Original Research Article

Response of Kabuli Chickpea (*Cicer kabulinum* L.) Varieties to Seed Inoculation with Biofertilizers and Supplementation with Molybdenum

ABSTRACT

The present investigation was conducted during*rabi* season 2016-17 at ICARDA, Amlaha farm, Sehore to study the supplementation of Mo along with *Rhizobium* + PSB inoculation in chickpea cultivars on biological nitrogen fixation and productivity.Research title“Response of Kabuli Chickpea *(Cicer kabulinum*L.*)* Varieties to Seed Inoculation with Biofertilizers and Supplementation with Molybdenum”.Six inoculants,with two kabuli chickpea varietiesevaluated in Factorial randomized block design(FRBD) with three replications.The results of present study revealed The seed inoculation, I_6*Rh.*+ PSB + Mo@1 g AMkg^{-1} seed was found best among other inoculants with respect to productivity and profitability in chickpea, and Variety Phule G 0517 produced higher values of growth and yield attributing .

*Keywords:Seed Inoculation;*A M - *Ammonium Molybdate;Chickpea;Rhizobium;Varieties.*

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a legume crop of the Fabaceae family, Faboideae subfamily. It originated in southeastern Turkey [12].The name Cicer is of Latin origin, derived from the Greek word 'kikus' meaning force or strength. It is also known as gram or Bengal gram, garbanzo or garbanzo bean, and is sometimes known as Egyptian pea, or chana. In Turkey, Romania, Bulgaria, Afghanistan, and adjacent parts of Russia, chickpea is called 'nakhut' or 'nohut' [20].There are two different kinds of chickpea, Desi and Kabuli, based on the size, shape and color of the seeds. Kabuli type is grown in temperate regions while the desi type chickpea is grown in the semi-arid tropics [13,15].Nutritionally, it contains 24% protein, 59.6% carbohydrates and 3.2% minerals [1].It has the ability to fix atmospheric nitrogen and can also tolerate high temperatures during and after flowering [3].It is one of the earliest cultivated legumes: 7,500-year-old remains have been found in the Middle East [2].

During 2021-22 (fourth estimate),chickpea production of India was 13.75 million tonnes from an acreage of 10.91 million ha. with a productivity of 12.6 q./ha (DES 2023,MOAF&W,GoI).Chickpea,solelycontributes nearly 50% of the Indian pulse production. States like Maharashtra (25.97% contribution to national production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%) and Uttar Pradesh (5.64%) are major chickpea producing states of India. (ICAR-IIPR Report)

Chickpea is considered to sustain cropping system productivity due to its ability to fix atmospheric nitrogen. This crop possess nodules on its roots where bacteria of the genus *Rhizobium* live with a specific function of converting the atmospheric nitrogen into plant available form called biological nitrogen fixation (BNF). 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 upon the cultivar, efficient strain and management practices. Artificial seed inoculation of chickpea in those soils lacking native effective rhizobia is a Very useful practice for improving root nodulation and yield of the crop[7,19].Microbial inoculants are cost effective, ecofriendly, and renewable sources of plant nutrients [10].*Rhizobium* and phosphate solubilizing bacteria (PSB) assume a great importance on account of their vital role in N_2-fixation and P-solubilisation. Use of *Rhizobium* and PSB had shown advantage in enhancing chickpea productivity [16].Further, the efficiency of N_2 fixation can be increased by seed dressing with Molybdenum (Mo) because Mo is an essential component of nitrate reductase and nitrogenase, which control the reduction of inorganic nitrate and helps in fixing N_2 to NH_3. Mo is also required for growth of most biological organisms including plants[6]. Generally, Mo is an essential micronutrient for plants and bacteria [14,21].reported that Mo is the key to nitrogen fixation by legumes. Since the information on response of cultivars of chickpea to inoculation with *Rhizobium* and phosphate solubilizing bacterial inoculants with Mo seed treatment is meager. Therefore, the present investigation was conducted during*rabi* 2016-17 at ICARDA, Amlaha farm, Sehore to study the supplementation of Mo along with *Rhizobium* + PSB inoculation in chickpea cultivars on biological nitrogen fixation and productivity.

2. MATERIALSANDMETHODS

The experiment was executed during *Rabi* 2016-17 at the ICARDA-IRP, Amlaha, Sehore (M.P.), India.Experiment consisted of twelve treatment combination, laid out in Factorial randomized block design (FRBD) with three replications. The treatment included six inoculants, with two kabuli chickpea varieties for 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 (Deptt. of Soil Science and Agricultural Chemistry) at R.A.K. College of Agriculture, Sehore. Soil was medium clay loam (vertisol), low in available nitrogen, medium in phosphorus,and high in available potash with Neutral pH .Various growth and yield attributing characters were studied.

List 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 AMKg^{-1} seed
I_6 :*Rh.*+PSB+Mo seed treatment 1.0g AM kg^{-1} seed
B. Variety – 02
V_1 : RVSJKG 102
V_2 : Phule G 0517

3. RESULTSANDDISCUSSION

Number of pods per plant

The number of pods per plant is one of the important yield attributes which have direct correlation with seed yield. The observation on this attribute was recorded at maturity. A perusal of data Table-1showed that the numbers of pods per plant was affected significantly by seed inoculants However varieties showed non-significant effect. Inoculation of chickpea with I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-1} seed) produced significantly maximum number of pods per plant (35.00) as compared to no inoculation or I_1 (control, 27.17). There was also significant difference between inoculants I_2 (*Rh.* + PSB) (29.17), I_3 (Mo Seed treatment @ 0.5 g AM kg^{-1} seed) (31.00) and I_4 (Mo Seed treatment @ 1 g AM kg^{-1} seed) (32.17) treatment but statistically at par with inoculants I_5 (*Rh.* +PSB + Mo seed treatment @ 0.5 g AM kg^{-1} seed). Between varieties, V_2 (Phule G 0517) observed numerically higher pod per plant(31.67) whereas minimum value was observed with V_1 (RVSJKG 102) (31.06).The interaction between seed inoculants and varieties (I×V) was found non-significant effect on number of pods per plant.

Seeds per pod

The number of seeds per pod is one of the most important yield attributes, which has direct correlation with the grain yield. The observation on this attribute was recorded at maturity. The data on seed per pod under different treatments are presented in Table-1. Seeds per pod was varied significantly due to seed inoculants and varieties. Inoculants I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-1} seed) produced significantly higher seeds per pod (1.13) and which 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). Minimum number of seeds per pod found under control. Between varieties, V_2 (Phule G 0517) recorded significantly higher pods per plant (1.09) than V_1 (RVSJKG 102). However, interaction (I x V) effect was non-significant.

Seed yield plant^{-1}(g),seed yield plot^{-1}(kg) and seed Index (g)

The data on seed yield/plant, seed yield/plot and seed Index are presented in Table-1. The data indicated that seed inoculants and variety showed significant effect on seed yield/ plant. The inoculants I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-1} seed) was significantly superior over other inoculants (9.92 g). Variety V_2 (Phule G 0517) recorded significantly higher seed yield per plant than V_1 (RVSJKJ 102).Seed yield/plot differed significantly due to seed inoculants and varieties,Inoculation I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-1} seed) was recorded significantly higher seed yield/plot (2.65 kg) but this was statistically at par with inoculation I_4 (Mo Seed treatment @ 1 g AM kg^{-1} seed) and I_5 (*Rh.* + PSB + Mo seed treatment @ 0.5 g AM kg^{-1} seed). Variety Phule G 0517 recorded significantly higher seed yield per plot (2.32 kg) than RVSJKG 102. Seed index not differed significantly due to seed inoculants and varieties. However, numerically maximum values were recorded by inoculants I_2 (*Rh.* + PSB)(54.95 g) and Variety V_2 (Phule G 0517) (51.42 g).

The higher yield attributes in I_6 (*Rh.* + PSB + Mo @ 1.0 g AM kg^{-1}seed) might be due to adequate availability of N and P which might have facilitated the production of primary branches, secondary branches and plant height which might in turn have contributed for the production of higher number of total pods, seeds per pod and seed yield per plant. Inoculation had a significant effect on growth, N contents and uptake in shoots increased its size in order to intercept light for photosynthesis, yield and yield components of chickpea. This may probably be due to the cumulative effect of phosphorus in the processes of cell division and balanced nutrition. The present result are in conformity with [4,11].

Variety effect on yield component were found also significant except pods per plant. The variety Phule G 0517 produce maximum at all yield component, where minimum effect on yield component produce by RVSJKG 102. Variation in yield component by variety was due to genetic effect of variety and natural habit also climatic effect on plant. This type of similar results was associate with [5,8,17].

Table-1: Yield and yield attributing traits influenced by inoculants and varieties.

Treatments	Pods/ Plant	Seeds/ pod	Seed yield/ plant (g)	Seed yield/ plot (g)	Seed index (g)
Seed Inoculants (I)					
I_1 : Control	27.17	1.04	5.17	1.64	49.52
I_2 : *Rhizobium*+ PSB	29.17	1.03	5.83	1.88	54.95
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	31.00	1.06	7.37	2.22	49.82
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	32.17	1.08	7.65	2.40	44.88
I_5: *Rh.*+ PSB +Mo seed treatment@ 0.5 g AM kg^{-1} seed	33.67	1.10	8.55	2.51	52.98
I_6:*Rh.* + PSB +Mo seed treatment @1g AM kg^{-1} seed	35.00	1.13	9.92	2.65	51.54

S.Em ±	0.78	0.02	0.42	0.13	1.71
CD5%	**2.27**	**0.06**	**1.25**	**0.37**	**NS**
Varieties : 02					
V_1 : RVSJKG 102	31.06	1.05	6.97	2.11	49.81
V_2 : Phule G 0517	31.67	1.09	7.86	2.32	51.42
S.Em ±:	0.32	0.01	0.25	0.07	2.96
CD5%	**NS**	0.03	**0.72**	**0.21**	**NS**
Interactions (I×V)					
S.Em±	1.09	0.03	0.60	0.18	4.19
C.D. (p=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
DAS : days after sowing **;NS** : Non-significant **;AM** : Ammonium Molybdate					

Seed yield (kg ha^{-1})

The seed yield is an important character and superiority of the treatment judged by its capacity to produce more seed yield, enables the investigators to select superior treatment combination. The data pertaining to seed yield (kg ha^{-1}) are presented in Table-2. The data indicated that seed yield per hectare differed significantly due to different inoculants and varieties. Seed yield was significantly higher with inoculation I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-1} seed) (2453 kg ha^{-1}) but statistically at par with inoculants I_4 (Mo Seed treatment @ 1 g AM kg^{-1} seed) (2226kg ha^{-1}) and I_5 (*Rh.* + PSB + Mo seed treatment @ 0.5 g AM kg^{-1} seed) (2322 kg ha^{-1}).

Varietal effect on seed yield was significantly higher by V_2 than V_1 . The result agrees with the work done by [9,18].who reported the vari*et*al difference in chickpea.

Straw yield (kg ha^{-1})

The data (Table-2) showed that straw yield was influenced significantly by seed inoculants and varieties. Seed inoculants, I_5 (*Rh.* + PSB + Mo seed treatment@ 0.5 g AM kg^{-1}seed) produced significantly higher straw yield (2717 kg ha^{-1}) but this was statistically at par with all inoculants except I_1 (Control) and I_2 (*Rh.*+ PSB). The minimum value was obtained by inoculants I_1 (Control) (2115 kg ha^{-1}) followed by I_2 (*Rh.*+ PSB) (2139 kg ha^{-1}).The varietal effect on straw yield was non-significant. However, numerically higher yield of straw was noticed with V_1 (RVSJKG 102) (2465 kg ha^{-1}) as compared to V_2 (Phule G 0517).

Biological yield (kg ha^{-1})

The result of biological yield from computed data was found significant due to seed inoculants presented in (Table-2). Significantly higher biological yield (5146 kg ha^{-1}) recorded by inoculants I_6 but it was statistically at par with inoculants I_4 and I_5 . However, minimum value was noticed in inoculant I_1 (Control) (3643 kg ha^{-1}).The varietal effect on biological yield was non-significant. The observed seed yield and biological yield improvements when inoculation with I_6 (*Rh*. + PSB + Mo@1 g AM kg^{-1} seed) might be due to the increased N from atmospheric nitrogen fixation from effective nodule formation in the vicinity of root zone and P availability by seed inoculants with PSB as result of improvements observed for the yield traits discussed above. These results are in line with [4].

Harvest index (%)

The data (Table-2) showed that the seed inoculants effect on harvest index was non-significant. The higher value of harvest index (47%) was obtained by I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-}

[1]seed) followed by I_3 (Mo Seed treatment @ 0.5 g AM kg^{-1} seed) (46%) and I_5 (*Rh.* + PSB + Mo seed treatment @ 0.5 g AM kg^{-1} seed)(46%). The varietal effect on harvest index was also non-significant and the maximum value was showed by variety V_2 (PHULE G 0517) (46%).

The interaction between seed inoculants and variety was found non- significant for seed yield, straw yield and harvest index but it was significant for biological yield (Table-3).

Significantly higher biological yield was recorded by interaction of I_6V_2 but statistically at par with I_5V_1, I_4V_2 and I_5V_2 . The minimum value was noticed with interaction effect of I_1V_1 (3851 kg ha^{-1}) and it was followed by V_2I_1.

Table-2 : Response of seed inoculant and variety on seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index(%).

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{1})	Biological Yield (kg ha^{-1})	Harvest index (%)
Seed Inoculants (I)				
I_1 : Control	1519	2115	3634	42
I_2 : *Rhizobium*+ PSB	1736	2139	3875	45
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	2058	2404	4462	46
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	2226	2629	4855	45
I_5: *Rh.*+ PSB +Mo seed treatment @ 0.5 g AM kg^{-1} seed	2322	2717	5039	46
I_6:*Rh.* + PSB +Mo seed treatment @ 1.0 g AM kg^{1} seed	2453	2696	5146	47
S.Em ±	116	144.98	154.68	2.25
CD5%	**341.65**	**425.22**	**453.65**	**NS**
Varieties : 02				
V_1 : RVSJKG 102	1954	2465	4419	44
V_2 : Phule G 0517	2151	2435	4586	46
S.Em ±:	67.25	83.71	89.30	1.30
CD5%	**197.25**	**NS**	**NS**	**NS**
Interactions (I×V)				
S.Em±	164.74	205.03	218.74	3.12
C.D. (*p*=0.05)	**NS**	**NS**	**641.55**	**NS**

Table-3: Biological yield of chickpea 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	3851	3780	4211	4475	4793	5401
V_2 Phule G 0517	3416	3970	4712	5237	5286	4891
S.Em ±	218.74					
C.D at 5%	**641.55**					

Economics analysis

The economics of various treatments was worked out by taking market rates of various production inputs and produce into account during the research period. According to the data from Table-4, the maximum net profit (₹192083 ha^{-1}) and B:C ratio (1:8.8) obtained with I_6 (*Rh.*+ PSB + Mo seed treatment@ 1.0 g AM kg^{-1} seed) and lowest profit was recorded with I_1

(control) (₹111479 ha^{-1}) with B:C ratio (1:5.6). The highest gross return (₹190208 ha^{-1}) and net profit (₹166913 ha^{-1}) were recorded with variety V_2 (Phule G 0517) compared to V_1 (RVSJKG102) (₹173493 ha^{-1}) and (₹149198 ha^{-1}). The B: C ratio was found same higher (1:7.8) due to V_2 (Phule G 0517) compared than V_1 (RVSJKG102)(1:7.3).

Table-4: Economics of the various treatments

Treatments	Return from grain (₹/ha)	Return from straw (₹/ha)	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net Income (₹/ha)	B:C ratio
Seed Inoculants (I)						
I_1 : Control	129153	6344	135497	24018	111479	1:5.6
I_2 : *Rhizobium*+ PSB	147568	6418	153987	24072	129915	1:6.3
I_3 : Mo Seed treatment @ 0.5 g AM kg^{-1} seed	174996	7209	182206	24268	156938	1:7.5
I_4 : Mo Seed treatment @ 1 g AM kg^{-1} seed	189281	7888	197170	24518	172652	1:8.0
I_5: *Rh.*+ PSB +Mo seed treatment@ 0.5 g AM kg^{-1} seed	197440	8151	205591	24322	181269	1:8.4
I_6:*Rh.* + PSB +Mo seed treatment@ 1g AM kg^{-1} seed	208577	8077	216655	24572	192083	1:8.8
Varieties : 02						
V_1 : RVSJKG 102	166098	7394	173493	24295	149198	1:7.1
V_2 : Phule G 0517	182906	7302	190208	24295	166913	1:7.8

4. CONCLUSIONS

The following conclusion are drawn based on results obtained by the present study:
1. The seed inoculation ***Rh.*+ PSB + Mo@1 g AM kg^{-1} seed** was found 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 higherproduction and yield component.

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