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Influence of Biofertilizers on Plant Growth and Seed Yield of Pea (*Pisum sativum* L.)

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A B S T R A C T

The present study was conducted to the Influence of biofertilizers on plant growth and seed yield of Pea (*Pisum sativum* L.). Based on the mean performance the Treatment- 8 (100% RDF + Rhizobium 200 gm/ kg) was found best treatment for plant growth and seed yield. This obtained high in plant height (50.65cm), Number of branches per plant (13.75), Number of leaves per plant (33.10), days to 50% flowering (49.33), Number of pods per plant (16.00), days to maturity (81.00), Pod length (8.10cm), Number of seed per pod (6.45), 100 seed weight (seed index) (17.45gm), seed yield per plant (17.35gm), Nodules per plant (21.95). Thus, it indicates that the process of seed treatment by biofertilizers may be better option for seed growers to achieve higher seed yield and yield attributes in pea. Biofertilizers are one of the most important tools in Agriculture for highest plant growth and seed production. Biofertilizers are prepared from live cells of different microorganisms and applied to soil, seed to the availability of nutrients and to improve fertility status of soil. Biofertilizers were found to be superior with regards to plant growth, and yield characters over control.

Introduction

Pulse crops have a specific importance for the vegetarian population of our country because pulses are the major source of protein. However, due to population explosion and low productivity of pulse crops, per capita availability of pulses is consistently decreasing. Per capita availability of pulses per day is only 47g as against the minimum requirement of 104 g as recommended by nutritional experts of World Health Organization/Food and Agriculture Organization (Hariprasanna and Bhatt 2002).

Pea (*Pisum sativum* L.) is a cool season legume crop that is grown on over 25 million acres worldwide. Field pea or dry pea is marketed as a dry, shelled product for either human or livestock food. It is commonly used throughout the world in human diets and has high levels of amino acid, lysine and tryptophan, which are relatively low in cereal grains and contains approximately 21-25% protein. Being a legume crop and has the inherent ability to obtain much of its nitrogen requirement from the atmosphere by forming a symbiotic relationship with Rhizobium bacteria in the soil (Schatz and Endres, 2009).

The favorable effect of Azotobacter and mineral nitrogen fertilizer on growth,

chemical composition of leaves, and yield was reported on pea indicated that both inoculation with Azotobacter and application of N increased seed yield (Verma *et al.*, 2000). A small dose of Biofertilizer is sufficient to produce desirable results because each gram of carrier of biofertilizers contains at least 10 million viable cells of a specific strain (Anandaraj and Delapierre, 2010).

Among the various fertilizers, biofertilizers are important sources of nutrients. Biofertilizers are natural fertilizers containing micro-organism which help in enhancing the productivity by Biological nitrogen fixation or solubilization of insoluble phosphate or producing hormones, vitamins and other growth regulators required for plant growth (Bhattacharya, 2000).

Rhizobium inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield (Sardana *et al.*, 2006).

The fixed phosphorus in the soil can be solubilized by phosphate solubilizing bacteria (PSB), which have the capacity to convert inorganic unavailable phosphorus form to soluble forms HPO_4^{2-} and $H_2PO_4^-$ through the process of organic acid production, chelating and ion exchange reactions and make them available to plants. Therefore, the use of PSB in agricultural practice would not only offset the high cost of manufacturing phosphate fertilizers but would also mobilize insoluble in the fertilizers and soils to which they are applied (Chang and Yang, 2009) Keeping these facts the present investigation was undertaken to assess the effect of different biofertilizers on growth and yield characters of pea.

Materials and Methods

The research work was conducted at the experimental farm of Department of Genetics & Plant breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during the year 2015-2016.The experiment were carried out in Randomized block design with 10 treatments included Bio fertilizers (Azotobacter, Phosphorus Solubilizing Bacteria, Rhizobium). The following observations were recorded such as growth parameters Plant height(cm), Number of leaves/plant, Days to 50% flowering, primary branch/plant, and Yield and yield characters, Number of pods per plant, seed yield per plant (kg), No.of seed/pod, days to maturity, Nodules /plant. The Pea variety Azad matar-3 was selected for this research trial and seed source is Indian Institute of Pulse Research (IIPR) Kanpur (U.P.) India. The ten treatments were laid out in Randomized Block Design with three replications. The gross area of field is about 216.48m^2 and net area 120 m^2 respectively. The fertilizer was applied at the time of sowing. Seeds were sown in line sowing method with 30 cm row to row spacing and 10 cm plant to plant spacing respectively. The soil of the experimental field was sandy loam and having pH 7.5. The recommended dose of nitrogen, phosphorus and potash was applied in all the plots except control. An optimum dose of nitrogen (25kgNha^{-1}) was applied, half of which was given at the time of seed sowing along with the full dose of phosphorus (60kg ha^{-1}) and potassium (40kg ha^{-1}) and the remaining half dose of nitrogen was applied as top dressing. Recommended seed rate of 60-80 kg/ha. In the present study the seed treatment method was followed, in this case for each kg of seed, slurry was prepared by mixing and warming 200g of bio-fertilizer culture *i.e.* Rhizobium, Azotobacter and phosphorus solubilizing bacteria (PSB) in 200 ml water containing 200g Juggery and in

interactional (co-inoculation) cases equal share of weight was taken from each member of the interaction corresponding to weight of 200g. The seed was kept for 15-20 minutes in slurry. After putting and taking out the seeds from the slurry after 15 – 20 minutes, then they were spread in shade for 20 – 30 minutes prior to their sowing in the prepared plots having size (2.0 × 2.0m) at 2.50 cm depth covering of furrows. The following treatment combinations were used in this research work such as T_0 (control), T_1 (100%RDF + Azotobacter 100 g/kg seed), T_2 (100%RDF + Rhizobium 100 g/kg seed), T_3 (100%RDF + Phosphorus solubilizing bacteria 100 g/kg seed), T_4 (100%RDF + Azotobacter 150 g/kg seed), T_5 (100%RDF + Rhizobium 150 g/kg seed), T_6 (100%RDF + Phosphorus solubilizing bacteria 150 g/kg seed), T_7 (100%RDF + Azotobacter 200 g/kg seed), T_8 (100%RDF + Rhizobium 200 g/kg seed), T_9 (100%RDF + Phosphorus solubilizing bacteria 200 g/kg seed). The statistical analysis was carried out as per the methods suggested by Panse and Sukhatme (1967)

Results and Discussion

The result of revealed that the T_8 application of (100% RDF + 200gm/kg seed) were show significantly higher value on plant height, No. of seed/plant, No. of pods/plant, Days to 50% flowering, Days to maturity, seed yield/plant, No. of seed/pod, No. of pods/plant followed by T_9 with (100%RDF + PSB 200gm/kg seed) while T_0 with (control) was show minimum value for all these observations (Figs. 1–3).

Effect on growth parameters

In case of Days to 50% flowering of pea it is evident from table 1 that significantly minimum days in Days to 50% flowering occurs by the T_8 with application of 100 % + Rhizobium @ 200 g/kg seed may be considered as the best treatment for early duration in days to 50% (49.33 days), followed by T_7 with 100% + Azotobacter 200gm/kg seed (50.00 days) and Maximum days was occured in T_0 with control (53.33 days). Similar results were reported by Dekhane *et al.,* (2011) conducted the cowpea seeds inoculated with Rhizobium significantly increased the growth parameters and yield attributes recorded by seed inoculation with 100% RDF+ Rhizobium. Kanaujia *et al.,* (1997) also reported that pea seed inoculation with *Rhizobium* culture attributed to higher number of nodules/plant at all the stages (45, 90 and 135 days after sowing) of plant growth, and this increase in nodulation and nitrogen fixation due to the inoculation led to significantly more plant height, days taken to flowering, higher green pod yield and dry matter over un-inoculated control.

In case of Plant height of pea it is evident from table 1 that significantly maximum increase in plant height occurs by the T_8 with application of 100% RDF + Rhizobium 200g/ kg Seed recorded high plant height (50.65cm), followed by T_9 with 100% + PSB 200gm/kg seed (50.30cm) and Minimum value was obtained in T_0 with control (42.20cm). Similar results were reported by Dekhane *et al.,* (2011) reported that the inoculation of pea seeds with Rhizobium was responsible for significant increments on plant height, number of leaves and branches, fresh and dry weight plant-1 and dry matter %, compared to the un-inoculated plants. Rather *et al.,* (2010) also find out the effect of biofertilizers (*Rhizobium*, *Azotobacter* and phosphate solubilizing bacteria (PSB)) application on growth, yield and economics of field pea (*Pisum sativum L.*). The co-inoculation of all the three bio-fertilizers *i.e. Rhizobium*, Azotobacter and PSB produced significantly higher growth characters as compared to absolute control and when inoculated them individually. The treatment T_8 comprising *Rhizobium* + *Azotobacter* +

PSB gave highest growth in terms of plant height (45.26 cm), number of branches/ plant (4.20), number of leaves/ plant. Sharma and Chauhan *(*2011) reported that 100% NPK + Vermicompost + Biofertilizers gave the maximum plant height of 72.83 cm which was statistically significant over all other treatments.

In case of branches per plant of pea it is evident from table 1 that significantly maximum increase in branches per plant occurs byT_8 with the application of 100 % RDF + Rhizobium @ 200 g/ kg seed exhibited higher mean value for number of branches (13.75), followed by T_9 with 100% + PSB 200gm/kg seed (13.35) and Minimum value was obtained in T_0 with control (11.65). Similar findings have been reported by Dekhane *et al.,* (2011), and Sarg and Hassan (2003) reported on pea plant, that plant height, leaves and branches number /plant and number of nodules were significantly increased with *Rhizobium* inoculation compared with the un-inoculated one.

In case of Leaves per plant of pea it is evident from table 1 that significantly maximum increase in Leaves per plant occurs byT_8 with application of 100% RDF + PSB @ 200 g/ kg seed exhibited higher mean value for number of leaves per plant (33.10), followed by T_9 with100% + PSB 200gm/kg seed (32.40) and Minimum value was obtained in T_0 with control (30.45). Similar results were reported by Rather *et al.,* (2010), and Dekhane *et al.,* (2011) and also Solieman *et al.,* (2003) on pea plant, that inoculation of pea seeds with *Rhizobium* significantly increased plant height, number of branches/plant compared to the un-inoculated one.

In case of Days to maturity of pea it is evident from table 1 that significantly minimum days in Days to maturity occurs by the T_8 with application of 100% RDF + Rhizobium @ 200 g/ kg seed recorded best treatment for days to maturity (81.00), followed by T_9 with100% + PSB 200gm/kg seed (82.00) and Minimum value was obtained in T_0 with control (84.65).

Effect on yield and yield attributes

In case of Number of seed per pod of pea it is evident from table 1 that significantly maximum increase in Number of seed per pod occurs by T_8 100% RDF + Rhizobium @ 200 g/ kg seed exhibited high number of seeds per pod (6.45), followed by T_9 with 100% + PSB 200gm/kg seed (5.75) and Minimum value was obtained in T_0 with control (4.80). Similar findings have been reported by Mishra *et al.,* (2010) also reported to the effect of biofertilizers in conjunction with inorganic fertilizers on growth and yield of dwarf field pea (cv. Jai) and found that number of pods plant^{-1}, number of seeds pods^{-1} at maturity attributed significantly increasing with the application of 100% DRF and seed inoculation of *Rhizobium* + PSB + PGPR.

In case of Seed index of pea it is evident from table 1 that significantly maximum increase in Seed index occurs by the treatment 8 (T_8 - 100% RDF + Rhizobium @ 200 g/kg seed) exhibited high seed index (17.45gm), followed by T_9 with 100% + PSB 200gm/kg seed (16.90gm) and Minimum value was obtained in T_0 with control (15.90gm). Similar results were reported by Dekhane *et al.,* (2011) reported on pea plant, that Seed index and number of nodules were significantly increased with *Rhizobium* inoculation compared with the un-inoculated one. In case of Pod length of pea it is evident from table 1 that significantly maximum increase in Pod length occurs by the T_8 (100% RDF + Rhizobium @ 200 g/ kg seed) exhibited high for pod length (8.10cm), followed by T_9 with 100% + PSB 200gm/kg seed (8.00cm) and Minimum value was obtained in T_0 with control (7.15cm).

Table.1 Mean performance of biofertilizers on plant growth and seed yield of pea

Sr. No.	Treatments	50% Flowering (Days)	Plant height (cm)	No. of Branches /plant	No. of Leaves/ plant	No. of Pods/ plant	Days of maturity (Days)	Pod length (cm)	No. of Seed /pod	100 seed weight (gm)	Seed yield/ plant (gm)	Nodules /plant
1.	T_0 = Control	53.33	42.20	11.65	30.45	10.75	84.65	7.15	4.80	15.90	14.55	12.60
2.	T_1 = RDF +Azotobacter (100 gm/kg seed)	51.65	43.15	11.80	31.26	13.25	83.00	7.90	5.45	16.50	14.95	14.35
3.	T_2 = RDF+ Rhizobium (100 gm/kg seed)	52.60	44.45	12.55	30.95	13.00	84.00	7.60	5.20	16.35	15.20	14.95
4.	T_3 = RDF + Phosphate solubilising bacteria (100 gm/kg seed)	53.00	45.30	12.20	31.65	13.90	83.65	7.40	5.30	16.70	15.80	15.20
5.	T_4 = RDF+ Azotobacter (150 gm/kg seed)	51.00	45.35	12.06	30.75	12.90	82.65	7.35	5.15	16.65	15.55	16.55
6.	T_5 = RDF+ Rhizobium (150 gm/kg seed)	50.33	46.90	13.00	32.00	13.15	83.30	7.70	5.25	16.60	16.00	18.05
7.	T_6 = RDF+ Phosphate solubilising bacteria (150 gm/kg seed)	51.33	47.55	13.25	30.80	13.70	82.30	7.75	5.40	16.15	15.90	18.00
8.	T_7 = RDF+ Azotobacter (200 gm/kg seed)	50.00	44.65	11.85	30.85	14.60	84.30	7.50	5.60	16.70	15.75	18.80
9.	T_8 = RDF+ Rhizobium (200 gm/kg seed)	49.33	50.65	13.75	33.10	16.00	81.65	8.10	6.45	17.45	17.35	21.95
10.	T_9 = RDF+ Phosphate solubilising bacteria (200 gm/kg seed)	52.66	50.30	13.35	32.40	14.75	82.00	8.00	5.75	16.90	16.30	20.60
11.	Mean	51.52	46.05	12.54	31.42	13.60	83.15	7.64	5.43	16.59	15.73	17.10
12.	S.Em	1.00	1.44	0.25	0.75	1.30	0.67	0.16	0.27	0.28	0.15	0.56
13.	C.D. 5%	2.97	4.30	0.74	2.23	3.87	2.00	0.48	0.82	0.83	0.47	1.67

Fig.1 Histogram depicting the effect of treatments on plant height (cm) in pea

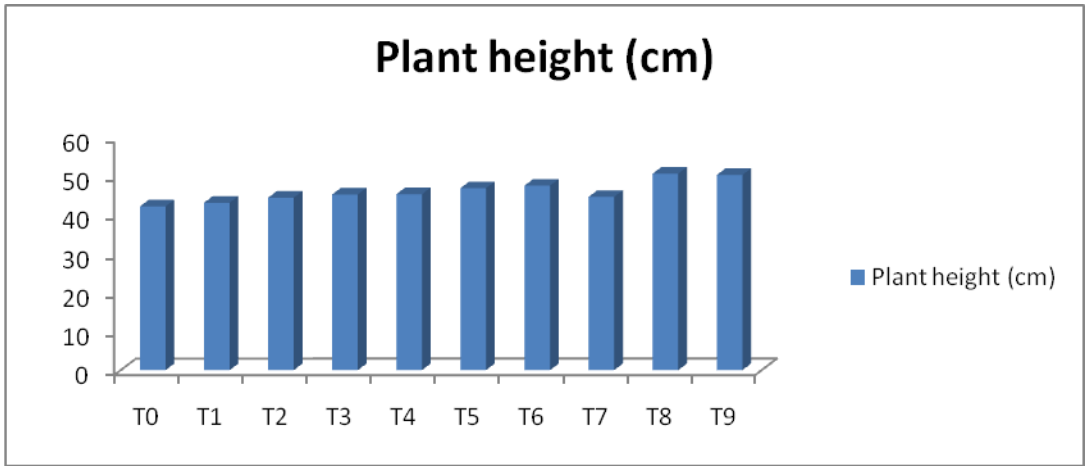


Fig.2 Histogram depicting the effect of treatments on seed index (g) in pea

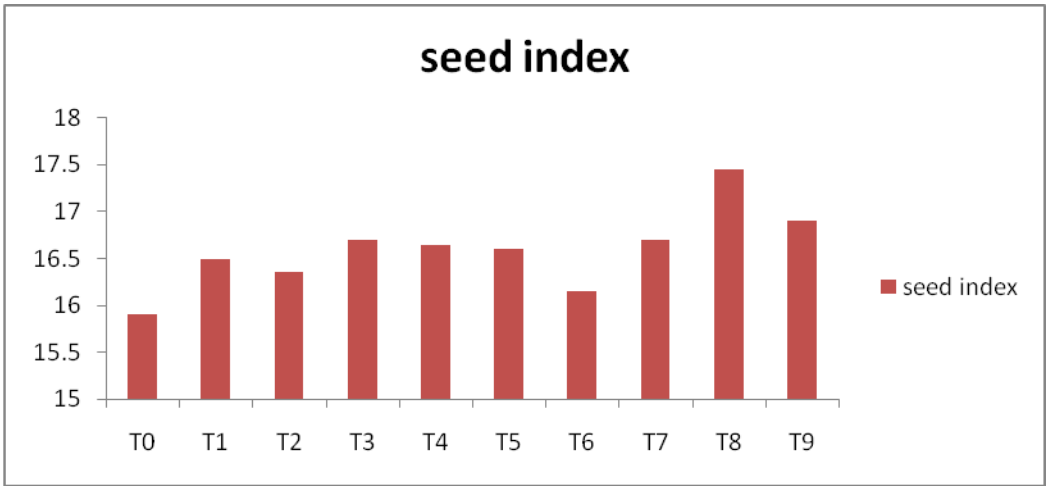
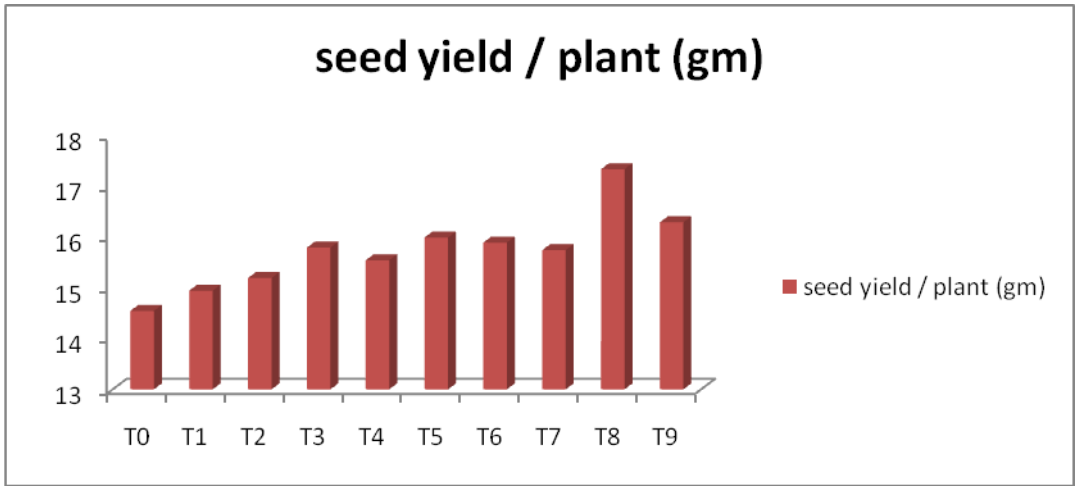


Fig.3 Histogram depicting the effect of treatments on seed yield / plant (g) in pea



Similar observations were reported by Dekhane *et al.,* (2011) reported on pea plant, that plant height, pod length, and number of nodules were significantly increased with *Rhizobium* inoculation compared with the un-inoculated one. In case of Seed yield per plant of pea it is evident from table 1 that significantly maximum increase in Seed yield per plant occurs by the T_8 with application of (100% RDF + Rhizobium @ 200 g/ kg seed) exhibited high seed yield per plant (17.35gm), followed by T_9 with 100% + PSB 200gm/kg seed (16.30gm) and Minimum value was obtained in T_0 with control (14.55gm). Similar observations were reported by Kanaujia *et al.,* (1997) revealed that seed inoculation of Rhizobium @30 g/kg seed along with 30 N/ha as basal application in broad bean have produced highest number of nodules/plant and Treatment also recorded maximum number of pods per plant (14.78) and seed yield (22.10q/ha) but failed to produce any significant influence on the number of seeds/pods seed weight.

In case of Nodules per plant of pea it is evident from table 1 that significantly maximum increase in Nodules per plant occurs by the T_8 (100% RDF + Rhizobium @ 200 g/ kg seed) exhibited high number of nodules per plant (21.95), followed by T_9 with 100% + PSB 200gm/kg seed (20.60) and Minimum value was obtained in T_0 with control (12.60). Similar findings have been reported by Gupta and Namdeo (1999), Prasad *et al.,* (2002) and Sarg and Hassan *et al.,* (2003), observed a significant increase in number of nodule/plant in pea crop, when organic amendments and bio-fertilizers are both applied in together combination and also reported by Ramadan (1997) indicated that seed inoculation with *Rhizobium*, revealed significant effect on all studied morphological characters; i.e. stem length (cm), number of branches, number of leaves and number of nodules/plant compared to un-treated one (control).

In case of Pods per plant of pea it is evident from table 1 that significantly maximum increase in Pods per plant by the T_8 (100% RDF + Rhizobium @ 200 g/ kg seed) exhibited higher mean value for number of pods per plant (16.00), followed by T_9 with100% + PSB 200gm/kg seed (14.75) and Minimum value was obtained in T_0 with control (10.75).

Similar findings have been reported by El-Mansi *et al.,* (2000) showed that seed inoculation with *Rhizobium* gave significantly higher values of pod number/plant and total yield/fed compared with check. Mishra *et al.,* (2010) also reported to the effect of biofertilizers in conjunction with inorganic fertilizers on growth and yield of dwarf field pea (cv. Jai) and found that number of pods plant-1, number of seeds pods-1 at maturity attributed significantly increasing with the application of 100% DRF and seed inoculation of *Rhizobium* + PSB + PGPR.

The above results showed that the integration of biofertilizers along with chemicals has a positive effect on the plant growth and yield attributes of pea. It is concluded from the present investigation that treatment T_8 (100% RDF + Rhizobium 200 g/ kg of seed) exhibited higher mean value for seed yield per plant, number of primary branches, number of leaves per plant, number of pods per plant, pod length, number of seeds per pod, plant height, seed yield per plant, seed index and nodules per plant followed by T_9 (100% RDF + PSB 200 gm/kg seed) and minimum value for these characters showed in control. T_0 with control showed more days to 50% flowering, T_8 (RDF + Rhizobium @ 200 g/ kg seed) recorded best treatment for days to early maturity and early flowering. Thus, it indicates that the process of seed treatment by biofertilizers may be better option for seed growers to achieve higher seed yield and yield attributes in pea.

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