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Effect of nitrogen, phosphorus and bio-fertilizers on growth and yield attributes of garden pea (*Pisum sativum* L.)

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Abstract
The field experiment was conducted at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *rabi* season year 2017-18. To study the Effect of Nitrogen, Phosphorus and Bio-fertilizers on Growth and Yield Attributes of Garden Pea (*Pisum sativum* L.) cv. Arkel. The experiment was laid out in RBD with 11 treatments in 3 replication on different nitrogen and phosphorus levels and in combination with bio-fertilizers compared to control. The treatment 20 Kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) showed significant increase in the growth and yield attributes as campared to control but statistically at par with 20 Kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 Kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4) where as green pod yield (kg/plot and q/ha) was found maximum at T_5 being statistically at par with T_3 and T_4.

Keywords: Nitrogen, phosphorus, *Rhizobium*, PSB, pea, growth, yield

Introduction
Garden pea [*Pisum sativum* (L.)] is an important vegetable crop grown throughout the world. In India, it is cultivated mainly as cool season crop in the plains of North India and as summer vegetable in the hills. It belongs to family leguminoceae (Fabaceae) and chromosome number 2n=14. It is thought to have originated in the Ethiopia, part of Europe and Asia as reported by Choudhary (1967) [5]. It is native of Europe and Western Asia as reported by Thompson and Kelly (1957) [16]. Peas are utilized mainly as a vegetable and consumed as pulses. It is used as fresh vegetable, canned, processed or dehydrated (Thamburaj and Singh, 2005) [15].

Pea occupies an area of 540 thousand hectares with the production of 5427 thousand tonnes grain in India (Anonymous, 2017) [2]. It is cultivated in Rajasthan on about 13831 hectares area with an annual production of 36375 tonnes grain (Anonymous, 2016) [1]. It is largely cultivated in Jaipur, Baran, Bundi, Kota and Bharatpur districts of Rajasthan.

Pea is highly responsive to nitrogenous fertilizer application especially in early stage. Nitrogen promotes the leaf, stem and other vegetative growth. It also increases the protein content in pea. It is an integral constituent of proteins and chlorophyll and is present in many other compounds of great physiological importance in plant metabolism, such as nucleotides, phosphatides, alkaloids, enzymes, hormones, vitamins etc. It imparts dark-green colour to plants, hastens rapid early growth and improves capacity to fix atmospheric nitrogen symbiotically. Nitrogen application to legumes at lower doses in the initial stage is essential for vigorous start. Growing of pulses without application of phosphatic fertilizer is an important factor for low yield. An adequate supply of phosphorus has been reported by various workers to be beneficial for better growth and yield, better quality in legumes (Sammauria *et al*., 2009) [10]. It acts as a structural component of membrane system of cells, chloroplasts and mitochondria. It is a constituent of energy phosphates like ADP and ATP, nucleic acid, nucleo proteins, purines, pyrimidine, nucleotides and several co-enzymes. It is involved in the basic reaction of photosynthesis. It plays an important role in cell division, carbohydrate break down for energy release, transfer of inherited characteristics and hastening the maturity of plants.

Use of bio-fertilizers play an important role in increasing fertilizers use efficiency. When the seeds of pulses are inoculated with *Rhizobium* and sown in such soils, it increases their number in the rhizosphere, thereby increasing the amount of microbiologically fixed nitrogen for the plant growth. About 93-99 per cent of the total phosphorus is insoluble in soil and hence directly not available to plants.

Only about a quarter of water soluble phosphate is taken up by plants in the season of the application and the remaining is converted into insoluble (unavailable) forms (Verma, 1993) [19]. Introduction of P solubilizing microorganisms in the rhizosphere of crop and soil increases the availability of P from insoluble sources of phosphate, desorption of fixed phosphates and also increases the efficiency of phosphatic fertilizers (Gaur, 1991) [6].

Materials and Methods

The experiment was carried out at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *rabi* season year 2017-18. The Bikaner spread between Altitude of 234.7 meters above mean sea level and latitude of 280.01' N and longitude of 730.22' E. Pea seeds (cv. Arkel) were sown @ 80 kg/ha. In Rows at 30 cm apart by *kera* method and observation on Plant height (cm) at 50 DAS, Chlorophyll content in plant leaves at 40 DAS and Yield attributes and yields, Pod length (cm), Fresh pod weight (g), Number of pods per plant, Number of seeds per pod, Green pod yield per plot (kg), Green pod yield per hectare (q) were recorded.

Result and Discussion

Plant height at 50 DAS

The data related to plant height is presented in table 1. Plant height significantly varied under different fertility levels and in combination with bio-fertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the maximum plant height of 45 cm at 50 DAS. However, T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P (T_1), 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4). Whereas, the minimum plant height (30 cm) was recorded under control (T_0). Similar results were reported by Singh *et al*. (2005) [14] and Mathur *et al.* (2008) [7] on pea.

Chlorophyll content in plant leaves at 40 DAS

The data clearly showed (table 1) that chlorophyll content significantly affected by different fertility levels and in combination with bio-fertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the highest chlorophyll content (2.57 mg per g) at 40 DAS; while the minimum chlorophyll content (1.46 mg per g) was recorded in control. However, T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3). The above findings are in agreement with Tiwari and Kumar (2009) [18].

Yield attributes and yield

Pod Length

The data related to pod length is presented in table 2. The pod length significantly varied under different nutrient levels and in combination with bio-fertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the maximum pod length of 7.85 cm and followed by 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4). Whereas, the minimum pod length 4.82 cm was recorded under control (T_0). Similar results were also reported by Mundra and Bhati (1994) [8], Shukla and Dixit (1996) [12] and Sibbal *et al*. (2002) [13]. These findings are in close conformity with that of Saraf *et al*. (1997) [11], Chattopadhyay and Dutta (2003) [4].

Fresh Pod Weight

Data related to fresh pod weight is presented in table 2. The fresh pod weight significantly varied under different levels of nutrients and in combination with biofertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the maximum fresh pod weight of 8.10 g. However, T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4). Whereas, the minimum fresh pod weight (5.25 g) was recorded under control (T_0). Similar results were reported by (Tisdale *et al*., 1995) [17].

Number of pods per plant

Data presented in table 3. Related to number of pods per plant, showed that pods per plant significantly varied under different fertility levels and in combination with bio-fertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the maximum number of pods per plant of 17.07. However, T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P (T_1), 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3), 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4) and 10 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_8) whereas, the minimum number of pods per plant (10.48) was recorded under control (T_0).

Number of seeds per pod

Data related to number of seeds per pod is presented in table 3. The number of seeds per pod significantly varied under different nutrients levels and in combination with bio-fertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the maximum number of seeds per pod of 6.90. However,T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P (T_1), 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3), 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4), 20 kg ha^{-1} N + 30 kg ha^{-1} P + PSB (T_7) and 10 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_8) and significantly superior to control (5.05).

Green pod yield per plot (kg)

Data presented in table 4. Related to green pod yield per plot revealed that yield per plot significantly varied under different nitrogen and phosphorus levels and in combination with bio-fertilizers compared to control. The treatment of 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the maximum green pod yield per plot (4.35 kg). However, T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P (T_1), 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4) and minimum green pod yield per plot (1.91 kg) was recorded under control (T_0). Similar findings were also reported by Vimla and Natarajan (2000) [20], Rajput and Pandey (2004) [9] and Balachandran *et al.* (2005) [3].

Green pod yield per hectare (q)

Data presented in table 4. Revealed that green pod yield significantly varied under different nitrogen and phosphorus levels and in combination with bio-fertilizers compared to control. The treatment 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) recorded the highest green pod yield per hectare (80.49 q). However, T_5 remained statistically at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P (T_1), 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4); whereas, the minimum green pod yield per hectare (36.22 q) was recorded under control (T_0).

Table 1: Effect of nitrogen, phosphorus and bio-fertilizers on plant and chlorophyll content of garden pea

	Treatments	Plant height (cm) at 50 DAS	Chlorophyll content (mg/g) at 40 DAS
T_0	Control	30.00	1.46
T_1	20 kg ha^{-1} N + 40 kg ha^{-1} P	41.00	2.12
T_2	*Rhizobium* + PSB	36.00	1.70
T_3	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	44.00	2.50
T_4	20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB	42.33	2.40
T_5	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB	45.00	2.57
T_6	20 kg ha^{-1} N + 20 kg ha^{-1} P + PSB	38.00	2.18
T_7	20 kg ha^{-1} N + 30 kg ha^{-1} P + PSB	39.00	2.30
T_8	10 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	40.00	2.36
T_9	10 kg ha^{-1} N + 30 kg ha^{-1} P + *Rhizobium* + PSB	38.00	2.32
T_{10}	10 kg ha^{-1} N + 20 kg ha^{-1} P + *Rhizobium* + PSB	37.00	2.15
S.Em+		1.61	0.05
CD at 5%		4.76	0.14

Table 2: Effect of nitrogen, phosphorus and bio-fertilizers on pod length and fresh pod weight of garden pea

	Treatments	Pod length (cm)	Fresh pod weight (g)
T_0	Control	4.82	5.25
T_1	20 kg ha^{-1} N + 40 kg ha^{-1} P	6.94	7.09
T_2	*Rhizobium* + PSB	5.10	5.49
T_3	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	7.50	7.79
T_4	20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB	7.40	7.50
T_5	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB	7.85	8.10
T_6	20 kg ha^{-1} N + 20 kg ha^{-1} P + PSB	6.04	6.05
T_7	20 kg ha^{-1} N + 30 kg ha^{-1} P + PSB	6.74	6.50
T_8	10 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	6.79	6.83
T_9	10 kg ha^{-1} N + 30 kg ha^{-1} P + *Rhizobium* + PSB	6.78	6.20
T_{10}	10 kg ha^{-1} N + 20 kg ha^{-1} P + *Rhizobium* + PSB	6.76	5.90
S.Em+		0.08	0.24
CD at 5%		0.23	0.71

Table 3: Effect of nitrogen, phosphorus and bio-fertilizers on no. of pods per plant and number of seeds per pod of garden pea

	Treatments	Number of pods per plant	Number of seeds per pod
T_0	Control	10.48	5.05
T_1	20 kg ha^{-1} N + 40 kg ha^{-1} P	15.50	6.50
T_2	*Rhizobium* + PSB	11.54	5.51
T_3	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	16.42	6.78
T_4	20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB	16.12	6.64
T_5	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB	17.07	6.90
T_6	20 kg ha^{-1} N + 20 kg ha^{-1} P + PSB	11.17	6.09
T_7	20 kg ha^{-1} N + 30 kg ha^{-1} P + PSB	14.68	6.30
T_8	10 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	15.15	6.40
T_9	10 kg ha^{-1} N + 30 kg ha^{-1} P + *Rhizobium* + PSB	14.90	6.19
T_{10}	10 kg ha^{-1} N + 20 kg ha^{-1} P + *Rhizobium* + PSB	14.14	5.90
S.Em+		0.66	0.24
CD at 5%		1.93	0.70

Table 4: Effect of nitrogen, phosphorus and bio-fertilizers on green pod yield per plot (kg) and green pod yield per hectare (q) of garden pea

	Treatments	Green pod yield per plot (kg)	Green pod yield per hectare (q)
T_0	Control	1.91	36.22
T_1	20 kg ha^{-1} N + 40 kg ha^{-1} P	3.79	70.07
T_2	*Rhizobium* + PSB	2.44	45.15
T_3	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	4.16	76.97
T_4	20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB	4.06	75.03
T_5	20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB	4.35	80.49
T_6	20 kg ha^{-1} N + 20 kg ha^{-1} P + PSB	3.62	67.53
T_7	20 kg ha^{-1} N + 30 kg ha^{-1} P + PSB	3.73	69.00
T_8	10 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium*	3.75	69.48
T_9	10 kg ha^{-1} N + 30 kg ha^{-1} P + *Rhizobium* + PSB	3.65	67.67
T_{10}	10 kg ha^{-1} N + 20 kg ha^{-1} P + *Rhizobium* + PSB	3.57	66.15
S.Em+		0.19	3.66
CD at 5%		0.57	10.88

Conclusion

Based on results of one year experimentation, it may be concluded that the combined application of 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* + PSB (T_5) (seed inoculation) proved the most superior treatment with regard to green pod yield (80.49 q ha^{-1}) of pea and further treatment combinations of 20 kg ha^{-1} N + 40 kg ha^{-1} P + *Rhizobium* (T_3) and 20 kg ha^{-1} N + 40 kg ha^{-1} P + PSB (T_4) were at par with 20 kg ha^{-1} N + 40 kg ha^{-1} P (T_1) in terms of green pod yield. These results are only indicative and require further experimentation to arrive at some more consistent and final conclusion.

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