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Effects of Hibor SF on soil health, growth and yield of pea (*Pisum sativum* L.) Cv. arkel

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Abstract
The field experiment was conducted on effects of Hibor SF on soil health, growth and yield of Pea (*Pisum sativum* L.) Cv. Arkel at the Soil Science Research Farm, Sam Higginbottom University of Agriculture & Technology Sciences during Rabi season 2017-2018. The number of pods plant^{-1} (17.75), number of seeds pod^{-1} (8.25) and pod yield (89.36 q/ha^{-1}) were significantly increased with the application of (Full Recommended of NPK with (Hibor SF (20 Kg) + Micronutrients Mixture). The maximum yield was obtained in T_1 – (Full Recommended of NPK with Hibor SF (10 Kg) + Micronutrients Mixture). Growth parameters, soil properties, increased significantly with the application of 100% recommended dose of NPK and micronutrients i.e. T_2 – [Full Recommended of NPK with Hibor SF (20 Kg) + Micronutrients Mixture], pH, EC (dSm^{-1}) and bulk density (gcm^{-3}) were decreased with increase in fertilizer levels. The lowest values related to all parameters were obtained in control treatment. Cost benefit ratio (C: B) 1:5.4 was highest in T_7 - (i.e. Hibor SF 10 Kg ha^{-1}) Full Recommended of NPK with Hibor SF (10 Kg) + Micronutrients Mixture was more profitable Rs. 223400.00 ha^{-1} than any other treatments and recommendations.

Keywords: NPK, hibor SF, micronutrients, cost benefit ratio, Pea

Introduction
Pea (*Pisum sativum* L.) is a valuable vegetable as well as pulse crop all over the world, is also known as 'Matar'. It belongs to the family *Leguminosae*, self-pollinated crop (Anonymous, 2004) [1]. Pea (*Pisum sativum* L.) is one of the important vegetables in the world and ranks among the top 10 vegetable crops. Pea is commonly used in human diet throughout the world and it is rich in protein (21-25%), carbohydrates, vitamin A and C, Ca, phosphorous and has high levels of amino acids lysin and trypophan (Bhat *et al*., 2013) [5]. The crop is grown in many countries and currently ranks fourth among the pulses in the world with a cultivated area of 6.33 million hectares (FAOSTAT, 2012). Globally, pea is grown in an area of 1.1 million ha with total production of 9.2 million tonnes and the productivity is 8.35 t ha^{-1} (Anonymous, 2011) [2]. In India, it is cultivated mainly in Uttar Pradesh, Madhya Pradesh, Jharkhand, Punjab, West Bengal, Haryana, Andra Pradesh, Bihar, Uttarkhand and Himachal Pradesh, where it is grown for both vegetable and pulse purposes and is a highly remunerative crop (Singh *et al*, 2005) [15]. In India, field pea occupies an area of 475.89 hectare with an annual production and productivity of 4651.53 tonnes and 9.5 tonnes/ ha respectively (Indian Horticulture Database-2014). Pulses crop offers a stable source of protein in vegetarian diet of masses. Besides their well recognized role in restoring soil fertility and its physical conditions, these pulse crops provide succulent and nutritious to our cattle therefore, have been described as "Unique jewels of Indian crop husbandary" (Swaminathan 1981). India has a major world's crop area under pulses and one fourth of the total production. Pulse crops offer stable source of protein in vegetarian diet of masses. Besides their well-recognized role in restoring fertility and its physical conditions, pulse crops provide succulent and nutritious to our cattle, therefore, have been described as "Unique jewels of Indian crop husbandry". Pulses add 0.8 to 1.5 tonnes of organic matter to the soil in the form of their roots left after harvesting of the crops, on an average, one hectare crop adds 15 to 30 kg nitrogen in readily available form form (Singh, 2001). The population of our country is at an alarming rate, which would be expected to reach 1280 million in 2020 and at this rate of population increase, India will need at least 30 million tonnes of pulses by 2020 (Kumar *et al*. 2004) [13]. Legumes have been recognized as an important component of any cropping system and as a low input approach towards improvement of soil fertility. Peas (*Pisum sativum* L.) a grain legume and a member of the leguminosae family grown throughout the world it is a native of central or Southeast Asia. It grows well in cool weather in the presence of ample moisture.

Peas are recognized as one of the earliest agricultural crops domesticated by human beings. It is most important cultivated legume next to soybean, groundnut and beans (Hules, 1994) [10]. It appears to have originated many thousands of years ago in central Asia and the Middle East. They were originally dried and stored for long periods, providing nutrition during the non-growing seasons. Peas are now grown throughout the world and are consumed in both fresh and dried conditions. It is widely cultivated in temperate regions for its fresh green seed. Peas are an excellent human food (Kakar *et al*. 2002) [12], either eaten as a vegetable or used in preparation of soup. The peas are full of nutrition because its grain is rich in protein, complex carbohydrates, vitamins, minerals, dietary fibers and antioxidant compounds (Bhatt *et al*. 2013).

The center of production of peas has moved from the traditional Middle East locale to Canada, which is now the largest single producer. Pea production in Western Canada has been increasing since 1997. France, China, and India are also large producers next to canada. Peas ranks 4th in the world on a production basis (441.53 thousand tonnes) among grain legumes after soybean, groundnut and French beans and is grown on an area of 528.71 thousand hectares in the world (WWW. FAO stat, 2009) [22]. The most pea growing states are U.P, M.P, Bihar and Maharashtra. Uttar Pradesh is the largest producer pea growing state in India *i.e*. 1,805.01 tonnes. Pea is grown as vegetable in various states of India. Major pea growing states are Utter Pradesh, Bihar, Haryana, Punjab, H.P, Orissa, and Karnataka. Uttarakhand is also emerging as vegetable pea growing state as farmers are taking three crops in a year. Total production of pulse, reported 2012-2013 (April/May) was at 17.3 million tonnes. In which from them pea was covered in production 37s44.84 tonnes. The major pea producing belts in different states are as Karnataka (Belgum, Bangalore, Kolar, Chikmagalur). Madhya Pradesh (Ujjain, Durg). Rajasthan (Jaipur, Alwar, Jodhpur, Udaipur). West Bengal (Nadia, Hooghly, 24 parganas.). Punjab (Jalandhar, Amritsar, Hoshiarpur). Haryana (Sonepat, Jhajjar, Rohtak, Karnal, Panipat, Hisar). Assam (Darrang, Kamrup, Nagao). (WWW.FAO stat, 2012) [8]. Uttar Pradesh is the major field pea growing state. Uttar Pradesh alone produces about 60 percent of total pea produced in India. Besides, Uttar Pradesh, Madhya Pradesh and Jharkhand are the major field pea producing states. (Singh *et al.*, 2005) [15]. In Uttar Pradesh it is grown over 216.39 ha, with production and productivity of 2454.07 tonnes and 9.6 tonnes/ ha (Indian Horticulture Database- 2014-15).

Materials and Methods

The field experiment on effects of Hibor SF on soil health, growth and yield of Pea (*Pisum sativum* L.) Cv. Arkel was conducted during the Rabi season of the year 2017-2018 at the Research Farm of Department of Soil Science, Sam Higginbottom university of Agriculture, Technology and Sciences. Allahabad (UP), located at 25'N latitude 81.50'E longitude and 98m above the mean sea level. Agroclimatically, Allahabad district represents the subtropical belt of the South East of Uttar Pradesh, and is endowed with extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46'C-48'C and seldom falls as low as 4'C -5'C. The relative humidity ranged between 20 to 94 percent. The average rainfall of this area is around 1100mm annually. It comes under subtropical climate receiving the mean annual rainfall of about 1100mm, major rainfall from July to end of September. However, occasional precipitation was also not uncommon during winter. The winter months were cold while summer months were very hot and dry. The minimum temperature during the crop season was to be 5.9 0c and the maximum is to be 29.04 ^{0}C. The minimum humidity was to be 42.72.0% and maximum was to be 93.28%. "Hibor Sf is a simple mixture of four major plant nutrients, Calcium, Magnesium, Boron and Sulfur. Chemical in nature and chemically named as Secondary Nutrient Mixture Fertilizer."

Table 1: The treatments consisted of nine treatments combinations of NPK and micronutrients source of fertilizer

Treatment	Treatment Combinations
T_0	Control
T_1	Full Recommended of NPK with Hibor SF (10 Kg) + Micronutrients Mixture
T_2	Full Recommended of NPK with Hibor SF (20 Kg) + Micronutrients Mixture
T_3	50% Dose of NPK + Hibor SF (20 Kg) + Micronutrients Mixture
T_4	25% Dose of NPK + Hibor SF (20 Kg) + Micronutrients Mixture
T_5	Hibor SF (20 Kg) + Micronutrients Mixture
T_6	Full Recommended Dose of PROM + Hibor SF (20 Kg)
T_7	Hibor SF (10 Kg)
T_8	Full Recommended of NPK

Result and Discussion

Experiment will be laid out in 2x2 randomized block design (RBD) with three levels of N P K and Micronutrients plot size was 2x2 m^2 for crop seed rate is 100-120 kg ha^{-1} (*Pisum sativum* L.) Cv. Arkel. Pea grows in 6th November 2017 and the source of Nitrogen, Phosphorus, Potassium and micronutrients were Urea, SSP, MOP, and Zn, Ca, Mg, S and B respectively. Basal dose of fertilizer was applied in respective plots according to treatment allocation uni furrows opened by about 5 cm. All the agronomic practices were carried out uniformly to raise the crop. The crop was harvested on 16th Jan 2018 first picking, 26th Jan 2018 second picking and 7th Feb 2018 third picking. Soil samples were collected from the soil 0-15 cm depth, air dried kept in an oven at 105^{0}C for 48 hrs for drying, pass through 2 mm sieve, soils were analysis by using standard procedures as described for pH 1:2 (w/v) (Jakson 1958) [11], EC (dSm^{-1}) (Wilcox 1950) [21], Organic Carbon (%) (Walkley and Black 1947) [19], available Nitrogen kg ha^{-1} (Subbiah and Asija 1956) [16], Phosphorus kg ha^{-1} (Olsen *et al.*, 1954) and Potassium kg ha^{-1} (Toth and Price 1949) [16], Boron kg ha^{-1} (Wilcox 1950) [22], Sulfur kg ha^{-1} (Bardsley and Lancaster 1960), Magnesium Meq/100g (Bower *et al.* 1952) [7], Calcium Meq/100g (Bower *et al.* 1952) [7]. The plant parameter, physical and chemical properties during the experiment are presented in Tables 2, 3, 4 and 5 respectively.

Table 2: Plant growth parameter

Treatment	Plants Height (cm)			Number of Leaves			Number of Branches		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_0	8.03	36.46	55.80	22.00	60.50	79.50	5.75	9.75	11.00
T_1	12.26	45.26	67.13	24.25	66.75	96.25	6.25	9.25	11.00
T_2	11.96	46.67	70.53	24.75	69.75	99.25	6.75	9.75	11.25
T_3	10.75	50.09	69.37	23.25	74.75	96.25	6.25	11.00	11.75
T_4	10.56	45.78	64.77	23.25	70.00	87.25	7.25	10.50	12.25
T_5	9.79	43.53	59.93	23.25	67.50	81.25	6.75	13.25	14.75
T_6	9.34	40.20	60.57	22.00	66.25	81.25	8.00	11.75	14.50
T_7	8.76	38.60	57.70	20.00	61.00	76.25	6.00	9.25	11.75
T_8	10.62	44.37	62.50	24.25	71.75	83.75	6.00	9.50	12.25
F-Test	NS	S	S	NS	S	S	NS	S	S
C.D	2.884	1.297	4.610	3.084	1.858	3.076	2.152	0.893	1.219

Table 3: Plant yield attribute parameters

Treatment	Pod plant $^{-1}$	Dry Weight (g)	Test Weight (g)	Seed Pod^{-1}	Pod Yield $^{-1}$
T_0	9.25	15.20	135.67	5.50	68.85
T_1	16.25	24.51	236.74	7.50	89.36
T_2	17.75	27.33	248.92	8.25	88.35
T_3	14.25	20.21	147.72	7.50	89.32
T_4	13.25	25.26	176.57	7.00	86.85
T_5	15.25	23.47	214.87	7.00	81.26
T_6	14.00	25.76	201.12	6.75	83.66
T_7	14.25	16.37	138.98	7.00	82.26
T_8	14.00	18.65	142.57	7.00	83.10
F-Test	S	S	S	S	S
C.D	0.881	1.609	5.657	1.292	3.434

Table 4: Physical properties of soil (pre- sowing)

Particulars	Results	Methods
Sand (%)	65.14	Bouyoucos Hydrometer method (1952)
Silt (%)	21.12	
Clay (%)	13.74	
Textural class	Sandy loam	
Soil Color	-	Munshell Color Chart (1915)
Dry Soil	10YR 6/4 light yellowish brown	
Wet Soil		10YR 4/3 brown

Table 5: Effect of different levels of NPK and Micronutrients on Physico-Chemical properties of soil after harvest of pea crop.

Treatment	Bd (Mg m^{-3})	Pd (Mg m^{-3})	Pore space (%)	pH 1:2 (w/v)	EC (dSm^{-1})	Organic carbon (%)	N (kg ha^{-1})	P2O5 (kg ha^{-1})	K2O (kg ha^{-1})	B (kg ha^{-1})	S (kg ha^{-1})	Ca (meq/100gm)	Mg (meq/100gm)	Zn (ppm)
T_0	1.12	2.45	51.85	7.33	0.84	0.32	76.58	14.11	269.27	0.51	11.94	3.70	1.45	0.74
T_1	1.12	2.45	53.70	7.43	0.87	0.40	87.75	20.17	291.20	0.61	12.06	4.33	2.25	0.82
T_2	1.13	2.50	53.27	7.53	0.89	0.43	98.30	21.33	308.72	0.70	14.81	3.98	2.30	0.83
T_3	1.13	2.57	53.75	7.5	0.84	0.37	80.60	16.50	280.00	0.59	13.19	3.87	2.13	0.75
T_4	1.17	2.57	55.09	7.43	0.86	0.36	85.29	15.25	294.93	0.61	14.31	3.80	2.15	0.79
T_5	1.19	2.62	54.37	7.43	0.89	0.38	85.50	16.50	287.47	0.57	14.58	3.81	1.80	0.77
T_6	1.20	2.68	55.02	7.5	0.85	0.39	79.5	18.00	283.73	0.62	13.57	3.80	1.70	0.76
T_7	1.21	2.57	56.22	7.4	0.87	0.35	79.50	16.42	280.00	0.60	13.60	3.70	1.77	0.80
T_8	1.22	2.68	57.73	7.37	0.86	0.37	84.75	19.83	270.31	0.55	13.22	3.70	1.77	0.75
F-Test	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S
C.D	0.081	0.185	5.144	0.019	0.017	0.054	10.19	4.48	16.725	0.087	1.42	0.341	0.449	0.55

Physical properties of soil (post-harvest)

The results in given Tables 5 indicates some of the important parameter on physical and chemical properties on Pea crop. NPK and Micronutrients fertilizers conjunction on bulk density, particle density and pore space to be non-significant. The bulk density (Mgm^{-3}), particle density (Mgm^{-3}) and pore space (%) of post-harvest soil was recorded 1.12, 2.45 and 51.85 with the treatment T_0 (Control) respectively. The slight decreased in bulk density, particle density and pore space may be due to tillage operation and increase in plant growth.

Chemical properties of soil (post-harvest)

The results in given Table 5 indicate some of the important parameter on physical properties on Pea crop. NPK and micronutrients fertilizers in conjunction on BD, PD, and pore space was found non-significant and pH, EC (dSm-1), Organic carbon (%), available nitrogen (kg ha-1), available phosphorus (kg ha-1), available potassium (kg ha-1) and Zn (ppm) was found significant. pH, EC (dSm-1), Organic carban (%), available nitrogen (kg ha-1), available phosphorus (kg ha-1), available potassium (kg ha-1),

available boron (kg ha-1), available sulfur (kg ha-1), available calcium (meq/100g), available magnesium (meq/100q) and available Zinc (ppm) was recorded (7.43, 0.87, 0.40, 87.75, 20.17, 291.20, 0.61, 12.06, 4.33, 2.25 and 0.82) respectively in the treatment T_2 that was significantly higher as compared to other treatment combination.

pH was recorded 7.33 in the treatment T_0 that were significantly lower as compared to other treatment combination. The slight decreased in soil pH and soil EC (dSm-1) and increased in Organic carbon (%), available nitrogen (kg ha-1), available phosphorus (kg ha-1), available potassium (kg ha-1) and available Zinc (ppm) may be due to increase in levels of NPK and micronutrients fertilizer and plant growth, which is increased the plant residues into soil. It may be concluded from trial that the various level of NPK and micronutrients used from different sources in the experiment, the treatment combination T_2 (Full Recommended of NPK with Hibor SF (20 Kg) + Micronutrients Mixture) was found to be the best, for improvement in physical and chemical properties of soil.

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