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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 29^0 01' N and longitudes of 77^0 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}. The data on growth, yield attributes and yield of chickpea were estimated as per the standard procedures. Growth parameters were significantly better in the treatment T_8 (*Rhizobium* + PSB+ DAP). The highest grain yield was recorded in T_8 where Growth and yield attributing characters were comparatively higher in T_8 during experimental trial of chickpea on the field.

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

1. Introduction
Chickpea (*Cicerarietinum* L.) belongs to the family Leguminoceae. It is one of the important grain legumes cultivated in the world. It is one of the earliest cultivated legumes, and 9500 years old remains have been found in the Middle East. The chickpea is important in Indian, Mediterranean and Middle Eastern cuisine. India was responsible for 70% of global chickpea production. Consequently, the impact of heat cultivation not only affects the protein content of the chickpea itself, but ecosystem that it supports as well. Increasing the height and size of chickpea plants involves using micronutrient fertilization with varying doses of inorganic phosphorus and nitrogen. Nitrogen nutrient is a factor that affects the yield of chickpea, although the application itself differs from other perennial crops with regards to the levels administered on the plant. High doses of nitrogen inhibit the yield of the chickpea plant. Inorganic phosphate ions are generally attracted towards charged minerals such as iron and aluminium oxides.

Microbial inoculants, commonly known as biofertilizers, are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers in sustainable agriculture system. They form an integral part of Integrated Plant Nutrient System.

The introduction of efficient strains of P-solubilizing species of *Bacillus megatherium* Biovar *phosphaticum, Bacillus polymyxa, Pseudomonas striata, Aspergillus awamori* and *Penicillium digitatum*in the rhizosphere of crops and soils has been reported to help in increasing the availabilityof phosphorus from insoluble sources of phosphates and its use efficiency since the information on response of elite genotypes of chickpea to dual inoculation with *Rhizobium* and phosphate solubilising bacterial inoculums*Rhizobium* and phosphate solubilizing bacteria assume a great importance on account of their vital role in the nutrition of crop plants.Inoculation with efficient strains of *Rhizobium* can bring about substantial increase in grain yield.

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 rrecommended dose of fertilizer was applied @ 30, 60 and 25 kg of N, P_2O_5 and K_2O /ha respectively at the time of sowing (Table 1).

Table 1: Details of Expermintal plan and Treatments

Layout Design	RBD (Randomized Block Desgin)
Number of treatments	08
Number of replications	03
Total number of plots	24
Gross plot size	5 × 3.6 = 18 m^2
Net plot size	4 × 2.6 = 10.4 m^2
Spacing of accomodated plants	30 x 10 cm
Main irrigation channel	3.0 m wide
Sub irrigation channel	1.5 m wide
Variety	Ujjawal (Kabuli)

Treatments Detail: T_1: Control (No fertilizer), T_2: *Rhizobium* (20 g kg^{-1}seed), T_3: PSB (20 g kg^{-1}seed), T_4: DAP, T_5: *Rhizobium* + PSB, T_6: *Rhizobium* + DAP, T_7: PSB + DAP, T_8: *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 $(S.E.)_{Diff}$ in each case and critical difference only for significance cases were computed at 5% levels of probability.

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

Where, EMS is the Error Mean Square

Critical difference (C.D.) = $(S.E.)_{Diff} \times t_{5\%}$ (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 T_8 (*Rhizobium* + PSB + DAP), which was significantly higher than the rest of the treatments. The plant height increased by 16.5% due to application of T_8 (*Rhizobium* + PSB + DAP) over control plot.

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
T_1 (Control (No fertilizer)	12.7	25.3	37.1	39.1
T_2 (*Rhizobium* (20g/kg seed)	13.2	27.1	40.3	42.3
T_3 PSB (20g/kg seed)	13.0	26.1	37.9	39.9
T_4 (DAP)	13.9	27.3	42.5	44.3
T_5 (*Rhizobium* + PSB)	13.7	26.4	39.6	41.4
T_6 (*Rhizobium* + DAP)	14.3	27.8	42.7	44.6
T_7 (PSB + DAP)	14.7	26.8	39.2	41.1
T_8 (*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

At 60 DAS, plant height ranged from 25.3 to 28.7 cm. The maximum plant height (28.7 cm) recorded in T_8 (*Rhizobium* + PSB + DAP) was statistically at par to plant height measured in T_2, T_3, T_4, T_5, T_6 and T_7 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 T_8 treatment was increased by 13.4% over control (T_1). At 90 DAS, plant height ranged from 37.1 to 43.2 cm. The maximum plant height (43.2 cm) recorded in T_8 (*Rhizobium* + PSB + DAP), which was statistically at par to T_2, T_4, T_5, T_6, and T_7 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 T_8 treatment was increased by 16.4% over control (T_1).

At harvest of chickpea, the plant height was ranged from 39.1 to 45.1 cm. The maximum plant height (45.1 cm) found in T_8 (*Rhizobium* + PSB + DAP) was significantly superior to rest of the treatments, which was statistically at par with T_2, T_4,

T_5, T_6 and T_7, while minimum (39.1cm) was observed in control (T_1).

3.1.2 Number of branches plant^{-1}

The data on number of branches counted at 30, 60, 90 DAS and at harvest as affected by different treatments are presented in Table 3.

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
T_1 (Control (No fertilizer)	2.1	3.6	5.1	4.8
T_2 (*Rhizobium* (20g/kg seed)	2.3	5.7	8.3	7.5
T_3 PSB (20g/kg seed)	2.3	4.9	7.2	6.3
T_4 (DAP)	2.6	5.1	7.5	6.7
T_5 (*Rhizobium* + PSB)	2.5	4.6	6.7	5.8
T_6 (*Rhizobium* + DAP)	2.6	5.4	7.9	7.3
T_7 (PSB+ DAP)	2.8	6.6	9.0	8.3
T_8 (*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 T_4, T_6 and T_7 the maximum number of branches (2.9 plant^{-1}) recorded in T_8 (*Rhizobium* + PSB + DAP) were significantly superior to rest of the treatments while, minimum number of branches (2.1 plant^{-1}) counted in T_1 (control). At 60 DAS, number of branches ranged from 3.6 to 6.9 plant^{-1}. With exception of T_7 the maximum number of branches (6.9 plant^{-1}) recorded in T_8 (*Rhizobium* + PSB + DAP) were significantly superior to rest of the treatments while, minimum number of branches (3.6 plant^{-1}) counted in T_1 (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 T_8 (*Rhizobium* + PSB + DAP), while minimum number of branches (5.1 plant^{-1}) in control (T_1). Number of branches in T8 (Rhizobium + PSB + DAP) were significantly higher the number of branches counted in remaining treatments with exception of T_7. At harvest, number of branches ranged from 4.8 to 8.6 plant^{-1}. The maximum number of branches (8.6 plant^{-1}) were recorded in T_8 (*Rhizobium* + PSB + DAP), while minimum number of branches (4.8 plant^{-1}) in control (T_1). Number of branches in T_8 (*Rhizobium* + PSB + DAP) were significantly higher the number of branches counted in remaining treatments with exception of T_7.

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 stage 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 T_8 (30.9 plant^{-1}), which was statistically at par to treatments T_7 (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 (T_1). Number of nodules plant^{-1} increased by 80.7% in T_8 (*Rhizobium* + PSB + DAP) over control (T_1).

At 75 DAS, maximum number of nodules recorded with application of *Rhizobium* + PSB+ DAP in treatment T_8 (27.6 plant^{-1}) followed by T_7 (PSB + DAP) and significantly higher than the rest of treatments, while minimum number of nodules recorded (14.6 plant^{-1}) in control plot (T_1). Number of nodules plant^{-1} increased by 89.0% in T_8 (*Rhizobium* + PSB + DAP) over control (T_1).

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±	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 T8 (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_7 (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±	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_4, 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).

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

Treatments	Yield attributes		
	Number of pods plant^{-1}	Number of seed pod^{-1}	Test weight (g)
T_1 (Control (No fertilizer)	29.5	2.0	161.2
T_2 (*Rhizobium* (20g/kg seed)	30.7	2.3	163.4
T_3 PSB (20g/kg seed)	30.2	2.4	162.3
T_4 (DAP)	32.4	2.4	168.5
T_5 (*Rhizobium* + PSB)	31.2	2.3	172.0
T_6 (*Rhizobium* + DAP)	32.5	2.6	182.5
T_7 (PSB+ DAP)	32.6	2.3	185.0
T_8 (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

3.2.2 Number of seed pod^{-1}

At harvest, higher numbers of seed recorded (2.6 pod^{-1}) with the application of T_6 (*Rhizobium* + DAP), which was statistically at par to T_8, and significantly higher than the rest of treatments, while minimum numbers of seeds recorded (2.0 pod^{-1}) in control plot (T_1).

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 T_8 (Rhizobium + PSB + DAP) and minimum (161.2 g) recorded in control (T_1).

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 T_6 (*Rhizobium* + DAP) and T_7 (PSB + DAP) and significantly higher than remaining treatments was found in T_8 (Rhizobium + PSB + DAP), while minimum significantly lower than the rest of treatments in control plot (T_1).

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 T_7 (PSB + DAP) and significantly higher than remaining treatments was found in T_8 (Rhizobium + PSB + DAP). Minimum grain yield (13.4 q ha^{-1}) significantly lower than the rest of the treatments was found in control (T_1). Significantly higher yield was obtained with the *Rhizobium* and PSB inoculation of application of in treatment T_8 (Rhizobium + PSB + DAP). The grain yield increased by 39.5% in T_8 (Rhizobium + PSB + DAP) over control (T_1).

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 T_6 (*Rhizobium* + DAP) and T_7 (PSB + DAP) and significantly higher than the rest of the treatments was found in T_8 (Rhizobium + PSB + DAP), while minimum (18.1 q ha^{-1}) in control (T_1). In comparison to T_1 (Control) straw yield increased by 59.7% in T_8 (Rhizobium + PSB + DAP).

Table 7: Effect of *Rhizobium* and PSB inoculation on yield (q ha^{-1}) and harvest index of chickpea

Treatments	Yield (q ha^{-1})			Harvest Index
	Grain	Straw	Biological	
T_1 (Control (No fertilizer)	13.4	18.1	31.5	42.5
T_2 (*Rhizobium* (20g/kg seed)	15.3	20.3	35.6	43.0
T_3 PSB (20g/kg seed)	14.2	19.5	33.7	42.1
T_4 (DAP)	17.2	24.1	41.3	41.6
T_5 (*Rhizobium* + PSB)	16.3	22.7	39.0	41.8
T_6 (*Rhizobium* + DAP)	17.8	25.1	42.9	41.5
T_7 (PSB+ DAP)	18.2	26.2	44.4	41.0
T_8 (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

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 T_2 (*Rhizobium* (20g/kg seed) than rest of the treatments during the study. Lowest harvest index (39.3%) was recorded in T_8 (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 T_8 (*Rhizobium* + PSB+ DAP), while shortest measured in control (T_1).

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 $plnat^{-1}$) were recorded in T_8 (*Rhizobium* + PSB+ DAP) at 30, 60, 90 DAS and harvest stage, respectively. However, lowest numbers of branches were recorded in control (T_1).

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 recorded in T_8 (*Rhizobium* + PSB+ DAP). However, lowest number of nodules and their fresh and dry weights were recorded in control (T_1).

The dry matter accumulation in chickpea was significantly affected by different treatments. The highest dry matter accumulation of 2.1, 13.7, 27.4 and 29.7 g $plant^{-1}$ found in T_8 (*Rhizobium* + PSB+ DAP) at 30, 60, 90 DAS and at harvest stage of chickpea, respectively. However, the lowest values were recorded in control (T_1), 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 T_8 (*Rhizobium* + PSB+ DAP). The grain yield increased by 39.5% in T_8 (Rhizobium + PSB + DAP) over control (T_1).

From the above study, it is concluded that the application of DAP with *Rhizobium* and PSB inoculation (T_8, *Rhizobium* + PSB+ DAP) gave best results and proved to be beneficial for Kabuli chickpea (Kabuli).

5. References

1. Dakshayini G, Reddy JB, Kumar SC. Evaluation of the efficient Phosphate Solubilising Bacteria on growth of chickpea under greenhouse conditions. Advances in Life Sciences. 2016; 5(2):662-666.
2. Khatkar R, Abraham T, Joseph SA. Effect of biofertilizers and sulphur levels on growth and yield of urdbean (*Vigna mungo* L.). Legume Research. 2015; 30(3):233-234.
3. Naganoyam, Bidyarani R, Babu S, Hussain F, Saxena AK. Enhancement of plant growth and yields in chickpea through novel *cyanobacteria* and bio filmed inoculants. Microbiological Research, 2016, 97-105.
4. Mohammad I, Yadav BL, Ahmed A. Effect of Phosphorus and Bio Organics on yield and soil fertility status of mungbean [*Vigna radiata* (L.)] Wilezek under semi-arid condition of Rajasthan, India. International

Journal of Current Microbial Applied Science. 2017; 6(3):1545-1553.
5. Monika Rana, Chandra R, Prateek N. Co-inoculation effect of Endophytic Bacteria with *Mesorhizobium sp*. in chickpea on nodulation, yields, Nutrient uptake and Soil Biological properties. Journal of Indian Society of Soil Science. 2015; 63(4):429-435.
6. Sadhana B. Interaction effect of AM Fungi, *Rhizobium* and draught stress on chickpea. Asian Journal of Science and Technology. 2014; 5(12):819-827.
7. Saha S, Samad R, Rashid P, Karmoker JL. Effect of sulphur deficiency on growth, sugars, proline and chlorophyll content in mungbean (Vigna radiata L. var. Bari mung-6). Bangladesh Journal of Botany. 2016; 45(2):405-410.
8. Singh Raghvendra, Singh V, Singh P, Yadav RA. Effect of phosphorus and PSB on yield attributes, quality and economics of summer greengram (*Vigna radiata* L.). Journal of Pharmacognosy and Phytochemistry. 2018; 7(2):404-408.
9. Singh A, Sachan AK, Pathak RK, Srivastav S. Study on the effect of PSB and *Rhizobium* with their combinations on nutrient concentration and uptake of chickpea. Journal of Pharmacognosy and Phytochemistry. 2018; 7(1):1591-1593.
10. Surya Kant, Kumar A, Kumar S, Kumar V, Gurjar OP. Effect of Bio-fertilizers and P-levels on Yield, Nutrient Content, Uptake and Physico-Chemical Properties of Soil under Black gram (*Vigna mungo* L.). International Journal of Current Microbiology and Applied Sciences 2017; 6(3):1243-1251.
11. Yadav SL, Verma A, Nepalia V. Effect of P, S and nutrient uptake in chickpea. Research on Crops. 2016; 17(3):496-502.