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Effect of Rhizobium inoculation and plant population on growth and yield of field pea (*Pisum sativum* L.) in Champhai District, Mizoram

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Abstract
A field experiment was conducted at KVK Instructional Farm under KVK Champhai, Mizoram during two years (2017-18 and 2018-19) to study the effect of Rhizobium inoculation and plant population on field pea with variety Aman. Results reveal that vegetable pea cultivation in rabi with Rhizobium inoculation at 4.0 lacs plant population was found most economic and viable among all the treatment combinations.

Keywords: Rhizobium, plant, population, pea, *Pisum sativum* L.

Introduction
Field pea has high levels of the amino acids, lysine and tryptophan, which are relatively low in cereal grains. Field pea contains approximately 21 to 25 percent protein. If lives saving irrigation facilities are available field pea can be grown as a late rabi crop due to availability of short duration and photo-insensitive varieties. Usually grain legumes are grown on marginal lands and poor yields in such soils are partly due to lack of proper nutrition. In the recent years the importance of Rhizobium inoculation in pulse nutrition has been well recognized and it helps in fixing more atmospheric nitrogen into the soil (Tandon, 1991). So among the production factors Rhizobium inoculation along with appropriate plant population are very important.

Materials and Methods
The experiment was laid out at KVK Instructional Farm under KVK Champhai, Mizoram during the rabi season of 2017-18 with field pea. The area is situated between 93^0 00' 32" to 93^0 26' 18" E longitude and 24^0 05' 03" to 23^0 00' 04" N latitude with an altitude of 1118 m from the mean sea level. The average rainfall of Champhai District is about 1940 mm per year of which 87 per cent is received from June to September.
The average maximum and minimum temperature round the year are 34.50 ^{0}C and 5.72 ^{0}C respectively. Humidity varies from 57.83 to 85.83 percent. The soil is Colluvial soil and acidic (6.2 pH) in nature with 0.37 percent organic carbon, 190.50 kg available nitrogen, 18.42 kg available P, 212.20 kg available K, 12.08 kg available S.
Crop was grown in split plot design with three replications. The whole experiment field was divided into three equal plots, keeping 3 plant population levels. Each main plot was divided into 2 sub plots allotted to 2 levels of inoculation. Crop response to treatments were measured in terms of various quantitative and qualitative indices like plant height, dry matter accumulation/m^2, and at harvest number of primary branches, number of pods/plant, number of grain/pod, test weight, grain yield, straw yield & harvest index. Economics of different treatments was also worked out.
P_1 = 5.0 lacs plant population
P_2 = 4.0 lacs plant population
P_3 = 3.33 lacs plant population
I_0 = control plot (without Rhizobium inoculation)
S_1 = Treated plot (with Rhizobium inoculation)

Results and Discussion

Growth parameters

Plant height increased with the increasing level of plant population. Number of primary branches per plant was maximum under P_3 (3.33 lacs/ha) plant population. The findings are in close conformity with the results of Rana and Ahuja (1986) [10], Panwar and Sirohi (1987) [9]. At different growth stages, dry matter accumulations were found the highest at 5.0 lacs plant population. It was followed by 4.0 and 3.33 lacs plant population level. A similar result has also been reported by Yadav and Warsi 1988 [14]. Numbers of nodules per plant and nodules dry weight per plant were maximum under 3.33 lacs plant population level (Shukla and Dixit, 1996) [11].

Rhizobium inoculation increased the plant height at all the growth stages. Inoculation exhibited increase in number of leaves per plant over uninoculated plots. Similar results were obtained by Srivastava and Varma (1982) [12] and Gill *et al.* (1985) [15]. Numbers of nodules per plant and nodules dry weight per plant were directly benefited by seed inoculation. This result was in conformity with the findings of Basu *et al.* (1989) [16] and Ardeshna *et al.* (1993) [17].

Table 1: Effect of *Rhizobium* inoculation and plant population on growth attributes of Field pea (pooled data of 2 years)

Treatment	Plant height at harvest (cm)	Number of leaves/plant	Number of nodules/plant	Nodules dry weight/plant
P_1	34.20	25.45	10.15	0.120
P_2	33.50	26.30	11.30	0.140
P_3	33.40	27.20	12.20	0.144
SE (d)	0.18	0.20	0.24	0.004
CD (P=0.05)	0.51	0.60	0.60	0.012
I_0	34.15	24.15	10.20	0.105
I_1	34.30	26.50	13.50	0.152
SE (d)	0.08	0.18	0.12	0.004
CD (P=0.05)	0.15	0.40	0.20	0.009

Yield attributes and yield

Plant stand per square at harvest stage was significantly higher under P_1 (5.0 lacs/ha) level of plant population. Number of pods per plant, number of grains per pod and seed index maintained its superiority under P_3 level of plant population over P_2 and P_1 level. Similar results were obtained by Bhosle and Andhale (1982) [2]. Maximum grain yield was associated under P_2 plant population level. It was followed by P_1 and P_3 level.

Table 2: Effect of *Rhizobium* inoculation and plant population on yield attributes and yield of field pea (pooled data of 2 years)

Treatment	Number of plant	No. of grains/pod	Seed Index(g)	Yield (q/ha)
P_1	9.25	4.25	12.75	9.80
P_2	11.20	5.20	13.65	10.60
P_3	11.80	5.35	13.80	10.20
SE (d)	0.09	0.10	0.35	0.10
CD (P=0.05)	0.25	0.30	0.63	0.25
I_0	8.75	4.20	12.60	8.50
I_1	10.25	5.15	13.50	10.50
SE (d)	0.05	0.03	0.10	0.15
CD (P=0.05)	0.09	0.08	0.20	0.34

There was a significant effect of inoculation on plant stand per square metre at harvest. Yield and yield attributes were also significantly increased by *Rhizobium* inoculation. Naidu and ram (1996) [8] and Shukla and dixit (1996) [11] also observed the marked effect of *Rhizobium* inoculation in increasing yield of grain legume particularly green gram.

Nitrogen uptake and protein yield

Nitrogen uptake was higher under P_2 plant population followed by P_1 and P_3. Protein content closely followed the pattern of nitrogen content. Maximum protein content was under P_2 plant population, whereas it was minimum under P_1 plant population. Total protein yield was the highest under P_2 plant population followed by P_3 and P_1. Trung and Yoshida (1985) [13] also found similar trend regarding seed crude protein content.

Rhizobium inoculation increased the nitrogen uptake than uninoculated plots. Protein content and protein yield also exhibited similar trend. Similar result was reported by Raju and Varma (1984) [18].

Table 3: Economics of field pea cultivation influenced by *Rhizobium* inoculation and plant population.

Treatment	Pooled grain yield (q/ha)	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit: Cost ratio
P_1	9.80	58800.00	30305.00	28495.60	1.94
P_2	10.60	63600.80	29705.00	33895.80	2.14
P_3	10.00	59300.00	29350.00	29950.00	2.02
I_0	8.50	51000.60	28505.00	22495.60	1.79
I_1	10.50	63000.80	29605.00	33395.80	2.13

The highest net profit of Rs. 16737.60/ha was obtained under *Rhizobium* inoculated condition with P_2 (4.0 lacs plant/ha) plant population level was maintained followed by P_3I_1 (3.33 lacs plant x *Rhizobium* inoculation).

Considering overall economics, *Rhizobium* inoculation under P_2 plant population level was found to be the most economic combination among all the treatments under study.

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