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Effects of organic nutrients in combination with bio-fertilizers on uptake N, P, K and yield of garden pea (*Pisum sativum* L.) CV. bonneville

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Abstract
The result revealed that revealed that status of the available Nitrogen, Phosphorus and Potassium (kg/ha) in the experimental plots of various treatments were found non-significant. The treatment F_5T_1 [Recommended dose of N as neem cake + Seed treatment with PSB (200 ml/ha)] was found significantly maximum yield of green pod per hectare (114.58 q). After crop harvesting, status of nitrogen, phosphorus & potassium of soil was non-significant during the both years (2013-2014) and in pooled.

Keywords: Bonneville, garden pea, nitrogen, phosphorus, potash, yield

Introduction
India is a thickly populated country and most of the residents of this country are vegetarian. The population being increased without check is the main handicap in our progress with the results of that food shortage, malnutrition and poverty occurs. The solution for control of these problems partly may be only the major source of adoption of intensive cultivation of vegetable crops. The growing of vegetable is the most intensive and remunerative and also may be adopted with small holders with profitable and gaining business. Apart from this, vegetables have an excellent dietary value and may be known as protective foods as they contain nutrients and play important role during physiology of human digestion.

Several kinds of vegetables are grown in India, out of them vegetable pea is one of the foremost versatile legume crop, having much more protein than other vegetables. Two types of peas are generally cultivated - field pea (*Pisum sativum* L. var. arvense) generally used for 'dal' making and garden pea (*Pisum sativum* L. var. hortense) is a green coloured, wrinkled seeded, sweet in taste used as green vegetable. Garden pea (*Pisum sativum* L. var. hortense) is also known as 'matar' in hindi or 'vatana' in gujarati. It belongs to family Leguminaceae. The chromosome number of pea is 2n=14. It is second important food legume of the world. The green and dry foliage are used as cattle fodder and green pods are preferred for culinary purpose. The high percentage of digestible protein (7.2 g), carbohydrates (15.8 g), Vitamin A (139 I.U.), Vitamin C (9 mg), magnesium (34 mg) and phosphorus (139 mg) per 100 g of edible portion (Gopalkrishnan, 2007) [10].

Pea is a native of South West Asia and is widely grown in temperate countries. Pea thrives best in the cool climate with cardinal temperature range between 10 °C to 30 °C. In India, it is grown as a winter vegetable in the plains of North India and as summer vegetable in the hills. Pea is grown in almost all types of soil with adequate drainage. Silt loam and clay loam soils having pH range of 5.5 to 6.5 are best for growing pea. India is the second largest producer of pea in the world. Pea occupies about 433.00 thousand hectares area which gives a total production of 39.61 lakh tonnes with 9.14 t/ha productivity (Anon, 2014) [1]. In the country, pea is grown in Uttar Pradesh, Madhya Pradesh, Assam, Jharkhand, Himachal Pradesh, West Bengal, Punjab, Rajasthan, Haryana, Uttarakhand, Bihar etc. In Gujarat, it is cultivated only as vegetable crop in North and Central regions.

To eradicate the malnutrition and improve the protein deficient diet and low yield of pea, it is necessary to increase pea production per unit area to meet the requirement of increasing population of the nation. Besides, good agronomic practices like growing high yielding varieties, providing proper spacing, irrigation, use of fertilizers, optimum sowing time and appropriate plant protection measures to be essentially followed in order to increase the productivity. Among all these factors, success of Indian agriculture depends heavily on use of fertilizers.

Nutrients play an important role in improving productivity and quality of garden pea. The nitrogen is one of the most important elements that cause intensive elongation growth of the main and lateral shoots (Tadeusz *et al.*, 2013) [22]. Being a legume crop, major portion of nitrogen requirement of the crop is met through biological nitrogen fixation. Besides nitrogen, phosphorus is a key element in the process involving for root growth and nodulation. Phosphorus is known to play an important role in growth and development of the crop and have direct relation with root proliferation, straw strength, grain formation, crop maturation and crop quality (Bhat *et al*., 2013) [4]. The lack of phosphorous supply and availability remains a severe limitation on nitrogen fixation and symbiotic interactions (Weisany *et al*., 2013) [25]. The potassium functions are enzyme activation, carbohydrate transportation, amino acid and starch synthesis, stomata opening and closing, ATP synthesis, nitrogen uptake, protein synthesis, grain formation, strengthening of roots and stems (Tisdale *et al*., 1995) [24].

To compensate the short supply and to mitigate recent price hike in inorganic fertilizers, use of indigenous sources like farmyard manure, vermicompost, poultry manure, neem cake, etc. should be necessary. Use of organic manures not only helps to sustain crop yields but also plays a key role in improving the physical, chemical and biological properties of the soil and also increases the efficiency of applied fertilizers (Singh and Biswas, 2000) [21]. FYM is principle source of organic matter in our country. Use of farm yard manure alone or in combination with bio-fertilizer helps in proper supply of nutrition and maintaining soil health. It supplies all the essential plant nutrients, which improve the physico-chemical properties, increases water holding capacity and encourages the soil microbial activities. FYM is also advantageous for its residual value, it contains about 0.64 % N, 0.20 % P_2O_5 and 0.50 % K_2O.

Vermicompost is used as organic manure produced by earth worms. Earth worms play an important role in organic farming by vermi technology. It is a cost effective method for converting all types of bio-wastes in to nutrient rich organic manure. It modified physical, chemical and bio-chemical properties of soil. It contains about 1.14 % N, 1.00 % P_2O_5 and 1.50 % K_2O. Poultry manure is nutrient rich organic manure, since in birds, liquid and solid excreta are excreted together resulting in a no urine loss. Poultry manure ferments very quickly. Poultry manure contains 2.35 % N, 1.15 % P_2O_5 and 0.48 % K_2O.Neem oil cake is a potential source of organic manure, which contains 5.25 % N, 1.50 % P_2O_5 and 1.20 % K_2O. Neem cake protects the plant roots from nematodes, soil grubs and white ants probably due to its residual limonoid content. It is acts as natural fertilizer with pesticidal properties and also reduces alkalinity level in soil, as it produces organic acids during decomposition. Being totally natural, it is compatible with soil microbes, improves and rhizosphere, micro flora and hence ensures fertility of soil. Neem cake improves the organic matter content of the soil, helping improve soil texture, water holding capacity, and soil aeration for better root development.

Soil contains an array of micro-organism, some of them are beneficial like nitrogen fixers, phosphate solublizers, potash mobilizing bacterial, plant growth promoting rhizobacteria etc. and they are cost-effective, eco-friendly and renewable sources of plant nutrients. The PSB strain *Bacillus polymyxa* supplemented to fulfill phosphatic requirement and it has direct impact on various growth and yield attributes of garden pea (Baswana and Rana, 2007) [3]. The KMB strain *Frateuria aurentia* supplemented to mobilize the potash from soil and makes availability to crop and also improved quality and increased the yield attributes of garden pea. The *Azospirillum* strain *Lipoferum* and *Brasilens* supplemented to increase the productivity and enhanced nutrient uptake from soil and also increased the yield of crop. To sustain soil health and benign environment there is a need for standardization the conjunctive use of organic manures and bio-fertilizers sources of nutrition in order to increase the productivity and alternately improving the soil health. The concept of organic nutrient management is gaining considerable momentum today but as far as the north Gujarat conditions are concerned, the negligible systematic study has so far been conducted.

Materials and methods

The investigation was conducted at Department of Vegetable Science, College of Horticulture, S. D. Agricultural University, Sardarkrushinagar. Five levels of organic nutrients including recommended dose of N as chemical fertilizer and six levels of bio-fertilizers were applied individually and with in combination. So, the total numbers of treatment combinations were thirty were tested during the *rabi* season of the year 2013 and 2014. The experiment was laid out in a Randomized Block Design (with factorial concept) with thirty treatments were employed and replicated thrice.

The details of treatments, their combinations and notations are furnished here in order to have their clear understanding.

Factors	Notation
A) Organic Fertilizers (Five levels)	
- Control (Recommended dose of N as Urea)	F_1
- Recommended dose of N as Farm Yard Manure	F_2
- Recommended dose of N as Vermicompost	F_3
- Recommended dose of N as Poultry Manure	F_4
- Recommended dose of N as Neem cake	F_5
B) Bio-fertilizers (Six levels)	
- Seed treatment with PSB (200 ml/ha)	T_1
- Seed treatment with KMB (200 ml/ha)	T_2
- Seed treatment with *Azospirillum* (200 ml/ha)	T_3
- Soil treatment with PSB (500 ml/acre)	T_4
- Soil treatment with KMB (500 ml/acre)	T_5
- Soil treatment with *Azospirillum* (500 ml/acre)	T_6

The experimental field had even topography with gentle slope and good drainage. For determination of the physico-chemical properties of experimental plot, soil samples were drawn by zigzag method before commencement of the experiment from each plot in the field at a depth of 15-30 cm and a composite sample was prepared and analysed for physical and chemical properties.

Table 1: Physical and chemical properties of experimental soil

Sr. No.	Properties	Soil depth (15-30 cm)		Method employed
		2013	2014	
[A]	**Physical properties**			
(a)	Coarse sand (%)	46.68	46.54	International Pipette method (Piper, 1966) [15]
(b)	Fine sand (%)	40.66	40.63	

(c)	Silt (%)	7.34	7.27	
(d)	Clay (%)	5.32	5.56	
(e)	Texture class	Loamy sand		
[B]	**Chemical properties**			
(a)	Organic carbon (%)	0.21	0.27	Walkley and Black's rapid titration method (Jackson, 1973) [12]
(b)	Available N (kg ha^{-1})	212.96	217.80	Kjeldahl's method (Jackson, 1973) [12]
(c)	Available P_2O_5 (kg ha^{-1})	35.49	38.76	Olsen's method (Chopra and Kunwar, 1974) [6]
(d)	Available K_2O (kg ha^{-1})	188.84	193.34	Flame photometric method (Jackson, 1973) [12]
(e)	Soil pH (1:2.5, soil: water ratio)	7.66	7.50	Blackman's pH meter (Jackson, 1973) [12]
(f)	Electrical conductivity (dSm^{-1}) (1:2.5, soil: water ratio)	0.16	0.19	Schofield method (Jackson, 1973) [12]

To raise the crop recommended package of practices were followed. The treatments were evaluated on the basis of nutrient uptake and yield performance from ten randomly selected tagged plants at different stages. The mean data were subjected to statistical analysis following analysis of variance technique (Panse, V.G. and Sukhatme, P.V. 1978) [14].

Results and discussion

1. Nutrients status of soil before crop sowing

1.1 Status of available Nitrogen, Phosphorus and Potassium (kg/ha) in the soil before crop sowing

The status of available Nitrogen, Phosphorus and Potassium (kg/ha) before crop sowing in the experimental plots of various treatments are presented in Table 1. The data furnished in table revealed that status of the available Nitrogen, Phosphorus and Potassium (kg/ha) in the experimental plots of various treatments were found non-significant. Its show that soil of the experimental field was homogenous in fertility level and most suitable for this type of experiment during both the year of experimentation.

Table 1: Status of available Nitrogen, Phosphorus and Potash (kg/ha) in the soil before crop sowing

Treatments	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potash (kg/ha)		
	Year 2013	Year 2014	Pooled	Year 2013	Year 2014	Pooled	Year 2013	Year 2014	Pooled
Organic Manures (F)									
F_1: Control (Recommended dose of N as urea)	213.24	217.74	215.49	35.48	38.54	37.01	188.40	192.89	190.65
F_2: Recommended dose of N as farmyard manure	213.22	218.28	215.75	35.57	38.65	37.11	188.75	193.26	191.00
F_3: Recommended dose of N as vermicompost	212.93	217.23	215.08	35.17	38.83	37.00	189.01	193.50	191.25
F_4: Recommended dose of N as poultry manure	212.81	217.90	215.35	35.29	38.98	37.14	188.68	193.18	190.93
F_5: Recommended dose of N as neem cake	212.73	218.39	215.56	36.10	39.00	37.55	189.65	194.14	191.89
S.Em.±	4.61	4.05	3.07	0.71	0.84	0.55	3.30	3.06	2.25
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Bio-fertilizers (T)									
T_1: Seed treatment with PSB (200ml/ha)	213.29	218.49	215.89	35.28	38.63	36.96	188.87	193.34	191.10
T_2: Seed treatment with KMB (200ml/ha)	213.32	218.89	216.11	34.81	38.97	36.89	188.80	193.30	191.05
T_3: Seed treatment with *Azospirillum* (200ml/ha)	213.00	217.67	215.34	34.79	38.59	36.69	188.57	193.07	190.82
T_4: Soil treatment with PSB (500ml/acre)	212.80	217.53	215.17	35.66	38.67	37.17	188.66	193.15	190.91
T_5: Soil treatment with KMB (500ml/acre)	212.86	216.71	214.78	36.23	39.24	37.73	188.98	193.47	191.23
T_6: Soil treatment with *Azospirillum* (500ml/acre)	212.64	218.14	215.39	36.37	38.69	37.53	189.50	194.00	191.75
S.Em.±	5.05	4.44	3.36	0.78	0.92	0.60	3.61	3.36	2.46
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (F×T)									
S.Em.±	11.29	9.93	7.52	1.74	2.05	1.35	8.07	7.50	5.51
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	9.18	7.89	8.55	8.47	9.17	8.87	7.4	6.72	7.06

2. Influences of organic nutrients in combination with bio-fertilizers on nutrients status of soil after crop harvesting

2.1 Influences of organic nutrients in combination with bio-fertilizers on available nitrogen (kg/ha) after crop harvesting

Available nitrogen (kg/ha) after crop harvesting in the soil as influenced by different organic nutrients and bio-fertilizers and their combinations are summarized in Table 2. Available nitrogen (kg/ha) after crop harvesting in the soil as influenced by various organic nutrients were found non-significant during both the years of experimentation (2013 and 2014) and in pooled data. The data recorded for various bio-fertilizers on available nitrogen after crop harvesting in the soil was found non-significant during both the years of experimentation (2013 and 2014) and in pooled data. The interaction effect between organic nutrients and bio-fertilizers treatments was found non-significant and showed inconsistency of treatments in respect of available nitrogen after crop harvesting (kg/ha).

2.2 Influences of organic nutrients in combination with bio-fertilizers on available phosphorus (kg/ha) after crop harvesting

Available phosphorus (kg/ha) after crop harvesting in the soil as influenced by different organic nutrients and bio-fertilizers and their combinations are summarized in Table 2. Available phosphorus (kg/ha) after crop harvesting in the soil as influenced by various organic nutrients were found non-significant during both the years of experimentation (2013 and 2014) and in pooled data. The data recorded for various bio-fertilizers on available phosphorus after crop harvesting in the soil was found non-significant during both the years of experimentation (2013 and 2014) and in pooled data. The interaction effect between organic nutrients and bio-fertilizers was found non-significant and showed inconsistency of

treatments in respect of available Phosphorus after crop harvesting (kg/ha).

2.3. Influences of organic nutrients in combination with bio-fertilizers on available potassium (kg/ha) after crop harvesting

Available potassium (kg/ha) after crop harvesting in the soil as influenced by different organic nutrients and bio-fertilizers and their combinations are summarized in Table 2. Available potassium (kg/ha) after crop harvesting in the soil as influenced by various organic nutrients were found non-significant during both the years of experimentation (2013 and 2014) and in pooled data. The data recorded for various bio-fertilizers on available potassium after crop harvesting in the soil was found non-significant during both the years of experimentation (2013 and 2014) and in pooled data. The interaction effect between organic nutrients and bio-fertilizers was found non-significant and showed inconsistency of treatments in respect of available Potassium after crop harvesting (kg/ha).

3. Influences of organic nutrients in combination with bio-fertilizers on yield of green pods per hectare (q)

Yield of green pods per hectare (q) as influenced by different organic nutrients and bio-fertilizers are summarized in Table 2. Significantly maximum yield of green pods per hectare recorded with treatment F_5 (101.35 q and 113.70 q) during both the years of experimentation (2013 and 2014) and treatment F_5 (107.52 q) in pooled, which was statistically at par with treatments F_1 & F_2 during the year 2013. The minimum yield of pods per hectare was observed with treatment F_3 (84.67 q) during the year 2013; treatment F_1 (98.82 q) during the year 2014 and treatment F_3 (92.91 q) in pooled analysis. The data recorded for different bio-fertilizers on yield of green pods per hectare (q) was found significant during the both the years (2013 and 2014) and in pooled analysis. Significantly maximum yield of green pods per hectare was observed with treatment T_1 (98.73 q and 112.28 q) during both the years of experimentation (2013 and 2014) and treatment T_1 (105.50 q) in pooled, which was statistically at par with treatments T_2, T_3, T_4 & T_5 during the year 2013; treatments T_3, T_5 & T_6 during the year 2014 and treatment T_5 in pooled analysis. The minimum yield of green pods per hectare was found with treatment T_6 (80.78 q) during the year 2013 and treatment T_4 (99.47 q) during the year 2014 and treatment T_6 (95.21 q) in pooled, respectively.

The interaction effect between organic manures and levels of bio-fertilizers was found significant during the both year 2013 and 2014 and in pooled. The effect of organic manures *viz.*, FYM, vermicompost, poultry manure, neem cake and bio-fertilizers in balanced proportion played a vital role in decomposition and easy release of different plant nutrients throughout the plant life. Initially, the bio-fertilizers provided rapidly better nutrition with all essential nutrients and their uptake by the plant which leads to better plant growth. In latter stage, the required plant nutrient provided through decomposed organic manures for the good development of the plant which in turn resulted into higher yield of the crop. It is fact that PSB produce organic acids like gluconic, guccinic, lactic, oxalic, citric and α-ketogluconic acid which convert the insoluble phosphate to soluble one and synthesis growth promoting substances which augment plant growth.

The overall development of plant in terms of root and shoot which might have absorbed more nutrient and enhanced photosynthesis and production of assimilates, which in turn increased the yield of pea. The results obtained in present investigation are in line with the findings of Tarafdar and Rao (2001) [23], Yadav *et al.* (2005) [26], Meena *et al.* (2007) [13], Chopra *et al.* (2008) [5], Shivkumar *et al.* (2008) [20], Selvakumar *et al.* (2009) [18], Bahadur *et al.* (2006) [2], El-Desuki *et al.* (2010) [9], Ramana *et al.* (2011) [16], Rather *et al.* (2010) [17], Sharma and Chauhan (2011) [19], Dubey *et al.* (2012) [8], Indiresh *et al.* (2012) [11] in vegetable crops and Deshmukh *et al.* (2014) [7] in garden pea.

Table 2: Influences of organic nutrients in combination with bio-fertilizers on available nitrogen, phosphorus, potassium (kg/ha) in the soil after crop harvesting and yield of green pod per hectare (q)

Treatments	Nitrogen			Phosphorus			Potassium			Yield per hectare		
	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled
Organic Manures (F)												
F_1: Control (Recommended dose of N as urea)	219.91	223.87	221.89	39.08	43.58	41.33	193.60	198.31	195.96	93.38	98.82	96.10
F_2: Recommended dose of N as farmyard manure	219.99	223.81	221.90	39.17	43.40	41.28	193.96	198.66	196.31	95.30	107.76	101.53
F_3: Recommended dose of N as vermicompost	219.28	223.07	221.18	38.77	43.29	41.03	194.21	198.93	196.57	84.67	101.14	92.91
F_4: Recommended dose of N as poultry manure	219.54	223.75	221.65	38.90	43.73	41.31	193.88	198.60	196.24	90.11	108.28	99.20
F_5: Recommended dose of N as neem cake	220.36	224.30	222.33	39.70	43.75	41.73	194.86	199.60	197.23	101.35	113.70	107.52
S. Em.±	3.97	4.54	3.02	0.76	0.90	0.59	3.53	4.55	2.88	3.11	1.95	2.06
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.80	5.38	5.80
Bio-fertilizers (T)												
T_1: Seed treatment with PSB (200ml/ha)	220.77	224.09	222.43	39.83	43.38	41.61	194.00	198.70	196.35	98.73	112.28	105.50
T_2: Seed treatment with KMB (200ml/ha)	220.59	223.94	222.27	38.41	43.72	41.07	194.08	198.85	196.46	92.91	101.61	97.26
T_3: Seed treatment with *Azospirillum* (200ml/ha)	219.75	223.92	221.83	38.39	43.34	40.86	193.78	198.49	196.13	93.80	104.27	99.03
T_4: Soil treatment with PSB (500ml/acre)	219.28	223.29	221.29	39.97	43.99	41.98	193.87	198.59	196.23	96.49	99.47	97.98
T_5: Soil treatment with KMB (500ml/acre)	218.66	223.27	220.97	39.26	43.42	41.34	194.70	199.40	197.05	95.06	108.35	101.70
T_6: Soil treatment with *Azospirillum* (500ml/acre)	219.85	224.03	221.94	38.88	43.44	41.16	194.18	198.89	196.53	80.78	109.65	95.21
S. Em.±	4.35	4.97	3.30	0.83	0.98	0.64	3.87	4.98	3.15	3.41	2.96	2.26
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	9.60	8.40	6.30
Interaction (F×T)												
S. Em.±	9.73	11.11	7.39	1.86	2.20	1.44	8.65	11.13	7.05	7.620	6.620	5.047
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	21.6	18.70	14.1
C.V. %	7.67	8.6	8.16	8.24	8.75	8.54	7.72	9.7	8.79	14.20	10.82	12.43

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