Influence of phosphatesolubilizing microorganisms and phosphorus levels on growthyield and quality of chickpea (*Cicer arietinum* L.) in inceptisol.

Abstract

A field study was conducted to know the "Influence of phosphatesolubilizing microorganisms and phosphorus levels on growth, yield and quality of chickpea (*Cicer arietinum* L.) in inceptisol."The experiment was laid in factorialrandomizedblockdesign(FRBD)withsixteentreatments,replicated thriceduring *Rabi* 2019-20 atdepartmentresearch farm of SSAC, College of Agriculture, Latur.The treatments comprises four main (absolute control,*Bacillusmegaterium, Aspergillusniger* and*Aspergillusawamori*@ 10 ml kg^{-1} seed treatment) and four sub treatments(0,45,60 and 75P_2O_5kg ha^{-1})The results indicates that,the incorporationofphosphatesolubilizingmicroorganisms*viz.Aspergilliusawamori*@ 10 ml kg^{-1} seedin combination with soil application of 75 P_2O_5kg ha^{-1}found to be effective in improving growth and yield attributing characters *Viz.* number of rootnodules, fresh and dry weight, chlorophyll content , grain yield and straw yield as compared to *Aspergillusniger*and*Bacillus megaterium*alongwith 60 P_2O_5kg ha^{-1} and overcontrol .Further results revealed that test weight and protein percentage was significantly influenced with the seed treatment of *Aspergilliusawamori*@ 10 ml kg^{-1} seedin combination with application of 75 P_2O_5kg ha^{-1}.

Keywords: chickpea,microorganisms, phosphorus, quality, yield

Introduction

Chickpea is the *Rabi* pulse crop grown in country supplementing protein (17-25 per cent), amino acid, Vit. A, Vit. C, Vit, B, Vit. K, source of folic acid for demand of vegetarian diet, also it plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. Phosphorus can be termed as 'life mineral' because of its crucial role in metabolic and energy transfer reactions in plant. Phosphorus is an essential element in DNA and RNA that contain the genetic code of the plant to produce protein and other compounds essential for plant structure, seed yield and also associated with increased root growth, chlorophyll content, and N2-fixation in legumes. Use of phosphorous in soils phosphorous solubilizing microorganisms (PSMs) and unlike bacteria, soil fungi also have ability to are capable to convert insoluble phosphorous to soluble forms can function as biofertilizers to increase the native phosphorous in soil (Narsian andpatel, 2000)[07]. It is low cost renewable source of plant nutrients, which supplement chemical fertilizer. Mittal *et al*.,(2008) [06]found that seed inoculation of chickpea with *Aspergillus awamori* increased shoot height by 7-12 per cent, a nearly 3 fold increase in seed weight as compared to un inoculated control. Seed inoculation with *Aspergillus awamori* increased the growth, total P content and biomass of mungbean (Jain *et al*., 2012)[02].

Material and Methods

The field experiment was conducted during *Rabi* 2019-20 at research farm departmental farm of SSAC, College of Agriculture, Latur using chickpea crop (Var.BDNG-797).

Inordertoevaluatetheinteractiveeffectofphosphatesolubilizingmicroorganisms and phosphorus levels on growth parameter, grain yield and seed quality of chickpea. After completion of preparatory tillage operations, the experiment was laid out in factorialrandomizedblockdesign(FRBD)withsixteentreatmentsreplicatedthrice.

Organic manures i.e. FYM was applied at the rate of 5 t ha^{-1} prior to 15 days of sowing of chickpea crop and all the plots were fertilized with recommendeddoseoffertilizerNPK (25:50:00 kg ha^{-1})wasapplied as a basal dosethroughurea,SSPtreatmentwiseatthetimeofsowing. The treatments comprises as a seedtreatmentT_0:Control, T_1: *Bacillusmegaterium@* 10 ml kg^{-1} seed, $T_{2:}$*Aspergillusniger@* 10 ml kg^{-1} seed,$T_{3:}$*Aspergillusawamori* @ 10 ml kg^{-1} seed as a main treatments and application P_0: 0 P kg ha^{-1}, P_1:45P kg ha^{-1}, P_2:60P kg ha^{-1}, P_3:75P kg ha^{-1} as a sub main treatments.

Chickpea seed was sown on 09th October 2019 by dibbling method as per randomly replicated plot having size 3× 2 m^2maintained row to row spacing 30 cm and plant to plant 10 cm and using a seed rate of 80 kg ha^{-1}.After sowing, seed was covered with soil. Sowing depth was kept almost 5 cm. The crop was harvested at maturitystage on 22 January 2020. The observation recorded viz. number of the nodules per plantwas recorded at 45 and 60 DAS. The fresh weight and dry weight was alsoweighedingrams. The seed yield, fodder yield were recorded at harvest stage.Quality parameter likeprotein, and test weight value were recorded. The data collected from the above observation were analysed statistically by the procedure prescribed by Panse and Sukhatme (1967)[09].

Result and Discussion

Totalnumberofrootnodule:

Total numberofrootnoduleperplantexpressed in table 1.It was observed that, among the different treatments,Total numberofrootnoduleperplantof chickpea were recorded significantly maximum(15.83and18.50perplant)withseedinoculationof*Aspergillusawamori*,followedbydeclinedupto13.33to16.00with*Aspergillus niger*and 13.16 and 14.75 with *Bacillus megaterium* at 45 and 60DAS, respectively. Whereas, the number of nodules per plant was recorded minimum in control at 45 and 60 DAS (i.e. 10.83 and 13.33 respectively). The data showed that maximum root nodules of chickpea(15.67 and 18.41) per plant was recorded with application @ 75 kg $P_2O_5ha^{-1}$increased at 45 and 60 DAS respectively. The number of root nodules per plant was further decreased to minimum (11.58 and 14.16) in control at 45 and 60 DAS of chickpearespectively.

Table No. 1: **Nodules per plant of chickpea as influenced by phosphatesolubilizing microorganismsand phosphoruslevels.**

PSM	**Phosphoruslevels(P_2O_5kgha^{-1})**				
	P0	**P45**	**P60**	**P75**	**Mean**
	Numberofnodulesperplantat45DAS				
T0	10.00	10.33	10.33	12.67	**10.83**
T1	11.67	13.00	13.33	14.67	**13.16**
T2	11.67	12.67	13.00	16.00	**13.33**
T3	13.00	15.00	16.00	19.33	**15.83**
Mean	**11.58**	**12.75**	**13.17**	**15.67**	
	T		**P**		**TXP**
SE	**0.20**		**0.20**		**0.40**
C.D at5%	**0.57**		**0.57**		**1.15**
	Numberofnodulesperplantat60DAS				
T0	11.66	12.66	13.33	15.66	**13.33**
T1	13.33	14.00	14.66	17.00	**14.75**
T2	14.33	15.66	15.00	19.00	**16.00**
T3	17.33	15.66	19.00	22.00	**18.50**
Mean	**14.16**	**14.50**	**15.50**	**18.41**	
	T		**P**		**TXP**
SE	**0.22**		**0.22**		**0.45**
C.D at5%	**0.65**		**0.65**		**1.31**

Theinteractioneffectofphosphatesolubilizingmicroorganismsandphosphorus levels was found significant at 45 and 60 DAS. The increase in therootnodulesperplantofchickpeaduetoseedinoculationof*Aspergillusawamori*increase d the availability of soluble phosphorus byproductionoforganicacid,thisacidsolubilizeunavailablephosphatetoavailable phosphorus helps to enhance nitrogen fixation which leads to increasein the number of root nodules per plant of chickpea.Similarly, phosphorusplays an important role in nodule initiation and increase the root proliferationthereby increase in the root nodules (Paratey and Wani, 2005)[10]. Similar resultsalso reportedbyVidhyashree*etal.*,(2017)[14].

FreshandDryweightofrootnodules:

Data in respect of freshanddryweightofrootnodules of chickpea presented in the table 2. Amongthephosphatesolubilizingmicroorganismsseedinoculationof*Aspergillusawamori*recordedsignificantfreshanddryweightof rootat45DAS(0.23and 0.13 g) and at 60 DAS (0.54 and 0.33 g). While minimum fresh and dry weight of nodule was recorded in control (0.12and 0.05 g). The similar pattern was observed in fresh and dry weight at 60DAS.

Table2: Freshanddryweightofrootnodule inchickpeaasinfluencedby phosphatesolubilizingmicroorganismsandphosphoruslevels.

PSM	Phosphoruslevels(P_2O_5kgha^{-1})				
	P0	**P45**	**P60**	**P75**	**Mean**
	FreshWeightofRoot Nodulesat45DAS(g)				
T0	0.10	0.12	0.13	0.14	**0.12**
T1	0.14	0.16	0.18	0.19	**0.17**
T2	0.20	0.20	0.21	0.22	**0.21**
T3	0.22	0.23	0.21	0.26	**0.23**
Mean	**0.16**	**0.18**	**0.18**	**0.20**	
	T		**P**		**TXP**
SE	**0.002**		**0.002**		**0.005**
C.Dat5%	**0.008**		**0.008**		**NS**
DryWeightofRoot Nodulesat45DAS(g)					
T0	0.02	0.03	0.04	0.10	**0.05**
T1	0.06	0.08	0.09	0.10	**0.08**
T2	0.10	0.11	0.12	0.11	**0.11**
T3	0.13	0.15	0.12	0.11	**0.13**
Mean	**0.07**	**0.09**	**0.09**	**0.11**	
	T		**P**		**TXP**
SE	**0.003**		**0.003**		**0.008**
C.D at5%	**0.010**		**0.010**		**NS**

FreshWeightofRoot Nodulesat60DAS(g)

T0	0.17	0.18	0.19	0.20	**0.18**
T1	0.26	0.27	0.29	0.32	**0.28**
T2	0.33	0.33	0.38	0.40	**0.36**
T3	0.47	0.52	0.56	0.62	**0.54**
Mean	**0.31**	**0.32**	**0.35**	**0.38**	
	T		**P**		**TXP**
SE	**0.008**		**0.008**		**0.015**
C.D at5%	**0.017**		**0.017**		**0.04**
DryWeightofRoot Nodulesat60DAS(g)					
T0	0.06	0.08	0.12	0.11	**0.09**
T1	0.17	0.15	0.16	0.14	**0.15**
T2	0.17	0.17	0.20	0.22	**0.19**
T3	0.26	0.30	0.35	0.42	**0.33**
Mean	**0.16**	**0.17**	**0.20**	**0.22**	**NS**
	T		**P**		**TXP**
SE	**0.012**		**0.012**		**0.024**
C.D at5%	**0.035**		**0.035**		**NS**

Among thedifferent levels of phosphorus application at @ 75 kg $P_2O_5ha^{-1}$ recorded maximumfresh (0.20 and 0.38 g) and dry weight (0.11 and 0.22 g) of root nodules at 45and 60 DAS respectively, over rest of the phosphorus levels. While, minimum fresh(0.16 g) and dry weight (0.07 g) was recorded with no application of phosphorusat 45 DAS. Similar trend in fresh and dry weight of nodule per plant was alsonoticed at 60 DAS. Theinteractioneffectofphosphatesolubilizingmicroorganismsandphosphorus levels showed non-significant effect on fresh weight at 45 DAS anddryweightat45and60DAS.However,itwasshowedsignificanteffectonfreshweightofr oot nodulesat60DASonly.Improvement in nodulation by the application of phosphate solubilizingmicroorganisms could be attributed to a greater solubility and availability ofphosphate,whichisessentialfornoduledevelopment(ParateyWani*etal.*,2005)[10]. Simila r results were also reported by Kumawat*et al.*, (2009) [04] andSingh*etal.*, (2018) [12].

Chlorophyllcontent:

The data furnished in table 3 revealed that *Aspergillus awamori*recordedmaximumchlorophylla,chlorophyllbandtotalchlorophyll(2.06,1.02an d 3.08mgg^{-1},respectively) at45DASfollowedby*Aspergillusniger*(1.8,0.92and2.70mgg^{-1}respectively)and*Bacillusmegaterium*(1.52,0.81and2.33mgg^{-1}). Whereas,lowestvaluesofchlorophylla,chlorophyllbandtotalchlorophyllcontent wasfound incontrol(1.03,0.63and 1.66mgg^{-1}).

Table3:Chlorophyllcontentasinfluencedby phosphatesolubilizing microorganisms and phosphatelevelsinchickpea.

Phosphoruslevels(P_2O_5kgha^{-1})					
PSM	**P0**	**P45**	**P60**	**P75**	**Mean**
Chlorophylla(mgg^{-1})					
T0	0.81	0.89	1.18	1.27	**1.03**
T1	1.33	1.46	1.60	1.71	**1.52**
T2	1.74	1.77	1.82	1.87	**1.80**
T3	1.93	1.92	2.15	2.24	**2.06**
Mean	**1.45**	**1.52**	**1.69**	**1.77**	
	T		**P**		**TXP**
SE	**0.01**		**0.01**		**0.02**
C.D at5%	**0.05**		**0.05**		**0.09**
Chlorophyllb(mgg^{-1})					
T0	0.55	0.58	0.69	0.72	**0.63**
T1	0.78	0.79	0.82	0.86	**0.81**
T2	0.87	0.90	0.91	0.93	**0.90**
T3	0.97	0.94	0.99	1.22	**1.02**
Mean	**0.79**	**0.80**	**0.85**	**0.93**	
	T		**P**		**TXP**
SE	**0.009**		**0.009**		**0.01**
C.D at5%	**0.02**		**0.02**		**0.05**
Totalchlorophyll(mgg^{-1})					
Phosphoruslevels(P_2O_5kgha^{-1})					
PSM	**P0**	**P45**	**P60**	**P75**	**Mean**
T0	1.36	1.47	1.87	1.99	**1.67**
T1	2.11	2.25	2.43	2.57	**2.33**
T2	2.61	2.72	2.80	2.90	**2.70**
T3	2.86	2.80	3.46	2.43	**3.08**
Mean	**2.24**	**2.32**	**2.46**	**2.70**	
	T		**P**		**TXP**
SE	**0.04**		**0.04**		**0.08**
C.D at5%	**0.12**		**0.12**		**0.25**

Theapplicationofphosphorus@75kgP_2O_5ha^{-1}wasinfluencedsignificantly and recorded maximum values of chlorophyll a, chlorophyll b andtotal chlorophyll content (1.77, 0.93 and 2.70 mg g^{-1} respectively) in chickpea(Table 6 and fig. 1). While minimum values of chlorophyll a, chlorophyll b and totalchlorophyllcontentwas foundin control(i.e.1.45,0.79 and2.24 mgg^{-1}).The combinedeffect of *Aspergillus awamori* and application of phosphorus @ 75 kg P_2O_5ha^{-1}showedhighestchlorophylla,chlorophyllbandtotalchlorophyllcontent. The application of higher dose ofphosphorusincombinationofphosphatesolubilizingmicroorganismsincreased the chlorophyll content in leaves of chickpea might be ascribed toincrease the solubility of phosphorus in the root environment thereby moreutilizationofphosphorusbyplantfortheirgrowthandmetabolicactivity(Kumawat *et al*.2009) [04].

Seedyield:

Theseedyieldofchickpeaasinfluencedbyphosphatesolubilizingmicroorganism narrated in table 4. The seed inoculation with *Aspergillus awamori* produced higher seedyield (1502.68 kg ha^{-1}) as compared to application of *Aspergillus niger*(1406.6kgha^{-1})and*Bacillus megaterium*(1344.53kgha^{-1}).Significantimprovementinyieldwasnoticedwiththeapplicationdifferent phosphorus levels. Among the differentphosphorus levels application of phosphorus @ 75 kg $P_2O_5ha^{-1}$ recorded higherseed yield (1451.0 kg ha^{-1}) as compare to application of phosphorus @ 60 kg$P_2O_5ha^{-1}$ (1403.25 kg ha^{-1}) and 45 kg $P_2O_5ha^{-1}$ (1346.18 kg ha^{-1}). While,minimumseedyield wasrecordedincontrol(1322.77kgha^{-1}).

Table4: Seedyieldofchickpeaasinfluencedbyphosphate solubilizing microorganisms andphosphorus levels.

PSM	Phosphoruslevels(P_2O_5kgha^{-1})				
	P0	**P45**	**P60**	**P75**	**Mean**
	SeedYieldkgha^{-1}				
T0	1198.85	1232.67	1303.35	1342.52	**1269.35**
T1	1344.64	1308.21	1354.48	1370.79	**1344.53**
T2	1345.15	1401.31	1416.74	1463.33	**1406.63**
T3	1402.44	1442.52	1538.42	1627.34	**1502.68**
Mean	**1322.77**	**1346.18**	**1403.25**	**1451.00**	
	T		**P**		**TXP**
SE	**12.59**		**12.59**		**25.18**
C.D at5%	**36.35**		**36.35**		**72.71**

Interactionbetweenphosphatesolubilizingmicroorganismsandphosphoruslevelswasfoundtobesignificant.Theseedinoculationwith*Aspergillus awamori* and application of phosphorus @ 75 kg $P_2O_5ha^{-1}$recordedhighest value of seed yield than rest of the interactions. This may attributed*Aspergillus awamori* increase more values of growth parameters at almost allgrowth stages and helped in reducingP fixation by its chelating effect and also solubilized the unavailable form of Pleadingtomoreuptakeofnutrientsresultedinbettergrowthoftheplant(Das*et al*, 2013)[01].The increase in seed yield due to increase in P levelmay beattributed to increase in the availability of P in soil. Similar findings arenoted byNawange*et al. (*2011)[08].

StrawYield:

It is evidenced from the data presented in table 5.The straw yield of chickpea as significantly influencedby phosphate solubilizingmicroorganism,The seed inoculation with *Aspergillus awamori* produced maximumstrawyieldofchickpea(1803.2kgha^{-1})ascomparedtoapplicationof*Aspergillusniger*(1688.0kgha^{-1}) and*Bacillusmegaterium*(1613.4kgha^{-1}).Amongthedifferentphosphorus levels application of phosphorus @ 75 kg P_2O_5ha^{-1}recorded higherstraw yield (1741.19 kg ha^{-1}) as compare to application of phosphorus @ 60 kgP2O5 ha^{-1} (1683.90 kg ha^{-1}) and 45 kg P2O5 ha^{-1} (1615.41 kg ha^{-1}). However, the minimum strawyield wasrecordedin control(1587.32 kgha^{-1}).Interactionbetweenphosphatesolubilizingmicroorganismsanddifferent phosphorus levels on straw yield was found to be significant. The seedinoculation with *Aspergillus awamori* and application of phosphorus @ 75 kgP_2O_5ha^{-1} recorded higher value of straw yield than rest of the interactions. Thiswasmainlyduetothefactthat*Aspergillus awamori* and application of phosphorus @ 75kgP_2O_5ha^{-1}increaseintheavailability of N and P caused better root development, bettergrowth and development of plantsandbetterdiversionofphotosynthatestowardssink Tagore*etal.*,(2013)[13].Kumar *et al.,* (2019)[03] reported that the straw yield of chickpea increased due toincrease in phosphorus levels might be because of increase in the microbialactivityintherootenvironmentwhichacceleratescelldivisionandformationofme ristem.

Table5:Strawyieldasinfluencedbyphosphatesolubilizingmicroorganismsand phosphoruslevelsinchickpea.

PSM	Phosphoruslevels(kgP_2O_5ha^{-1})				
	P0	P45	P60	P75	Mean
	StrawYieldkgha^{-1}				
T0	1438.6	1479.2	1564.0	1611.0	**1523.2**
T1	1613.6	1569.8	1625.4	1644.9	**1613.4**
T2	1614.2	1681.6	1700.1	1756.0	**1688.0**
T3	1682.9	1731.0	1846.1	1952.8	**1803.2**

Mean	**1587.32**	**1615.41**	**1683.90**	**1741.19**	
	T		**P**		**TXP**
SE	**15.11**		**15.11**		**30.22**
C.D at5%	**43.63**		**43.63**		**87.26**

ProteinYield:

The data pertaining to protein content and protein yield influenced significantly and presented intable 6. The maximumprotein yield (426.96 kg ha^{-1}) and protein content (23.62 %) was recorded withseed inoculation of *Aspergillus awamori* followed by *Aspergillus niger*(392.47kgha^{-1}and23.24%respectively)and*Bacillusmegaterium*(362.27and22.42% respectively). Whereas minimum protein yield (312 kg ha^{-1}) and proteincontent (23.62%)wasrecordedincontrol.Thedataoneffectofdifferentlevelsofphosphorusapplicat ionshows that maximum proteinyield and protein content was noticed with the application of phosphorus @ 75 P_2O_5kgha^{-1}(412.15 kg $ha^{-1}$and 23.62% respectively).The grain yield and proteincontentreducedsignificantlywithdecrementinphosphoruslevelsuptoapplicationof phosphorus@60kg$P_2O_5ha^{-1}$(378.87kgha^{-1}and22.44%)and45 kg $P_2O_5ha^{-1}$ (344.48 kg ha^{-1} and 21.25 %). The minimum protein yield(357.26kgha^{-1})andproteincontent(22.38%)wasrecordedwithnoapplication ofphosphorus.

Table 6: Protein content and protein yield as influenced by phosphate solubilizingmicroorganismandphosphoruslevelsinchickpea.

PSM	**Phosphoruslevels(kg$P_2O_5ha^{-1}$)**				
	P0	**P45**	**P60**	**P75**	**Mean**
	ProteinContent(%)				
T0	18.92	19.97	20.71	22.04	**20.41**
T1	22.21	20.84	23.30	23.33	**22.42**
T2	24.16	22.75	22.43	23.63	**23.24**
T3	24.21	21.46	23.33	25.47	**23.62**
Mean	**22.38**	**21.25**	**22.44**	**23.62**	
	T		**P**		**TXP**
SE	**0.12**		**0.12**		**0.25**
C.D at5%	**0.36**		**0.36**		**0.73**
ProteinYield(kgha^{-1})					
T0	272.68	295.78	324.31	355.47	**312.06**
T1	358.61	327.56	378.88	384.05	**362.27**
T2	390.20	382.92	381.46	415.32	**392.47**
T3	407.57	371.66	430.85	497.77	**426.96**

Mean	357.26	344.48	378.87	413.15	
	T		P		TXP
SE	3.04		3.04		6.09
C.D at5%	8.80		8.80		17.60

Theinteractioneffectofphosphatesolubilizingmicroorganismsandphosphorus levels shows significant effect on protein yield and protein content.This may be due to bothnutrientsplaysmainroleinproteinmetabolism.Similarly increase in protein content in seed due to application of phosphorusresembles to increase in higher uptake of Nby plant which is main constituentof amino acid and building block of protein. Similar results are also noted by Mir*etal*.,(2013)[05]andSingh*etal*.,(2018)[12].

TestWeight:

The data furnished in table 7 revealed that,the high value of test weight (158.00g) was recorded with seed inoculation of *Aspergillus awamori* followed by*Aspergillusniger*(157.62g)and*Bacillusmegaterium*(157.14g).Theminimumtestweight (156.99g)wasnoticedincontrol.The application of @ 75 kg $P_2O_5ha^{-1}$recorded maximum test weight (158.49 g), followed by application of 60 kg$P_2O_5ha^{-1}$(157.71g)and45kg$P_2O_5ha^{-1}$(156.49 g).Thecombinedeffectofphosphatesolubilizingmicroorganismsandvaried levels of phosphorus influenced and the increaseintestweightduetocombinedapplicationofphosphatesolubilizing microorganisms and phosphorus levels attribute to increase in thesymbiotic nitrogen fixation by adding more phosphorus which help to seeds for theirdevelopment and ultimately increase the size of seed (Tagore *et al.*, 2013)[13].These findings arein line with the findings reported Prajapti*et al.*,(2017)[11].

Table7:Testweightofchickpeaseedasinfluencedbyphosphatesolubilizing microorganismsandphosphoruslevels.

PSM	Phosphoruslevels($P_2O_5ha^{-1}$)				
	P0	P45	P60	P75	Mean
	TestWeight(g)				
T0	156.35	157.59	156.77	157.27	**156.99**
T1	155.88	156.86	157.70	158.13	**157.14**
T2	155.94	157.37	158.14	159.04	**157.62**
T3	157.77	156.45	158.25	159.51	**158.00**
Mean	156.49	157.07	157.71	158.49	
	T		P		TXP
SE	0.07		0.07		0.15
C.D at5%	0.21		0.21		0.43

Conclusion

It can be inferred and concluded that , incorporationofphosphatesolubilizingmicroorganisms*viz.Aspergillius awamori* in combination with application of phosphorus @ 75 kg $P_2O_5 ha^{-1}$improved growth attributes, yield attributes and quality of chickpea.

References

1. Das, S., Pareek, B.L., Kumavat, A. and Dhikwal, S.R. (2013) Effect of phosphorus and biofertilizers on production of chickpea (*Cicer arietinum* L)in north western Rajasthan, *Ind. Legume. Res*. 36(6): 511- 514.
2. Jain R., Saxena J., Sharma V. (2010). The evaluation of free and encapsulated *Aspergillus awamori* for phosphate solubilization in fermentation and soil-plan system. *App. Soil. Eco.* 46, 90-94.
3. Kumar, J. Kumar, S. and Prakash V. (2019) effect of biofertilizers and phosphorus levels on soil fertility yield and nodulation in chickpea (*Cicer arietinum* L.). *J. Ind.Soci. Soil. Sci.* 67 (2):199-203.
4. Kumawat, N., Sharma, O.P., Kumar, R. and Kumari, A. (2009). Response of organic manures, PSB and phosphorus fertilization on growth and yield of mungbean. *Envi. Eco.* 27(4): 2024-2027.
5. Mir, A.H., Lal, S.B., Salmani, M. Abid, M. and Khan, I. (2013) Growth, yield and nutrient content of blackgram (*vigna mungo*) as influenced by levels of phosphorus, sulphur and phosphorus solubilizing bacteria. *SAARC. J. Agri.*, 11(1): 1-66.
6. Mittal, V., Singh, O., Nayyar, H., Kaur, J. and Tewari, R. (2008). Stimulatory effect of phosphate-solubilizing fungal strains (*Aspergillus awamori* and *Penicillium citrinum*) on the yield of chickpea (*Cicer arietinum* L. cv. GPF2). *Soil. Bio. Bioche.* (40) 718-727.
7. Narsihan, V., Patel, H.H. (2000). Aspergillus aculeatus as a rock phosphate solubilizer. *Soil. Bio. Bioche.* (32):559-565.
8. Nawange, D.D., Yadav, A.S. and Singh, R.V. (2011). Effect of phosphorus and sulphur application on growth, yield attributes and yield of chickpea (*Cicer arietinum* L.). *Legume. Res.* 34(1):48-50.
9. Panse VG, SukhatmePK.(1985) Statistical methods for agriculture workers, *(IV Edn.)ICAR, New Delhi. 1985, 145-156.*

10. Paratey, P.R. And Wani, P.V. (2005). Response of soybean to phosphate solubilizing biofertilizers. *Legume .Res.* 28(4): 268-271.
11. Prajapati, B.J., Gudadhe, N. Gamit, V.R. and Chhaganiya, H.J. (2018). Effect ofintegrated phosphorus management on growth, yield attributes and yield of chickpea. *Fmg. &Mngmt.* 2(1): 36-40.
12. Singh, R. Singh, P. Singh, V. and Yadav, R.A. (2018). Effect of phosphorus and PSB on growth parameters, yield, quality and economics of summer greengram (*Vigna radiata* L.) *Int. J. Chem. Stud.* 6(4): 2798-2803.
13. Tagore, G.S., Namdeo, S.L., Sharma, S.K. and Kumar, N. (2013). Effect of *Rhizobium* and Phosphate Solubilizing Bacterial Inoculants on Symbiotic Traits, Nodule Leghemoglobin, and Yield of Chickpea Genotypes. *Int. J. Agron.* 8:581627.
14. Vidhyashree,V., Naga, S.R., Yadav, B.L., Koli D.K. and Rao I.J. (2017). Effect of phosphorus and biofertilizers on growth and yield of mungbean [*Vigna radiate* (L.)Wilczek]. *Int. J. Curr. Micro. App. Sci*. 6(7): 3992- 3997.