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Short communication

Nodules as influenced by *Rhizobium* inoculation, phosphorus application and their interactions in cowpea [*Vigna unguiculata* (L.) Walp]

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Cowpea [*Vigna unguiculata* (L.) Walp] is an important legume crop with manifold uses. It is used as vegetable, pulse, green manuring and fodder crop in dry and semi-arid zones of the world. Potentiality of chemical fertilization for increasing vegetable production has been well established since time immemorial but the major limiting factor in their usage in the high cost. During present period of, energy crisis the scarcity and rising cost of petro-chemical has forced a rethinking for augmenting the biological nitrogen fixation. This would be such to minimize our dependence on fertilizer nitrogen, as the abundant quantities of di-nitrogen can easily be tapped for agricultural purposes through a number of symbiotic bacteria called as *Rhizobium*. These bacteria take-up free nitrogen from the air and convert it into nitrogenous compounds for the use of crop plants. The bacteria penetrate the rootlets and induced the plant to produce nodules at the point of entry. Phosphorus plays important role in the plant metabolism and is a constituent of various organic substances. It is important in photosynthesis, respiration and other physiological processes of plant. The vital role played by the phosphorus in reaction involving energy transfer and move specifically ATP in nitrogenase, activity suggests that plants dependent on symbiotic nitrogen for growth nay require more phosphorus than those dependent on combined nitrogen. There are now overwhelming evidence that most legumes show a good response to phosphate application owing to their favorable influence on root proliferation, nodule development, bacterial activity and nitrogen fixation. Keeping in view the above fact the present study was undertaken to study the number of nodules per plant as influenced by *Rhizobium* inoculation, phosphorus application and their interaction effect in cowpea.

The field experiment was carried out at Vegetable Research Farm and Laboratories of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the years 2007 and 2008. The treatment consisted of five levels of phosphorus and two *Rhizobium* culture i.e. inoculated and un-inoculated seed. For treating the seeds the sticker solution was prepared by dissolving 2.5 g of sugar with 1.0 of Acacia in 1000 ml water, the solution was-sterilized and maintained. Bacteria grown in broth and sticker solution will-mixed together in a ratio 2:l. Phosphorus was applied @ 0, 25, 50, 75 and 100 kg/ha. Nitrogen and potash were applied @ 25 kg and 30 kg/ha respectively to all the plots. For studying the nodules samples were taken after 30th, 40th and 50th day after sowing and at harvesting. During sampling, all possible precautions were taken to minimize the breakage of roots and lose of nodules In order to avoid shrinkage of nodules the roots were dipped in water containing a stray. Number of nodules was recorded.

The data recorded pertaining to the number of nodules per plant at various stages of plant growth, as influenced by *Rhizobium* and phosphorus application and their interactions are presented in Table 1.

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First stage: *Rhizobium* inoculation exhibited significant improvement in number of nodules per plant at 30 days after sowing in two years. The maximum i.e.24.29 and 23.80 and minimum 18.74 and 18.52, nodules were observed under Rh+ and Rh- (control) during 2007 and 2008 respectively. The growth of plants, total N content, percentage of AM colonization, nodulation and nitrogenase activity were found to be maximum in plants raised after dual inoculation with *Rhizobium* and Glomus reported by Rao *et al.* (2005).

A perusal of data recorded at this stage of plant growth for number of nodule per plant showed significant effect of phosphorus during both the years of experimentation. The maximum number, i.e. 23.53 and 23.45 were produced under highest level of phosphorus application while minimum values, i.e., 19.24 and 18.95 were obtained under control in two years respectively.

Combined use of *Rhizobium* and phosphorus levels showed significant effect only during 2008. The maximum (26.50) and minimum (16.33) nodules were recorded under Rh+P_{100} and control during 2008.

Second stage: It is evident from the result obtained at 40 days after sowing that *Rhizobium* inoculation showed significant influence during both the years of experimentation. The maximum nodules, i.e. 53.16 and 60.44 were recorded under *Rhizobium* inoculated plants and minimum number was noted from in inoculated minimum number was noted from un-inoculated plants in two years respectively.

Application of different doses of phosphorus made significant effect on number of nodules per plant during 2007 and 2008. The highest number, i.e., 52.75 and 57.90 were recorded under highest dose of phosphorus application, while the lowest, i.e., 33.45 and 39.09 were obtained under control in two years respectively. Value counted under P_{75} and P_{100} treatments, in 2008 were at par.

The treatment combinations also exhibited significant effect on number of nodules per plant during both the years. The maximum number of nodules per plant i.e., 61.65 and 65.60 were recorded under highest dose of phosphorus application along with *Rhizobium* inoculation while minimum number, i.e. 26.88 and 36.00 were obtained under control in both the years. Similar result was also reported by Taiwo *et al.* (2001).

Third stage: Observations noted at 50 days after sowing in respect of number of nodules per plant showed significant effect sowing to *Rhizobium* inoculation during both the years of investigation. The maximum nodules, i.e., 56.41 and 67.28 were obtained under Rh+ treatment

Table 1: Number of nodules per plant as influenced by Rhizobium inoculation, phosphorus application and their interactions in cowpea

Treatment	Days after sowing							
	30		40		50		At harvest	
	2007	2008	2007	2008	2007	2008	2007	2008
Rhizobium culture								
Rh-	18.74	18.52	34.15	42.00	46.32	47.65	7.08	6.83
Rh_+	24.29	23.80	53.16	60.44	56.41	67.28	8.45	8.66
SEm±	**0.01**	**0.06**	**0.15**	**0.42**	**0.58**	**0.16**	**0.03**	**0.05**
C. D.	**0.30**	**0.18**	**0.43**	**1.23**	**1.69**	**0.45**	**0.08**	**0.15**
P_2O_5kg/ha								
P_0	19.24	18.95	33.45	39.09	43.89	47.39	6.70	6.43
P_{25}	20.79	19.63	38.71	47.43	48.85	54.25	7.20	7.10
P_{50}	21.75	21.08	45.05	54.76	50.29	60.11	7.25	7.60
P_{75}	22.25	22.68	48.30	56.91	54.48	62.05	8.25	8.50
P_{100}	23.53	23.45	52.75	57.90	59.31	63.51	8.80	9.10
SEm±	**0.16**	**0.10**	**0.23**	**0.67**	**0.92**	**0.25**	**0.05**	**0.08**
C.D.	**0.47**	**0.28**	**0.67**	**1.94**	**2.67**	**0.72**	**0.13**	**0.24**
Rh-P_0	16.55	16.33	25.35	26.88	36.00	38.08	6.18	5.25
Rh-P_{25}	18.35	17.55	29.53	37.13	44.85	44.60	6.70	6.30
Rh-P_{50}	18.85	18.68	33.65	47.40	45.40	49.55	7.30	6.60
Rh-P_{75}	19.38	19.65	38.35	48.40	48.03	51.75	7.40	7.60
Rh-P_{100}	20.55	20.40	43.85	50.20	57.30	54.25	7.80	8.40
Rh+P_0	21.93	21.60	41.55	51.30	51.78	56.70	7.23	7.60
Rh+P_{25}	23.23	21.70	47.90	57.73	52.85	63.90	7.70	7.90
Rh+P_{50}	24.65	23.48	56.45	62.13	55.18	70.68	8.40	8.60
Rh+P_{75}	25.13	25.70	58.25	65.43	60.93	72.35	9.10	9.40
Rh+P_{100}	26.50	26.50	61.65	65.60	61.33	72.78	9.80	9.80
SEm±	**0.23**	**0.14**	**0.33**	**0.95**	**1.30**	**0.35**	**0.07**	**0.12**
C. D.	**N. S.**	**0.40**	**0.95**	**2.75**	**3.77**	**1.02**	**0.19**	**0.33**

N. S. = Not significant

while minimum nodules, i.e.46.32 and 47.65 were obtained under control during 2007 and 2008 respectively.

Addition of phosphorus also proved to be significantly beneficial in respect of nodule per plant at this stage of plant growth during both the years. The maximum number of nodule, i.e. 59.31 and 63.51 were noted with 100kg/ha phosphorus application, while minimum number of nodules, i.e. 43.89 and 47.39 were obtained under control during both the years respectively. It is also clear that values recorded under P_{25} and P_{50} were at par in 2007.

Combined use of *Rhizobium* and phosphorus significantly increased the nodules during both the years of study. The maximum nodules, i.e. 6133 and 72.78 and minimum nodules, i.e. 36.00 and 38.08 were counted under Rh+P_{100} and Rh-P_0 (control) in 2007 and 2008 respectively. The inoculants along with the lower P rate (15 kg/ha) resulted in the greatest root length and volume. AMF + 0 kg P_2O_5/ha recorded the highest number of effective nodules (32.0 per plant) reported by Mathew *et al.* (2002).

Fourth stage: It is obvious from the results obtained at last harvesting stage of plant that number of nodule were sharply reduced in comparisons third stage. But, *Rhizobium* inoculation made significant increase in number of nodule also at this stage of plant growth during both the years of study. The maximum number of nodules, i.e. 8.45 and 8.66 and minimum number, i.e.7.08 and 6.83, were recorded from *Rhizobium* inoculated and un-inoculated plants during 2007 and 2008 respectively.

A perusal of data showed that a marked reduction in number of nodules at that stage of observation. However, the maximum nodules, i.e. 8.80 and 9.10 were counted under highest level of phosphorus application, while the minimum nodules, i.e. 6.70 and 6.43 were noted under control in two years respectively. It was also noted that the values obtained under P_{25} were at par with P_{50} in 2007.

Interactions of *Rhizobium* and phosphorus were also found to be significant at last harvest stage in both the years. The maximum number of nodules, i.e., 9.80 and 9.80 were recorded under 100kg/ha phosphorus applications along with *Rhizobium* inoculation, while minimum nodules, i.e. 6.18 and 5.25 were noted under control during 2007 and 2008 respectively.

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