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Effect of bio-formulations on growth and yield of Pea (*Pisum sativum* L.)

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ABSTRACT

An experiment was conducted to study the effect of different bio-formulations on performance of garden pea (variety-Sakata, Sweet Pearl) under Namsai conditions of Arunachal Pradesh in the Agricultural Research Farm of Arunachal University of Studies. The experiment consisted of 10 treatment combinations involving three doses each of Bio-N (4, 5, 6 t/ha), Bio-P (2, 3, 4 t/ha) and Bio-K (2, 3, 4 t/ha) with uniform dose of pH regulator and organic manure in three replications in a randomized block design. Application of Bio-N:Bio-P:Bio-K @ 4:3:3 t/ha recorded the maximum plant height and maximum number of branches per plant. Number of pods and weight of pods per 100g was found highest in T2 (Bio-N 4t/ha + Bio-P 3t/ha + Bio-K 3t/ha) and maximum length of pods in T1 (Bio-N 4t/ha + Bio-P 2t/ha + Bio-K 2t/ha) which was at par with T2. The maximum yield (6.63 t/ha) was obtained in T2 (Bio-N 4t/ha + Bio-P 3t/ha + Bio-K 3t/ha), T4 (Bio-N 5t/ha + Bio-P 2t/ha + Bio-K 2t/ha) and T6 (Bio-N 5t/ha + Bio-P 4t/ha + Bio-K 4t/ha) respectively. The higher quantity of Bio-P and Bio-K in T2 showed a significant contribution in increasing the yield of crop. Considering the overall performance and comparative doses the application of Bio-N:Bio-P:Bio-K @ 4:3:3 t/ha can be recommended for eastern himalayan agro-climatic conditions.

Key words : *Bio-formulation, Eastern Himalayan, Pisum sativum, Yield.*

Introduction

Field pea is a popular winter season pulse crop of India belonging to Fabaceae family. It provides a variety of vegetarian dishes and hence it is liked throughout the world. Basically this crop is cultivated for its green tender pods and green seeds mostly used as vegetables which serve as excellent food for human consumption. It is highly nutritive and contains high proportion of digestible protein, mineral, fat, carbohydrates, calcium, iron, magnesium, copper, riboflavin, phosphorous and vitamin C (Watt and Merrill, 1993; Bhat *et al*., 2013). Large portion of peas are produced for consumption during the off-season. Pea straws are use for livestock fodder. In India the main peas growing states are Uttar Pradesh, Punjab, Haryana, Bihar, Himachal Pradesh, Orissa and Karnataka.

Crop nutrition is an important factor deciding the productivity of the crops. Among the different components of nutrients, organic manures are important. Farm yard manure is the common organic manure used in agriculture. Manure as a source of crop nutrients and soil amendment, contains most ele-

ments required for plant growth including NPK and micronutrients. Reddy *et al.* (1998) reported the highest yield of pea with 10 t ha^{-1} vermicompost + 100 % recommended dose of N:P:K (37.5:60:50). Achakzai and Bangulzai (2006) revealed that maximum pod yield $plant^{-1}$, fresh pod yield ha^{-1}, were recorded with fertilizer dose of 100:60:40 kg NPK ha^{-1} in pea. Sharma and Chauhan (2011) reported that 100% NPK +Vermicompost + Biofertilizers resulted in maximum plant height (72.83 cm) in Pea. Combined application of NPK as chemical fertilizers along with organics like FYM, vermicompost as well as biofertilizers has been reported to increase the growth significantly (Mishra, 2014; Susheela *et al*., 2007).

The use of chemical fertilizers and pesticides for food production to satisfy the demand of food has gradually affected the quality of the soil. Technologies such as bio-formulation have emerged in order to minimize the environment impacts and pollution. Bio-formulations usually contain an active ingredient (Bio-N,-P,-K) a carrier material, and an additive. The active ingredient is mostly a viable organism which contains multiple microbes and its survival during storage is very essential for successful formulation development. A liquid formulation contains 10-40% microorganisms, 1-3% suspender ingredient, 1-5% dispersant, 3-8% surfactant and 35-65% carrier liquid (water or oil). Bio-formulation has reduced the use of chemical fertilizer by 15-40%. They have long shelf life and it is easy to produce and apply in the field. They supplement the chemical fertilizers for meeting the integrated nutrients demand for the crop. Application of bio-formulation results in increased water uptake, root development, vegetative growth and nitrogen fixation. They act as antagonists and suppress the incidence of soil borne plant pathogens and thus, help in the bio-control of diseases. They help to maintain soil fertility and increase growth promoting substances and vitamins having important role in recycling of plant nutrients. *Rhizobium +Azotobacter* + PSB resulted to highest growth in terms of plant height, number of branches/plant, number of leaves/plant in pea crop (Rather *et al.,* 2010).

A lot of research work has been conducted on impacts of bio-formulations on growth and yield of peas in India but there is lack of research work on influence of bio-formulations on growth and yield of field peas under agro climatic conditions of eastern Himalayan region. Keeping these points in view the present investigations was carried out to find out the effect and the optimum dose of various bio-formulations for optimum growth and yield of pea in Namsai agro-climatic condition.

Materials and Methods

The investigation was conducted in the Agricultural Research Farm of Arunachal University of Studies during Rabi season of 2019-20. The location of Namsai falls under the eastern himalayan climatic zone with an average rainfall of 3500-4000 mm at an average of 156 meters from the mean sea level. Its geographical position is between 94 °10 to 96 °20 East longitude and 27 °30 to 27 °55 North latitude. The topography of the experimental field was plain. The temperature during winter ranges from 10 ºC - 25º C and during summer ranges from 28 ºC- 40 ºC.

The layout followed the Randomized Block Design (RBD) with 3 replications and spacing 30 cm x 20 cm. The plot size was 2m x 2m (4 m^2). The experiment consisted of ten treatments combinations involving three doses each of Bio-N, Bio-P and Bio-K; and uniform dose of pH regulator and organic manure as shown in Table 1. The crop variety used for the experiment was garden pea (Variety-Sakata, Sweet Pearl). The growth attributes such as plant

Table 1. Details of the experimental treatments

T1	Bio-N 4t/ha + Bio-P 2t/ha + Bio-K 2t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T2	Bio-N 4t/ha + Bio-P 3t/ha + Bio-K 3t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T3	Bio-N 4t/ha + Bio-P 4t/ha + Bio-K 4t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T4	Bio-N 5t/ha + Bio-P 2t/ha + Bio-K 2t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T5	Bio-N 5t/ha + Bio-P 3t/ha + Bio-K 3t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T6	Bio-N 5t/ha + Bio-P 4t/ha + Bio-K 4t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T7	Bio-N 6t/ha + Bio-P 2t/ha + Bio-K 2t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T8	Bio-N 6t/ha + Bio-P 3t/ha + Bio-K 3t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T9	Bio-N 6t/ha + Bio-P 4t/ha + Bio-K 4t/ha + pH regulator 12.5 kg/ha + 12 t cowdung/ha
T10	Local control

height (cm), number of branches per plant, number of flowers per plant, number of pods, weight of pods, pod length and vegetable yield were recorded for observations. Statistical analysis of the data was conducted with the help of OPSTAT software.

Results and Discussion

Growth parameters

The findings pertaining to growth parameters viz., plant height, number of branches per plant, and number of flowers per plant indicated significant difference among the treatments (Table 2).

The highest plant height of T6 (Bio-N 5t/ha + Bio-P 4t/ha + Bio-K 4t/ha) (22.03 cm) was found at par with T4 (Bio-N 5t/ha + Bio-P 2t/ha + Bio-K 2t/ha) (21.69 cm), T1 (Bio-N 4t/ha + Bio-P 2t/ha + Bio-K 2t/ha) (20.73 cm), T2 (Bio-N 4t/ha + Bio-P 3t/ha + Bio-K 3t/ha) (20.42 cm), T7 (Bio-N 6t/ha + Bio-P 2t/ha + Bio-K 2t/ha) (21.46 cm), T8 (Bio-N 6t/ha + Bio-P 3t/ha + Bio-K 3t/ha) (21.06 cm) and T9 (20.14 cm). The lowest plant height of T10 (local control) (15.50 cm) was found at par with T3 (Bio-N 4t/ha + Bio-P 4t/ha + Bio-K 4t/ha) (19.50 cm). The highest number of branches were observed in T6 (6.13), and all others were at par with each other (6.00 to 6.03). The number of flowers per plant at 45 DAS is shown in Table 2. Application of bio-formulations in different doses significantly influenced the number of flowers per plant. The maximum number of flowers was observed in T8 (7.40), which were at par with T1 (7.03), T2 (7.13), T5 (7.00) and T6 (6.27). The lowest number of flowers per plant was observed in T10 (4.20) and was found at par with T3 (5.20), T7 (6.07) and T4 (5.27). The results showed that growth parameters increased at higher doses of bio-formulations. Sahai *et al*. (2011) marked that dual inoculation benefitted the chick pea (*Cicer arietinum* L.) plants, enhanced availability of phosphorous favoured nitrogen fixation and rate of photosynthesis and consequently led to better plant height and branches per plant. Similarly, Nisar *et al.* (2010) also reported that co-inoculation of *Rhizobium*, *Azotobacter a*nd phosphorous solubilising microorganisms (PSM) recorded the highest growth in terms in garden pea (*Pisum sativum* L.). Kalita *et al*. (2015) reported the performance of bio-formulation on crop plants such as tomato (*Solanum lycopersicum*), chilli (*Capsicum annuum*), cauliflower (*Brassica oleraceae var botrytis*) and brinjal (*Solanum melongena*) where bio-formulation increases the shoot height, number of leaves and total biomass. The result also showed increased in the plant height, early flowering, and number of leaves as well as the biomass content of the treated plants as compared to the control crops. PGPR directly enhanced the plant growth by different mechanism viz., fixation of atmospheric nitrogen that is transferred to the plant production of siderophores that chelate iron and make it available to the plant root, solubilization of minerals such as phosphorous and synthesis of phytohormones. Direct enhancement of mineral uptake due to increases in specific ion fluxes at the root surface in the presence of PGPR has also been reported (Shivran *et al*.,

Table 2. Bio-formulation effect on growth characteristics of pea under eastern Himalayan agro-climatic condition

Treatments	Bio-NPK ratio	Plant height (cm) (30 DAS)	No. of branches per plant (30 DAS)	No. of pods per 100g	No. of flowers per plant at (45 DAS)	Weight of pods (g)	Length of pods (cm)	Total vegetable yield (kg/ha)	Productivity (t/ha)
T1	2: 1: 1	20.73	6.00	16.67	7.03	4.83	10.20	5665	5.67
T2	4: 3: 3	20.42	6.00	19.33	7.13	5.70	10.03	6625	6.68
T3	1: 1: 1	19.59	6.00	16.67	5.20	4.73	9.60	5507.5	5.51
T4	5: 2: 2	21.69	6.00	18.00	5.27	4.80	9.27	6582.5	6.63
T5	5: 3: 3	20.29	6.00	16.67	7.00	4.87	8.67	5995	5.98
T6	5: 4: 4	22.03	6.13	17.33	6.27	4.90	9.17	6505	6.51
T7	3: 1: 1	21.46	6.03	17.00	6.07	4.67	8.83	5662.5	5.66
T8	2: 1: 1	21.04	6.00	17.33	7.40	4.70	9.23	4922.5	4.92
T9	3: 2: 2	20.14	6.00	18.33	5.23	4.73	9.17	4847.5	4.85
T10	-	15.50	5.00	16.00	5.11	4.73	8.00	4850	4.85
SE±	-	0.57	0.01	1.20	0.16	2.81	0.51	307.31	
CD at 5%	-	1.67	0.04	NS	1.85	0.84	1.52	921	
CV	-	6.31	0.42	11.90	16.81	9.97	9.38	22.89	

2013). This work was also supported by Bora *et al.* (2016) in the application of bio-formulations as combination of seed treatment, root application, soil application at transplanting and soil application at 30 days after transplanting which showed minimum wilt incidence and maximum yield in tomato, brinjal and chilli.

Yield attributes and yield

Total yield of pods is a function of various yield contributing characters like number of pods, average pod length, average pod weight etc. The final yield of any crops depends on the source and relationship and on different components of sink *viz*., number of pods per 100g, average weight of pods, length of pods and total vegetable yield. The maximum weight of pods was recorded in T2 (5.70g), which was significantly superior to all other treatments and the minimum was observed in T4 (4.8) and T7 (4.67g), which was at par with T6 (4.9 g). The maximum length of pod was observed in T1 (10.2 cm), which was at par with T2. Significant increase in vegetable yield was observed by application of higher doses of various bio-formulation treatments. The highest yield was recorded in T2 (6625 kg/ha) which was at par with T4 (6582.5 kg/ha), T6 (6505 kg/ha) and T5 (5995 kg/ha). The lowest yield was obtained from T9 (4847.5 kg/ha), and it was on par with T10 (4850 kg/ha) and T8 (4922.5 kg/ha). The better development of the plant in terms of plant height, number of branches, yield of crops, is probably due to increased soil fertility influenced by different doses of bio-formulation. The high quantity of Bio-P and Bio-K showed a significant contribution in increasing the yield of crop. Similar result has been recorded in other crops by Meena *et al*. (2001). Senthil and Sivagurunathan (2012) observed that seed inoculation with bacterial biofertilizers like *Rhizobium*, Phosphobacteria and *Azospirillum* at various treatments was significantly increased in plant growth and yield of green gram and cowpea plants.

Conclusion

The present study revealed that the different treatment combinations and doses of bio-formulations significantly influenced the growth and yield attributes of peas. The results indicated that the lowest and highest doses of bio-formulations resulted in low yield. The optimum dose was T2 (Bio-N 4t/ha + Bio-P 3t/ha + Bio-K 3t/ha) which resulted in maximum yield of crop. It was observed that the relative ratios of NPK formulations had some effect on growth and yield, apart from the total dose. Considering the overall performance and comparative doses, T2 (Bio-N 4t/ha + Bio-P 3t/ha + Bio-K 3t/ha) can be recommended for cultivation of peas in eastern himalayan agro-climatic conditions.

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