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Effect of *Rhizobium*, PSB and Mo on the Growth of Different Varieties of Kabuli Chickpea (*Cicer kabulinum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

The present investigation was conducted with the objective of finding out the Effect of *Rhizobium*, PSB and Mo on the Growth of Different Varieties of Kabuli Chickpea. The study comprised six treatments of Inoculants I_1-Control, I_2-*Rhizobium(Rh.)*+phosphate solubilizing bacteria (PSB) seed inoculation, I_3-Molybdenum (Mo)@0.5 g AM* kg^{-1} seed, I_4-Molybdenum @1.0 g AM kg^{-1} seed, I_5-*Rh.*+PSB+Mo seed treatment @0.5g AM kg^{-1} seed, I_6-*Rh.*+PSB+Mo seed treatment 1.0g AM kg^{-1} seed and two varieties V1-RVSJKG 102, V2-Phule G 0517, evaluated in Factorial randomized block design (FRBD) with three replications. The results of the present study revealed that the seed inoculation, I_6*Rh.*+ PSB + Mo@1 g AM kg^{-1} seed was found to be the best among other inoculants with respect to growth in chickpeas, and Variety Phule G 0517 produced higher values of growth and yield attributing.

Keywords: Seed inoculation; molybdenum; phosphate solubilizing bacteria (PSB); rhizobium; chickpea; CGR; RGR; varieties..

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1. INTRODUCTION

"India is the world's largest producer of pulse(25% of global production) consumer (27% of global consumption) and importer (14%) of pulses in the world. The English word pulse is taken from the Latin puls, meaning pottage or thick pap. Pulse is an important source of protein" [1]. "These food legumes have been grown by farmers since millennia providing nutritionally balanced food to the people" [2]. "The major pulse crops that have been domesticated and are under cultivation are black gram, chickpea, cowpea, mung bean, lentil, moth bean, pea and pigeon pea etc". Chickpea (*Cicer arietinum* L.) belongs to family fabaceae originated in south-eastern turkey and derived from the Greek word 'kikus' meaning force or strength. Chickpea is known by various names in different countries like- garbanzo in *Spanish*, kichar or chicher in *German,* pois chiche in *French*, chana in Hindi and gram or bengal gram in English. In some countries of the world (Turkey, Romania, Bulgaria, Afghanistan) it is also called 'nakhut' or 'nohut'. "In addition to being used to make a range of snacks, sweets, and sauces that are extremely beneficial for blood cleansing and stomach illnesses, chickpea is primarily consumed in the form of processed whole-seed and Dal. The primary source of high quality and nutritional value in livestock feed is pulses and their crop wastes. Chickpea contains 18-22 per cent protein, 52-70 per cent carbohydrate, 4-10 per cent fat and sufficient quantity of minerals, calcium, phosphorus, iron and vitamins" [3]. "It also contains 50% Oleic and 40% Linolic acid. Chickpea is considered to sustain cropping system productivity due to its ability to fix atmospheric nitrogen. It can fix about N 25-30 kg/ha through symbiosis [4] and these minimize dependency on chemical fertilizers"."Many legumes have the ability to form nitrogen (N2) fixing root nodules with soil bacteria called rhizobia [5] and thus contribute to biological nitrogen fixation". In this way an appreciable amount of free of cost nitrogen is deposited in the soil which can be used by the same crop and the subsequent one. The efficiency of such crop in fixing maximum nitrogen depends on the cultivar, efficient strain and management practices.

"Artificial seed inoculation of chickpea in soils lacking native effective rhizobia is a Very useful practice for improving root nodulation and yield of the crop" [6]. "Microbial inoculants are cost effective, eco-friendly, and renewable sources of plant nutrients" [7]. "*Rhizobium* and phosphate solubilizing bacteria (PSB) assume great importance on account of their vital role in N_2-fixation and P-solubilisation. Use of *Rhizobium* and PSB has shown advantage in enhancing chickpea productivity" [8]. "PSB is the cheapest source to improve P availability, particularly in legumes, which increases agricultural yield, It possess the ability to bring sparingly soluble inorganic or organic phosphates into soluble form by secreting organic acids. In soils with a high organic matter content but little accessible phosphorus, phosphobacterin is present. A crucial characteristic in sustainable farming for boosting plant yields is PSB capacity to transform insoluble forms of P into an accessible form.Further, the efficiency of N_2 fixation can be increased by seed dressing with Molybdenum (Mo). Micronutrient deficit causes a large yield loss in chickpea" [9]. "Because it is an essential component of the enzymes nitrate-reductase, nitrogenase, xanthine-reductase, and SO3-oxidase, molybdenum (Mo) plays a crucial role in critical processes such as nitrogen metabolism, nitrogen-fixation and the transportation of sulfur-containing amino acids in legumes" [10]. "Mo is required for growth of most biological organisms including plants" [11]. Keeping in the view the above facts, the present experiment was to beundertaken to find out "Response of Kabuli Chickpea *(Cicer kabulinum* L.*)* Varieties to Seed Inoculation with Biofertilizers and Supplementation with Molybdenum"

2. MATERIALS AND METHODS

This experiment was laid out during the Rabi season of 2016-17 at the ICARDA-IRP, Amlaha, Sehore (M.P.), India. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications and comprised of twelve treatment combination.The treatment included six inoculants, with two kabuli chickpea varieties to estimate the individual or combined effect of various treatment on production and symbiotic traits at field level. The soil condition of the experimental field was good health with proper drainage system, soil status tested in Soil Science laboratory (Department of Soil Science and Agricultural Chemistry) at R.A.K. College of Agriculture, Sehore. The soil was medium clay loam (vertisol), low in available nitrogen, medium in phosphorus, and high in available potash with Neutral pH. Data recorded on different aspects of crop, viz., growth, yield attributes were subjected to statistically analysis by analysis of variance method and economic data analysis mathematical method.

2.1 Different Physiological Parameters were Calculated by Following Formulas

Crop growth rate (CGR, g m^{-2} day^{-1}): It is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the following formula and expressed as g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{P(t_2 - t_1)}$$

Where, W_2 and W_1 are dry matter of preceding and succeeding stages and t_2 and t_1 represent the time period at which W_2 and W_1 were recorded. P is the ground area.

Relative growth rate (RGR, g g^{-1}day^{-1}): Relative growth rate (RGR) is also a measure used to quantify the speed of plant growth. It expresses the dry weight increase in time interval in relation to the initial weight and is expressed in g/day. It is also called efficiency index. It was proposed by Fisher (1958).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the dry weights (g) at times t_2 and t_1 respectively.

Table 1. Details of the treatments

A. Inoculants- 06		
I_1 : Control		
I_2 : *Rhizobium (Rh.)* + phosphate solubilizing bacteria (PSB) seed inoculation.		
I_3 : Molybdenum (Mo)@0.5 g AM* kg^{-1} seed		
I_4 : Molybdenum @1.0 g AM kg^{-1} seed		
I_5 : *Rh.*+PSB+Mo seed treatment @0.5g AM Kg^{-1} seed		
I_6 : *Rh.*+PSB+Mo seed treatment 1.0g AM kg^{-1} seed		
B. Variety – 02		
V_1 : RVSJKG 102		
Treatment combination :		
T_1 - I_1V_1	T_5 - I_3V_1	T_9 - I_5V_1
T_2 - I_1V_2	T_6 - I_3V_2	T_{10} - I_5V_2
T_3 - I_2V_1	T_7 - I_4V_1	T_{11} - I_6V_1
T_4 - I_2V_2	T_8 - I_4V_2	T_{12} - I_6V_2

3. RESULTS AND DISCUSSION

3.1 Result

3.1.1 Plant height (cm)

Plant height is an important character of the vegetative phase and indirectly influences the yield components. The plant height was periodically recorded at 30 days interval starting from 30 days, up to maturity stage. The analyzed data is presented in Table 2. Data indicated that under all the treatment plant height increased up to 90 DAS and there after found stable until maturity .The periodical increment was almost uniform up to 90 DAS.The plant height was differed significantly due to seed inoculation at all the growth stages of chickpea except at 30DAS. Amongst the six seed inoculants, I_6 (*Rh*+PSB+Mo@1AMkg^{-1}seedinoculation) recorded significantly maximum plant height (60.89 cm as compared to the other treatments at 60 DAS, but it was on par with I_2 (*Rhizobium* +PSB), I_3 (Mo Seed treatment @ 0.5 g AM kg^{-1} seed) and I_5(*Rh.*+PSB+Mo seed treatment @0.5g AM kg^{-1} seed), whereas I_2 (*Rh.*+PSB, 68.28 cm) was recorded significantly maximum at 90 DAS but it was on par with all other inoculant treatments except I_1 (Control).At maturity, the result was same as 90 DAS on plant height.The variation in plant height in both the varieties was significant at all the stages of plant growth. V_2 (Phule G 0517) gave significantly superior plant height at all the stages (28.11, 60.24, 67.44 and 64.83 cm, at 30, 60, 90 DAS and at maturity respectively) as compared to V_1 (RVSJKG 102).

The interaction between variety and seed inoculation (V×I) didn't show any significant effect on plant height at all successive growth stage.

3.1.2 Number of branchesplant^{-1}

The number of branches per plant at different growth stages is presented in Table 2. It is revealed from the data that the number of primary branches per plant continuously increased up to 90 DAS under all treatments and thereafter it was constant up to maturity stage.The number of branches per plant was also significantly influenced by seed inoculation at all the stage except 30 DAS.At 60 DAS seed inoculantion with I_5 *(Rh.* + PSB + Mo@0.5 g AM kg^{-1} seed) recorded significantly higher branches(17.55 plant^{-1}) than all the other treatment. but it was on par with seed inoculation with I_6 *(Rh.*+ PSB + Mo @1 g AM kg^{-1} seed) however I_6 *(Rh.*+ PSB + Mo @1 g AM kg^{-1} seed) was observed higher values at 90 DAS and at harvest but it was on par with I_5 (*Rh.*+ PSB +Mo seed treatment @ 0.5 g AM kg^{-1} seed) and I_4 (Mo Seed treatment @ 1 g AM kg^{-1} seed). The significant difference in number of branches per Plant was found at all 30, 60, 90 DAS and maturity stages due to varieties. Variety, V_2 (Phule G 0517) recorded significantly higher branches per plant at all the growth stages (12.43, 16.57, 26.17 and 26.17, at 30,60,90 and at maturity respectively) than V_1 (RVSJKG 102).

Interaction effect between seed inoculation and variety (I×V) was found non-significant at all the growth stages.

3.1.3 Number of root nodules plant^{-1}

The variation in number of root nodules due to different seed inoculation was recorded significant effect at all the stages of crop growth (Table 3).

Data showed that the increase of root nodules per plant significantly higher in I_6 (*Rh.* + PSB + Mo@1 g kg^{-1} seed) at both 30, 45 and 60 DAS (18.72, 27.28 and 39.88 per plant, respectively) than all other treatment but it was on par with I_5 (*Rh.*+ PSB + Mo@ 0.5 g AM kg^{-1} seed) at 30 @ 90 DAS. Varietal effect on root nodules recorded non-significant at 30 DAS stage of observation. Variety, V_2 (Phule G 0517) recorded highest root nodules at 45 and 60 DAS stages of observation (19.52 and 30.10 per plant, respectively) than V_1(RVSJKG 102).

Inoculants and varieties interaction (I×V) effect on number of root nodules found non-significant.

3.1.4 Dry weight of root nodules plant^{-1} (mg)

The data on dry weight of root nodules per plant was recorded at 45 and 60 DAS under different treatments and is presented in Table 3.The data indicated that application of inoculants significantly increased nodule dry weight at both the stages. Treatment I_6 recorded significantly higher nodules dry weight (98.55 and 150.27 mg plant^{-1}) over all the other inoculants at 45 and 60 DAS.With regards to varieties, nodule dry weight showed non-significant differences. However, V_2 recorded numerically higher values at both the stages.

The interactions (IxV) at 45 DAS found non-significant, but at 60 DAS, $I_6 \times V_2$ recorded significantly higher nodules dry weight than other treatments which was on par with $I_6 \times V_1$ and $I_5 \times V_2$.(Table 4).

3.1.5 Dry weight plant^{-1}(g)

The data on Plant dry weight (g plant^{-1}) recorded at 40, 60 DAS and physiological maturity stage under different treatments are presented in Table 5. Dry matter accumulation in plant was influenced significantly at all stages of observation due to seed inoculations. Treatment I_6 (*Rh.* + PSB + Mo seed treatment @ 1.0 g kg-1 seed) recorded significantly superior dry matter weight per plant at 40 DAS, 60 DAS and at maturity stages (4.93, 9.88 and 24.80 g plant^{-1}, respectively) than all the other inoculants. Minimum value recorded due to inoculant I_1 (Control) at 40,60 DAS and at maturity stages(2.58, 4.99, and 12.91 g plant^{-1}, respectively).

There was also significantly superior effect on dry matter accumulation observed due to variety V_2 (Phule G 0517) at 40,60 DAS and at maturity (3.93, 7.77, 19.64 g plant^{-1},respectively) over V_1 (RVSJKG102) at the same growth stages (3.48, 6.42 and 17.92 g plant^{-1}, respectively).

Interaction effect of seed inoculants and varieties (V×I) was non-significant on plant dry matter at all the growth stages

3.1.6 Crop growth rate (CGR, g m^{-2} d^{-1})

The crop growth rate at different periods of the crop growth stages is presented in the Table 6. Crop growth rate is the most important phenomenon to evaluate growth of plant at all stage. Data indicated that there were significant differences among the inoculants at 30-60 and 60-90 DAS interval, inoculants I_6 (*Rh.* + PSB + Mo seed treatment @ 1.0 g AM kg-1 seed) showed significantly superior CGR at 30-60 and 60-90 Day interval (8.21 and 24.86 g m^{-2} day^{-1}, respectively). Minimum value obtained of CGR at the same growth period due to I_1(Control) (4.01 and 13.21 g m^{-2} day^{-1},respectively).

Similarly, the effect of varieties on CGR was also found significantly superior at 30-60 DAS. At 60-90 DAS interval, CGR (6.41 and 19.78 g m^{-2} d^{-1}) was significantly higher with variety V_2 (Phule G 0517) at 30-60 and 60-90 Day interval, respectively than V_1 (RVSJKG 102) (5.73 and 17.50 g m^{-2} day^{-1}) at the same growth duration.

The interaction effect between seed inoculants and varieties (IxV) on CGR was found non-significant at both stages of plant growth.

3.1.7 Relative growth rate (RGR, g g^{-1}d^{-1})

The relative growth rate of chickpea at different periods of crop growth is presented in Table 6. Data recorded at 40-60 and 60-80 days interval

Table 2. Plant height (cm) and Number of branches plant^{-1} of chickpea as influenced by seed inoculants and varieties

Treatments	**Plant height (cm)**				**Number of branches plant^{-1}**			
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**	**30 DAS**	**60 DAS**	**90 DAS**	**Maturity**
Seed inoculants (I)								
I_1 : Control	26.00	52.05	62.16	62.16	11.67	15.22	21.67	21.67
I_2 : *Rhizobium*+ PSB	25.78	57.11	68.28	68.28	11.56	15.33	24.33	24.33
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	26.45	57.33	68.22	68.22	12.17	15.66	24.06	24.06
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	27.72	54.33	64.89	64.89	11.89	16.11	24.72	24.72
I_5: *Rh.*+ PSB +Mo seed treatment @ 0.5 g AM kg^{-1} seed	26.78	60.05	65.00	65.00	11.94	17.55	25.00	25.00
I_6:*Rh.* + PSB +Mo seed treatment @ 1.0 g AM kg^{-1} seed	27.72	60.89	68.27	68.27	12.78	17.50	26.89	26.89
S.Em ±	1.30	1.41	1.44	1.44	0.35	0.23	0.75	0.75
CD5%	NS	**4.14**	**4.22**	**4.22**	**NS**	**0.68**	**2.19**	**2.19**
Varieties : 02								
V_1 : RVSJKG 102	25.37	53.68	64.83	64.83	11.57	15.88	22.72	22.72
V_2 : Phule G 0517	28.11	60.24	67.44	67.44	12.43	16.57	26.17	26.17
S.Em ±:	0.75	0.81	0.83	0.75	0.20	0.40	0.43	0.43
CD5%	2.21	**2.39**	**2.43**	**2.43**	**0.59**	**1.18**	**1.26**	**1.26**
Interactions (I×V)								
S.Em±	1.84	1.99	2.03	2.03	0.49	0.40	1.05	1.05
C.D. (p=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

DAS : days after sowing **;NS** : Non-significant **;AM** : Ammonium Molybdate

Table 3. Number of nodules plant^{-1}and Dry weight of root nodules plant^{-1} (mg) of chickpea as influenced by the seed inoculants and different varieties

Treatments	Number of nodules plant^{-1}			Dry weight [root nodules plant^{-1} (mg)]	
	30 DAS	**45 DAS**	**60 DAS**	**45 DAS**	**60 DAS**
Seed Inoculants (I)					
I_1 : Control	9.89	10.94	14.05	42.00	48.89
I_2 : *Rhizobium*+ PSB	12.77	13.44	19.44	46.22	55.16
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	14.44	16.94	27.27	54.05	89.05
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	15.61	18.94	32.94	68.27	112.10
I_5: *Rh.*+ PSB +Mo seed treatment@0.5 g AM kg^{-1} seed	16.72	21.61	36.11	79.94	108.16
I_6:*Rh.* + PSB +Mo seed treatment @ 1g AM kg^{-1} seed	18.72	27.28	39.88	98.55	150.27
S.Em ±	101	1.29	1.51	4.97	6.87
CD5%	**2.96**	**3.78**	**4.41**	**14.58**	**20.14**
Varieties : 02					
V_1 : RVSJKG 102	14.11	16.87	26.46	61.63	83.40
V_2 : Phule G 0517	15.27	19.52	30.10	68.05	104.48
S.Em ±:	0.58	0.74	0.87	2.87	3.96
CD5%	**NS**	**2.18**	**2.55**	**NS**	**NS**
Interactions (I×V)					
S.Em±	1.43	1.83	2.13	7.03	9.71
C.D. (*p*=0.05)	**NS**	**NS**	**NS**	**NS**	**28.48**

DAS : days after sowing **;NS** : Non-significant

Table 4. Dry weight of root nodules per plant of chickpea at 60 DAS influenced by the interaction of seed inoculants and varieties

Variety	Inoculant					
	I_1	**I_2**	**I_3**	**I_4**	**I_5**	**I_6**
V_1 RVSJKG 102	41.55	44.11	76.99	113.76	75.33	148.66
V_2 Phule G 0517	56.22	66.22	101.11	110.44	141.00	151.88
S.Em±			9.71			
C.D at 5%			**28.48**			

Table 5. Dry weight per plant (g) as influenced by seed inoculants and varieties

Treatments	**Dry weight per plant (g)**		
	40 DAS	**60 DAS**	**Maturity**
Seed Inoculants (I)			
I_1 : Control	2.58	4.99	12.91
I_2 : *Rhizobium*+ PSB	2.91	5.81	14.56
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	3.69	7.32	18.43
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	3.83	7.61	19.13
I_5: *Rh.*+ PSB +Mo seed treatment@ 0.5 g AM kg^{-1} seed	4.27	8.47	21.36
I_6:*Rh.* + PSB +Mo seed treatment@1 g AM kg^{-1} seed	4.96	9.88	24.80
S.Em ±	0.21	0.44	1.06
CD5%	**0.62**	**1.29**	**3.11**
Varieties : 02			
V_1 : RVSJKG 102	3.48	6.92	17.42
V_2 : Phule G 0517	3.93	7.77	19.64
S.Em ±:	0.12	0.25	0.61
CD5%	**0.36**	**0.75**	**1.80**
Interactions (I×V)			
S.Em±	0.30	0.62	1.50
C.D. (*p*=0.05)	**NS**	**NS**	**NS**

DAS : days after sowing **;NS** : Non-significant **;AM** : Ammonium Molybdate

Table 6. Crop growth rate ($gm^{-2}d^{-1}$) and relative growth rate ($g\ g^{-1}\ d^{-1}$) as influenced by seed inoculants and varieties

Treatments	Crop growth rate (CGR) ($g\ m^{-2}\ day^{-1}$)		Relative growth rate (RGR) ($g\ g^{-1}\ d^{-1}$)	
	30 - 60 Day interval	**60 - 90 day interval**	**30 – 60 day interval**	**60 – 90 day interval**
Seed Inoculants (I)				
I_1 : Control	4.01	13.21	0.01	0.02
I_2 : *Rhizobium*+ PSB	4.83	14.59	0.01	0.02
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	6.05	18.51	0.01	0.02
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	6.30	19.21	0.01	0.02
I_5: *Rh.*+ PSB +Mo seed treatment@ 0.5 g AM kg^{-1} seed	7.00	21.48	0.01	0.02
I_6:*Rh.* + PSB +Mo seed treatment @ 1g AM kg^{-1} seed	8.21	24.86	0.01	0.02
S.Em ±	0.39	1.04	0.0001	0.0001
CD5%	**1.13**	**3.05**	**0.0004**	**0.0004**
Varieties : 02				
V_1 : RVSJKG 102	5.73	17.50	0.01	0.02
V_2 : Phule G 0517	6.41	19.78	0.01	0.02
S.Em ±:	0.22	0.60	0.00	0.00
CD5%	**0.65**	**1.76**	**NS**	**NS**
Interactions (I×V)				
S.Em±	0.55	1.47	0.0002	0.0002
C.D. (*p*=0.05)	**NS**	**NS**	**NS**	**NS**

DAS : days after sowing **;NS** : Non-significant **;AM** : Ammonium Molybdate

showed that RGR was minimum at early growth stage and there after it increased with advancement of time and were found statistically significantly higher due to inoculant I_6 (*Rh.* + PSB + Mo @ 1g AM kg^{-1} seed) at 30-60 and 60-90 day interval. Varital and Interaction (I×V) effect were found non-significant on RGR.

3.2 Discussion

3.2.1 Plant height and number of branches

"Growth attributing characters *viz*. plant height , number of primary and secondary branches are the important parameters that contribute to yield of crop. These parameters significantly increased due to supplementation of various seed inoculants *Rh.*, PSB and Mo at all the growth stages except 30 DAS. Seed inoculants with *Rh.*+ PSB + Mo might have favored the microbial activity and mineral nutrition in crops which resulted better plant height , number of primary and secondary branches at various stages of crop growth. Significant increase in plant height and number of branches with use of I_6 (*Rh.* + PSB + Mo @ 1g AM kg^{-1} seed inoculants) might be due to enhanced nitrogen fixation by increased nitrogenase and nitrate reductase activities due to Mo seed inoculation along with *Rh.* + PSB" [12,13]. "However variety effect was also found significant effect on growth attributing character like plant height and number of branches at all growth stages of plant. Phule G 0517 produced taller plants at all the stages, whereas the number of primary and secondary branches also produced maximum in Phule G 0517 at all the stages. The differential behavior of Kabuli chickpea varieties with respect to these characters could be explained solely by the variation in their genetic makeup and adaptability to soil and climatic conditions" [14-16].

3.2.2 Number and dry weight of root nodules plant^{-1}

"The application of the inoculants affects the nodulation in chickpea.the highest number of nodules per plant. For that parameter, the highest number of nodules per plant and nodule dry weight were recorded when the seeds were inoculated with I_6 (*Rh.* + PSB + Mo @ 1g AM kg^{-1} seed)at all the growth stages. The significant positive effect of high rates of inoculation (high number of rhizobia per seed) have been demonstrated (Date, 2001). The High number of viable cells on the seed is an important criterion for good nodulation" [17,18].

Variety influence on nodule number and nodule dry weight was not significant, except Number of nodules per plant at 45 and 60 DAS. The highest nodule number and nodule dry weight were produced by the variety PHULE G 0517 followed by the RVSJKG 102. This variation among the varieties was also noticed by the result [19].

3.2.3 Dry weight plant^{-1}, Crop growth rate (CGR) and Relative growth rate (RGR)

The analysis of variance indicated that the effect of seed inoculants was found to be significant on plant dry weight, CGR and RGR throughout crop growth period. The seed inoculation with I_6 (*Rh.* + PSB + Mo @ 1 g AM kg^{-1} seed) recorded highest dry weight per plant at various stages of crop growth which might be due to enhanced microbial activity through inoculated rhizobia along with molybdenum application which favorably increase the dry weight per plant. Where I_6 (*Rh.* + PSB + Mo@1 g kg^{-1} seed) seed inoculants found maximum crop growth and relative growth rate followed by I_5 (*Rh* .+ PSB + Mo@0.5 g kg^{-1} seed).The similar result was also reported by [20,21].

Variety effect on plant dry weight and CGR was found significant while non-significant effect on RGR. Dry weight per plant, CGR and RGR were found maximum by Phule G 0517 followed by RVSJKG 102. This shows that , the varieties studied had equal crop growth and plant dry weight potential. The reason behind that the conditions for growth were similar, so producing similar dry matter attest to the fact that, the growth potentials were similar growth condition is indication of similar potential.

4. CONCLUSIONS

1. The seed inoculation *Rh*+ PSB + Mo@1 g AM kg^{-1} seed was found to be the best among other inoculants with respect to productivity and profitability in chickpea.
2. Variety Phule G 0517 produced higher values of growth and yield attributing parameters and seed and biological yields of kabuli chickpea.
3. Treatment combination *Rh.*+ PSB + Mo@1 g AM kg^{-1} seed with Phule G 0517 produce higher pods per plant, seeds per pod, seed yield per plant, however *Rh.* + PSB with Phule G 0517 on seed index prove better combinations for higher production and yield component.

5. SUGGESTIONS FOR FUTURE WORK

In order to confirm the result the experiment may be repeated over years and locations with more accuracy. The investigation may be tested with some other promising varieties, *rhizobium* strains and levels of ammonium molybdate inoculation may be used.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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