAP) gave best results and proved to be beneficial for Kabuli chickpea.

Keywords: Chickpea, *Rhizobium*, PSB inoculation, growth, yield attributes & yield

1. Introduction

Pulses play a vital role in our lives and the cheapest source of dietary proteins. The content of protein in pulses makes the diet more nutritive for vegetation when taken with other cooked food items. Pulses are also known for increasing productivity of soil through fixation of nitrogen from atmosphere, addition of biomass to soil and secretion of growth promoting substances. Pulses are well suited in rainfed conditions and require less farm resources, hence farmers prefer to grow them from economic point of view throughout the country, among this chickpea is one of them.

Chickpea (*Cicer arietinum* L.) belongs to the family Leguminosae. It is one of the important grain legumes cultivated in the world. It originated in south eastern Turkey (Ladizinski), 1975. The name *Cicer* is of Latin origin derived from the Greek word ‘*Kikus*’ meaning force or strength. Chickpea is an important grain legume in Asia and being a rich and cheap source of protein can help people improve the nutritional quality of their diets. Seeds average about 22-24% protein, 5% fat and 55% carbohydrates. Pulse crops play an important role in Indian agriculture and India is the largest producer and consumer of pulse in the world. Pulses contain a high percentage of quality protein nearly three times as much as cereals. Thus, they are cheaper source to overcome protein malnutrition among human beings. For vegetarian diet, pulses form the major source of protein. In fact, lysine is the most limiting essential amino acid in cereals which is very well supplemented by the protein of pulses.

Chickpea (*Cicer arietinum* L.) is one of the major *rabi* pulse crop. India is a major pulse growing country to feed its vegetarian population at large. It being a rich source of protein and amino acids form an essential part of daily diet. It recorded a highest ever production of 11.38
Mt at a record productivity level of 1078 kg/ha in an area of 10.56 Mha. Major 07 states to contribute >71 per cent in gram production have been Madhya Pradesh (4.60 Mt), Maharashtra (1.83 Mt) and Rajasthan (1.69 Mt).

1.1 (Directorate of Economics and Statistics, DAC & FE 2019)
Chickpea occupies a unique position in pulse crops, but its production is very low. Continuous addition of chemical fertilizers possesses many problems like toxicity, acidity/alkalinity etc. High amount of salts as a residue of fertilizers, deteriorate the physical properties of the soil imparting improper aeration and soil water-plant relationship, resulting in decreased productivity. The increasing cost of chemical fertilizers, growing environmental concern and energy crises have created considerable interest for search of alternative cheap source of plant nutrients.

Chickpea, like most legumes, establishes a symbiotic association with a compatible strain of *Rhizobium*. The *Rhizobium*-legume symbiosis is a well-organized system involving many steps; signal exchange and recognition of the symbiotic partners; attachment of the *Rhizobia* to the plant root hairs; root hair deformation; invasion of the root hair by *Rhizobia*; infection thread formation; nodule initiation; bacterioid development; and formation and fixing of nodules. *Rhizobium* is one of the classical nitrogen fixing bacteria which fix atmospheric nitrogen by the symbiotic association with leguminous plants. It has been estimated that 20-35% of the nitrogen fixed by the biological agencies comes through the nitrogen fixed by other soil elements such as insoluble phosphates of iron, aluminium and calcium (Khan et al., 2010).

2. Materials and Methods
The experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) in *rabi* season 2018-19, to evaluate the effect of *Rhizobium* and PSB inoculation on growth, yield attributes and yield of Chickpea (*Cicer arietinum* L.). The soil of the experimental field was sandy loam in texture, availability of NPK is 185.7, 17.1 and 189.3 Kg/ha, respectively.

The experiment was formulated and conducted in Randomized Block Design (RBD). The eight treatments combinations including control were tried and replicated thrice. All the recommended dose of fertilizer was applied @ 30, 60 and 25 kg of N, P₂O₅ and K₂O /ha respectively at the time of sowing (Table 1).

Table 1: Details of Experimtial plan and Treatments

| Layout Design | RBD (Randomized Block Design) |
|---------------|--------------------------------|
| Number of treatments | 08 |
| Number of replications | 03 |
| Total number of plots | 24 |
| Gross plot size | 5 × 3.6 = 18 m² |
| Net plot size | 4 × 2.6 = 10.4 m² |
| Spacing of accommodated plants | 30 x 10 cm |
| Main irrigation channel | 3.0 m wide |
| Sub irrigation channel | 1.5 m wide |
| Variety | Ujjawal (Kabuli) |

Treatments Detail: T₁: Control (No fertilizer), T₂: *Rhizobium* (20 g kg⁻¹seed), T₃: PSB (20 g kg⁻¹seed), T₄: DAP, T₅: *Rhizobium* + PSB, T₆: *Rhizobium* + DAP, T₇: PSB + DAP, T₈: *Rhizobium* + PSB + DAP

All the recommended cultural practices and plant protection measures were followed throughout the experimental periods. The height of plant, number of branches effective nodules, dry matter, test weight, pod plant-1, yield and yield contributing characters were recorded from all plots at pertinent stages.

All obtained data from experiment were statistical analysis using analysis of variance technique (ANOVA) for randomized block designed as prescribed by Cochran and Cox (1959). Standard error of difference between the treatment means (S.E.)ᵣₑ in each case and critical difference only for significance cases were computed at 5% levels of probability.

(S.E.)ᵣₑ = \sqrt{\frac{2 \text{EMS}}{r}} (equal No. of replications), where r is number of replications

Where, EMS is the Error Mean Square

Critical difference (C.D.) = (S.E.)ᵣₑ × 15% (at error degree of freedom)

3. Result and Discussion
3.1 Growth Attributes
3.1.1 Plant height (cm)
Plant height measured at 30, 60, 90 DAS and at harvest, as affected by *Rhizobium* and PSB inoculation application is presented in Table 2. The plant height of chickpea which increased progressively at successive observations with advancement of crop age was highest at harvest and differs significantly under the influence of different treatments. At 30 DAS, plant height ranged from 12.7 to 14.8 cm. The maximum plant height (14.8 cm) recorded in T₈ (*Rhizobium* + PSB + DAP), which was significantly higher than the rest of the treatments. The plant height increased by 16.5% due to application of T₈ (*Rhizobium* + PSB + DAP) over control plot.
At 60 DAS, plant height ranged from 25.3 to 28.7 cm. The maximum plant height (28.7 cm) recorded in T8 (Rhizobium + PSB + DAP) was statistically at par to plant height measured in T2, T3, T4, T5, T6 and T7 significantly higher than the rest of treatments, while minimum plant height which was significantly lower than the rest of treatments with few exception was found in control. Plant height of T8 treatment was increased by 13.4% over control (T1). At 90 DAS, plant height ranged from 37.1 to 43.2 cm. The maximum plant height (43.2 cm) recorded in T8 (Rhizobium + PSB + DAP), which was statistically at par to T2, T3, T4, T5 and T7 and significantly higher than the rest of treatments while minimum plant height, which was significantly lower than the rest of treatments with few exception was found in control plot. Plant height of T8 treatment was increased by 16.4% over control (T1).

At harvest, number of branches (9.4 plant) measured in T8 (Rhizobium + PSB + DAP) was significantly superior to rest of the treatments, while minimum number of branches (2.1 plant) counted in T1 (control). Number of branches counted at 30, 60, 90 DAS and at harvest as affected by different treatments are presented in Table 3.

### Table 2: Effect of Rhizobium and PSB inoculation on plant height (cm) at different stages in chickpea

| Treatments                  | Plant height (cm) | 30 DAS | 60 DAS | 90 DAS | At harvest |
|-----------------------------|-------------------|--------|--------|--------|------------|
| T1 (Control No fertilizer)  | 12.7              | 25.3   | 37.1   | 39.1   |            |
| T2 (Rhizobium 20g/kg seed) | 13.2              | 27.1   | 40.3   | 42.3   |            |
| T3 PSB (20g/kg seed)       | 13.0              | 26.1   | 37.9   | 39.9   |            |
| T4 (DAP)                   | 13.9              | 27.3   | 42.5   | 44.3   |            |
| T5 (Rhizobium + PSB)       | 13.7              | 26.4   | 39.6   | 41.4   |            |
| T6 (Rhizobium + DAP)       | 14.1              | 27.8   | 42.7   | 44.6   |            |
| T7 (PSB + DAP)             | 14.7              | 26.8   | 39.2   | 41.1   |            |
| T8 (Rhizobium + PSB + DAP) | 14.8              | 28.7   | 43.2   | 45.1   |            |
| SEM±                        | 0.4               | 0.9    | 1.3    | 1.4    |            |
| CD (P=0.05)                | 1.3               | 2.6    | 3.9    | 4.1    |            |

### Table 3: Effect of Rhizobium and PSB inoculation on number of branches plant⁻¹ at different stages in chickpea

| Treatments                  | Number of branches plant⁻¹ | 30 DAS | 60 DAS | 90 DAS | At harvest |
|-----------------------------|----------------------------|--------|--------|--------|------------|
| T1 (Control No fertilizer)  | 2.1                        | 3.6    | 5.1    | 4.8    |            |
| T2 (Rhizobium 20g/kg seed) | 2.3                        | 5.7    | 8.3    | 7.5    |            |
| T3 PSB (20g/kg seed)       | 2.3                        | 4.9    | 7.2    | 6.3    |            |
| T4 (DAP)                   | 2.6                        | 5.1    | 7.5    | 6.7    |            |
| T5 (Rhizobium + PSB)       | 2.5                        | 4.6    | 6.7    | 5.8    |            |
| T6 (Rhizobium + DAP)       | 2.6                        | 5.4    | 7.9    | 7.3    |            |
| T7 (PSB + DAP)             | 2.8                        | 6.6    | 9.0    | 8.5    |            |
| T8 (Rhizobium + PSB + DAP) | 2.9                        | 6.9    | 9.3    | 8.6    |            |
| SEM±                        | 0.1                        | 0.2    | 0.3    | 0.2    |            |
| CD (P=0.05)                | 0.3                        | 0.5    | 0.8    | 0.6    |            |

Number of branches which increased at successive observation was affected by different treatments. At 30 DAS, number of branches ranged from 2.1 to 2.9 plant⁻¹. With exception of T3, T5 and T7 the maximum number of branches (2.9 plant⁻¹) recorded in T8 (Rhizobium + PSB + DAP) were significantly superior to rest of the treatments while, minimum number of branches (2.1 plant⁻¹) counted in T1 (control). At 60 DAS, number of branches ranged from 3.6 to 6.9 plant⁻¹. With exception of T3 the maximum number of branches (6.9 plant⁻¹) recorded in T8 (Rhizobium + PSB + DAP) were significantly superior to rest of the treatments while, minimum number of branches (3.6 plant⁻¹) counted in T1 (control).

At 90 DAS, number of branches ranged from 5.1 to 9.3 plant⁻¹. The maximum number of branches (9.3 plant⁻¹) were recorded in T8 (Rhizobium + PSB + DAP), while minimum number of branches (5.1 plant⁻¹) in control (T1). Number of branches in T8 (Rhizobium + PSB + DAP) were significantly higher than the number of branches counted in remaining treatments with exception of T7.

3.1.3 Number of nodules plant⁻¹

The numbers of nodules plant⁻¹ in chickpea were significantly influenced by Rhizobium and PSB inoculation at flowering of the crop growth. The data pertaining to number of nodules plant⁻¹ are presented in Table 4. At 50 DAS, maximum number of nodules recorded with application of Rhizobium + PSB + DAP in treatment T8 (30.9 plant⁻¹), which was statistically at par to treatments T6 (PSB + DAP) and significantly higher than the rest of treatments, while minimum number of nodules plant⁻¹ recorded (17.1 plant⁻¹) in control plot (T1). Number of nodules plant⁻¹ increased by 80.7% in T8 (Rhizobium + PSB + DAP) over control (T1).

At 75 DAS, maximum number of nodules recorded with application of Rhizobium + PSB+ DAP in treatment T8 (27.6 plant⁻¹) followed by T5 (PSB + DAP) and significantly higher than the rest of treatments, while minimum number of nodules recorded (14.6 plant⁻¹) in control plot (T1). Number of nodules plant⁻¹ increased by 89.0% in T8 (Rhizobium + PSB + DAP) over control (T1).
Table 4: Effect of *Rhizobium* and PSB inoculation on nodules formation at different stages of chickpea crop

| Treatments                        | Number of nodules plant\(^{-1}\) | Nodules fresh weight (mg plant\(^{-1}\)) | Nodules dry weight (mg plant\(^{-1}\)) |
|-----------------------------------|----------------------------------|----------------------------------------|--------------------------------------|
|                                   | 55 DAS  | 75 DAS  | 55 DAS  | 75 DAS  | 55 DAS  | 75 DAS  |
| T\(_1\) (Control (No fertilizer)) | 17.1    | 14.6    | 62.2    | 60.2    | 38.0    | 31.4    |
| T\(_2\) (Rhizobium (20g/kg seed)) | 20.6    | 17.4    | 81.3    | 72.0    | 44.3    | 40.4    |
| T\(_3\) PSB (20g/kg seed)         | 19.2    | 16.1    | 75.5    | 67.5    | 42.4    | 37.3    |
| T\(_4\) (DAP)                     | 23.1    | 20.3    | 102.2   | 83.6    | 55.3    | 51.2    |
| T\(_5\) (Rhizobium + PSB)        | 22.0    | 19.1    | 91.1    | 78.3    | 49.7    | 45.1    |
| T\(_6\) (Rhizobium + DAP)        | 25.2    | 22.6    | 112.3   | 87.4    | 59.2    | 56.3    |
| T\(_7\) (PSB+ DAP)               | 28.8    | 24.9    | 119.5   | 91.2    | 62.2    | 59.4    |
| T\(_8\) (Rhizobium + PSB + DAP)  | 30.9    | 27.6    | 128.3   | 96.3    | 67.3    | 62.2    |
| SEm\(_{p}\)                       | 0.8     | 0.8     | 3.2     | 2.6     | 1.7     | 1.6     |
| CD (P= 0.05)                     | 2.3     | 2.3     | 9.5     | 7.7     | 5.1     | 4.7     |

3.1.4 Nodules fresh weight (mg plant\(^{-1}\))

The nodules fresh weight (mg plant\(^{-1}\)) in chickpea was significantly influenced by *Rhizobium* and PSB inoculation at crop growth stages. The data pertaining to nodules fresh weight (mg plant\(^{-1}\)) are presented in Table 4. At 50 DAS, maximum nodules fresh weight (mg plant\(^{-1}\)) recorded with application of *Rhizobium* + PSB + DAP in treatment T\(_8\) (128.3 mg plant\(^{-1}\)), which was statistically at par to treatments T\(_7\) (PSB + DAP) and significantly higher than the rest of treatments, while minimum nodules fresh weight (mg plant\(^{-1}\)) recorded (62.2 mg plant\(^{-1}\)) in control plot (T\(_1\)). Nodules fresh weight (mg plant\(^{-1}\)) increased by 106.3% in T\(_8\) (Rhizobium + PSB + DAP) over control (T\(_1\)).

At 75 DAS, maximum nodules fresh weight recorded with application of T\(_8\) (Rhizobium + PSB + DAP) (96.3 mg plant\(^{-1}\)), which was statistically at par with treatments T\(_7\) (PSB + DAP) and significantly higher than the rest of treatments, while minimum nodules fresh weight recorded (60.2 mg plant\(^{-1}\)) in control plot (T\(_1\)). Nodules fresh weight (mg plant\(^{-1}\)) increased by 59.9% in T\(_8\) (Rhizobium + PSB + DAP) over control (T\(_1\)).

3.1.5 Nodules dry weight (mg plant\(^{-1}\))

The data pertaining to nodules dry weight are presented in Table 4. The nodules dry weight of chickpea was significantly influenced by *Rhizobium* and PSB inoculation at flowering stage (50 DAS) of the crop. The nodules dry weight observed with the application of *Rhizobium* + PSB + DAP in treatment T\(_8\), which was statistically at par to T\(_1\) (PSB + DAP) and significantly higher the remaining treatments. The nodules dry weight increased by 77.1% in T\(_8\) (Rhizobium + PSB + DAP) over control (T\(_1\)). The maximum nodules dry weight plant\(^{-1}\) (67.3 mg) were seen in T\(_8\) (Rhizobium + PSB + DAP) and minimum (38.0 mg) in control (T\(_1\)).

At 75 DAS, the nodules dry weight observed with the application of Rhizobium + PSB + DAP in treatment T\(_8\), which was statistically at par to T\(_7\) (PSB + DAP) and significantly higher the rest of the treatments. Over the control (T\(_1\)) the nodules dry weight increased by 98.1% in T\(_8\) (Rhizobium + PSB + DAP), respectively. The maximum nodules dry weight plant\(^{-1}\) (62.2 mg) were seen in T\(_8\) (Rhizobium + PSB + DAP) and minimum (31.4 mg) in control (T\(_1\)).

3.1.6 Dry matter accumulation (g plant\(^{-1}\))

The data on an average dry matter accumulation recorded at 30, 60, 90 DAS and at harvest as affect by different treatments are presented in Table 5. It is clear from the data that the dry matter accumulation in chickpea were significantly affected by different treatments. At 30 DAS, maximum dry matter accumulation (2.1 g plant\(^{-1}\)) statistically at par to T\(_7\) (PSB + DAP) and significantly higher than the rest of treatments was found in T\(_8\) (Rhizobium + PSB + DAP), while minimum (1.4 g plant\(^{-1}\)) significantly lower than the rest of the treatments in control plot (T\(_1\)).

At 60 DAS, the maximum dry matter accumulation (13.7 g plant\(^{-1}\)) recorded in T\(_8\) (Rhizobium + PSB + DAP), which was significantly higher than other treatments, except T\(_7\) (PSB+ DAP), which remained statistically at par while, minimum dry matter accumulation (7.9 g plant\(^{-1}\)) significantly lower than the remaining treatments was found in control (T\(_1\)).

At 90 DAS, the maximum dry matter accumulation (27.4 g plant\(^{-1}\)) recorded in T\(_8\) (Rhizobium + PSB + DAP), which was significantly higher than other treatments, except T\(_7\) (PSB+ DAP), which remained statistically at par while, minimum dry matter accumulation (15.8 g plant\(^{-1}\)) significantly lower than the remaining treatments was found in control (T\(_1\)).

Table 5: Effect of *Rhizobium* and PSB inoculation on dry matter accumulation (g plant\(^{-1}\)) at different stages in chickpea

| Treatments                        | Dry matter accumulation (g plant\(^{-1}\)) |
|-----------------------------------|------------------------------------------|
|                                   | 30 DAS | 60 DAS | 90 DAS | At harvest |
| T\(_1\) (Control (No fertilizer)) | 1.4    | 7.9    | 15.8   | 17.7       |
| T\(_2\) (Rhizobium (20g/kg seed)) | 1.8    | 8.9    | 17.7   | 19.9       |
| T\(_3\) PSB (20g/kg seed)         | 1.5    | 8.3    | 16.6   | 18.2       |
| T\(_4\) (DAP)                     | 1.7    | 11.7   | 23.4   | 25.6       |
| T\(_5\) (Rhizobium + PSB)        | 1.7    | 9.7    | 19.3   | 21.4       |
| T\(_6\) (Rhizobium + DAP)        | 1.8    | 11.8   | 23.5   | 25.5       |
| T\(_7\) (PSB+ DAP)               | 1.9    | 12.8   | 25.6   | 27.6       |
| T\(_8\) (Rhizobium + PSB + DAP)  | 2.1    | 13.7   | 27.4   | 29.7       |
| SEm\(_{p}\)                       | 0.07   | 0.4    | 0.7    | 0.8        |
| CD (P= 0.05)                     | 0.21   | 1.1    | 2.1    | 2.3        |

At harvest the maximum dry matter accumulation (29.7 g plant\(^{-1}\)), which was statistically at par with T\(_7\) (PSB + DAP) and significantly higher than other treatment was found in T\(_8\) (Rhizobium + PSB + DAP), while minimum (17.7 g plant\(^{-1}\)) was observed T\(_1\) (control) which was significantly lower than the rest of the treatments.

3.2 Yield attributing characters

The yield attributes viz., number of pods plant\(^{-1}\), number of seed pod\(^{-1}\) and test weight (1000 grains weight in gram) as affect by *Rhizobium* and PSB inoculation were recorded at harvest stage and data are presented in Table 5.

3.2.1 Number of pods plant\(^{-1}\)

At harvest higher numbers of pods recorded (33.5 plant\(^{-1}\)) with the application of T\(_8\) (Rhizobium + PSB + DAP), which was statistically at par to T\(_3\), T\(_5\), T\(_6\) and T\(_7\) and significantly higher than the rest of treatments, while minimum numbers of pods recorded (29.5 plant\(^{-1}\)) in control plot (T\(_1\)).
Plants heights under different treatments differ significantly (Rhizobium + PSB + DAP). The lowest harvest index (39.3%) was recorded in T1 (Control) followed by T2 (Rhizobium + PSB + DAP), while maximum harvest index value (43.0%) was observed in T7 (PSB + DAP) and significantly higher than the rest of the treatments in control plot (T1).

3.2.3 Test weight (g)

The test weight (1000 grains weight) differ significantly due to application of Rhizobium and PSB inoculation and ranged from 161.2 to 187.4 (g). The maximum (187.4 g) 1000 grains weight was found in T8 (Rhizobium + PSB + DAP) and minimum (161.2 g) recorded in control (T1).

3.3 Yields

Data regarding the effect of Rhizobium and PSB inoculation on grain, straw, biological yield and harvest index of chickpea are given Table 7. It is clear from the data that the grain, straw and biological yields were significantly affected by different treatments. Biological yield ranged from 31.5 to 47.6 q ha⁻¹ under different treatments. Maximum biological yield (47.6 q ha⁻¹) followed by T6 (Rhizobium + DAP) and T7 (PSB + DAP) and significantly higher than remaining treatments was found in T8 (Rhizobium + PSB + DAP), while minimum significantly lower than the rest of treatments in control plot (T1).

Grain yield of chickpea under different treatment ranged from 13.4 to 18.7 q ha⁻¹. Maximum grain yield (18.7 q ha⁻¹), which was statistically at par to T7 (PSB + DAP) and significantly higher than remaining treatments was found in T8 (Rhizobium + PSB + DAP). Minimum grain yield (13.4 q ha⁻¹) significantly lower than the rest of the treatments was found in control (T1). Significantly higher yield was obtained with the Rhizobium and PSB inoculation of application of in treatment T8 (Rhizobium + PSB + DAP). The grain yield increased by 39.5% in T8 (Rhizobium + PSB + DAP) over control (T1). Straw yield varied from 18.1 to 28.9 q ha⁻¹ under different treatments. Maximum straw yield (28.9 q ha⁻¹) followed by T8 (Rhizobium + DAP) and T7 (PSB + DAP) and significantly higher than the rest of the treatments was found in T8 (Rhizobium + PSB + DAP), while minimum (18.1 q ha⁻¹) in control (T1). In comparison to T1 (Control) straw yield increased by 59.7% in T8 (Rhizobium + PSB + DAP).

| Treatments | Yield attributes | Test weight (g) |
|------------|------------------|----------------|
|            | Number of pods plant⁻¹ | Number of seed pod⁻¹ |                   |
| T1 (Control) | 29.5             | 2.0             | 161.2            |
| T2 (Rhizobium (20g/kg seed) | 30.7             | 2.3             | 163.4            |
| T3 PSB (20g/kg seed) | 30.2             | 2.4             | 162.3            |
| T4 (DAP) | 32.4             | 2.4             | 168.5            |
| T5 (Rhizobium + PSB) | 31.2             | 2.3             | 172.0            |
| T6 (Rhizobium + DAP) | 32.5             | 2.6             | 182.5            |
| T7 (PSB + DAP) | 32.6             | 2.3             | 185.0            |
| T8 (Rhizobium + PSB + DAP) | 33.5             | 2.5             | 187.4            |
| SEM± | 1.0             | 0.08            | 4.3              |
| CD (P= 0.05) | 2.9             | 0.24            | 12.7             |

### Table 6: Effect of Rhizobium and PSB inoculation on yield attributes at different stages in chickpea

| Treatments | Number of pods plant⁻¹ | Number of seed pod⁻¹ | Test weight (g) |
|------------|------------------------|----------------------|----------------|
|            |                        |                      |                |
| T1 (Control) | 13.4             | 18.1             | 31.5             | 42.5             |
| T2 (Rhizobium (20g/kg seed) | 15.3             | 20.3             | 35.6             | 43.0             |
| T3 PSB (20g/kg seed) | 14.2             | 19.5             | 33.7             | 42.1             |
| T4 (DAP) | 17.2             | 24.1             | 41.3             | 41.6             |
| T5 (Rhizobium + PSB) | 16.3             | 22.7             | 39.0             | 41.8             |
| T6 (Rhizobium + DAP) | 17.8             | 25.4             | 42.9             | 41.5             |
| T7 (PSB + DAP) | 18.2             | 26.2             | 44.4             | 41.0             |
| T8 (Rhizobium + PSB + DAP) | 18.7             | 28.9             | 47.6             | 39.3             |
| SEM± | 0.21             | 0.31             | 0.63             | 0.56             |
| CD (P= 0.05) | 0.59             | 0.94             | 1.86             | NS               |

### Table 7: Effect of Rhizobium and PSB inoculation on yield (q ha⁻¹) and harvest index of chickpea

Harvest index express proportion of economic yield in total biological yield did not differ significantly by the Rhizobium and PSB inoculation during the experimentation. Numerically maximum harvest index value (43.0%) was observed in T2 (Rhizobium (20g/kg seed) than rest of the treatments during the study. Lowest harvest index (39.3%) was recorded in T8 (Rhizobium + PSB + DAP).

4. Summary and Conclusion

Plant heights under different treatments differ significantly and varied from 12.7 to 14.8 cm at 30 DAS, 25.3 to 28.7 cm at 60 DAS, 37.1 to 43.2 cm at 90 DAS and 39.1 to 45.1 cm at harvest. The highest plant height was recorded in T8 (Rhizobium + PSB + DAP), while shortest measured in control (T1).

Numbers of branches per plant were significantly influenced by the different treatments at all the crop growth stages. The highest number of branches (2.9, 6.9, 9.3 and 8.6 plant⁻¹) were recorded in T8 (Rhizobium + PSB + DAP) at 30, 60, 90 DAS and harvest stage, respectively. However, lowest numbers of branches were recorded in control (T1).

The number of nodules plant⁻¹ and their fresh and dry weight in chickpea were significantly influenced by different treatments. The highest number of nodules (30.9 and 27.6 plant⁻¹ at 55 and 75 DAS, respectively), nodules fresh weight (128.3 and 96.3 mg plant⁻¹ at 55 and 75 DAS, respectively) and their dry weight (67.3 and 62.2 mg plant⁻¹ at 55 and 75 DAS, respectively) were significantly influenced by different treatments.
DAS, respectively) were recorded in T8 (Rhizobium + PSB+ DAP). However, lowest number of nodules and their fresh and dry weights were recorded in control (T1).

The dry matter accumulation in chickpea was significantly affected by different treatments. The highest dry matter accumulation of 21.3, 13.7, 27.4 and 29.7 g plant⁻¹ found in T8 (Rhizobium + PSB+ DAP) at 30, 60, 90 DAS and at harvest stage of chickpea, respectively. However, the lowest values were recorded in control (T1), irrespectively of the crop growth stages.

The application of DAP with inoculation of Rhizobium and PSB significantly increased the values of yield attributes viz., number of pods plant⁻¹ (33.5), number of seed pod⁻¹ (2.5), test weight (187.4 g), protein content (22.5%), protein yield (420.8 kg ha⁻¹), grain yield (18.7 q ha⁻¹), straw yield (28.9 q ha⁻¹) and biological yield (47.6 q ha⁻¹) of chickpea than the control while, harvest index (39.3%) did not differ significantly. The maximum grain yield 18.8 q ha⁻¹ significantly higher than remaining treatments was found in T8 (Rhizobium + PSB+ DAP). The grain yield increased by 39.5% in T8 (Rhizobium + PSB + DAP) over control (T1).

From the above study, it is concluded that the application of DAP with Rhizobium and PSB inoculation (T8, Rhizobium + PSB+ DAP) gave best results and proved to be beneficial for Kabuli chickpea (Kabuli).

5. References
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