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Effect of organic manures and biofertilizers on seed yield and soil nutrient status after harvest of spinach beet (*Beta vulgaris* var. *bengalensis*)

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Abstract
A field experiment was conducted at Vegetable Experimental Field, SKUAST- K Shalimar during *Rabi* season 2016-17 to evaluate the effect of organic manures and biofertilizers on seed yield and soil nutrient status after harvest of spinach beet. The experiment was laid out in RCBD with nine treatment combinations replicated three times. The treatments comprised of organic manures *viz*., farm yard manure, sheep manure, vermicompost, mustard cake and two types of bio-fertilizers namely *Azospirillum* and PSB, including RFD (recommended fertilizer dose) as control. Results revealed that sole application of vermicompost @ 3.0 t ha^{-1} increased the seed yield per plot (0.437 kg), seed yield per hectare (11.02 q), 100 seed weight (1.93), available phosphorous ha^{-1} (22.96 kg), available potassium ha^{-1} (214.60 kg), organic carbon (1.33 %) and electrical conductivity (0.120 dS m^{-1}). Results further indicated that application of biofertilizers @ 5.0 kg ha^{-1} in combination with vermicompost @ 3.0 t ha^{-1} (T_6) significantly increased the seed yield per plot (0.633 kg), seed yield per hectare (15.88 q), 100 seed weight (2.33), available nitrogen ha^{-1} (287.16 kg), available phosphorous ha^{-1}(28.91 kg), available potassium ha^{-1} (229.03 kg), organic carbon (1.35 %) and electrical conductivity (0.122 dS m^{-1}). Treatments RFD (control) and mustard cake recorded the lowest values for seed yield and soil parameters.

Keywords: Spinach beet, vermicompost, biofertilizers, seed yield, soil

Introduction
Spinach beet (*Beta vulgaris* var. *bengalensis*; 2n=2x=18), commonly known as 'Indian spinach' in English and 'Palak' in Hindi, is one of the important leafy vegetable consumed all over the country. Its tender soft succulent leaves are used as vegetable. Organic manures have been advocated for the cultivation of leafy vegetables. The application of manures to soil provides potential benefits including improving the fertility, structure, water holding capacity of soil, increasing soil organic matter thereby reducing the amount of synthetic fertilizer needed for crop production (Blay *et al.*, 2002) [1]. Vermicompost contains nutrients in the readily available form to the plants such as exchangeable phosphorous, soluble potassium, calcium and magnesium (Edwards and Burrows, 1988) [2]. The water soluble components of vermicompost such as humic acid, growth regulators, vitamins and micronutrients increases the availability of plant nutrients resulting in increased yield. It also plays a vital role in restoring the soil fertility and stabilizing the crop productivity.
With an intention to increase the yield, farmers are tempted to apply higher quantities of fertilizers which may badly affect the soil and make it low in nutrients needed for crop production. Indian soils are poor to medium status in available nitrogen and available phosphorus. So biofertilizers were used with an aim to enhance the nutrient availability with plant growth promoting activities. With this background, the present study was undertaken in order to study the effect of organic manures and biofertilizers on yield and nutrient status of soil after crop harvest.

Materials and Methods
The present study was carried out during *Rabi* season of 2016-17 at Vegetable Experimental Field of Division of Vegetable Science, SKUAST-Kashmir, using one variety of spinach beet "Pusa Jyoti" with a spacing of 30 cm apart in rows and later thinned to 10 cm spacing between

plants within a row experimented in Randomized Complete Block Design with three replications. The soil was loamy clay in texture, pH 7.15 (near neutral), EC 0.025 dS m^{-1} (normal), medium in organic carbon (1.09%), low in available nitrogen (240.88 kg/ha), medium in available phosphorus (19.75 kg/ha) and medium in available potassium (211.20 kg/ha) content. The treatment details are as below:

T_1=Recommended dose of fertilizer (RDF) *i.e.* N @ 60.0 kg ha^{-1}
T_2=Vermicompost @ 3.0 t ha^{-1}
T_3=Farmyard manure @ 12.0 t ha^{-1}
T_4=Sheep manure @ 10.0 t ha^{-1}
T_5 =Mustard cake @ 1.2 t ha^{-1}
T_6=T_2 +Biofertilizers (*Azospirillum* + PSB @ 5.0 kg ha^{-1})
T_7=T_3 +Biofertilizers (*Azospirillum* + PSB @ 5.0 kg ha^{-1})
T_8=T_4 +Biofertilizers (*Azospirillum* + PSB @ 5.0 kg ha^{-1})
T_9=T_5 +Biofertilizers (*Azospirillum* + PSB @ 5.0 kg ha^{-1})

The seed yield observations were recorded on seed yield per plot, seed yield per hectare and 100 seed weight. Soil parameters were recorded on pH, EC, OC, N, P and K. Data was analyzed as per standard statistical procedures (Gomez and Gomez, 1984) [3].

Results and Discussion

Soil Parameters

Bio-fertilizers in combination with organic manures showed beneficial effect on soil health by way of improving the soil structure, soil texture, water retention capacity, buffering capacity, nutrient status and microbial population. The present investigation reveals that organic manures alone and in combination with bio-fertilizers increases nutrient status and fertility of soil besides improving soil physiology. Experimental data presented in Table 1 reveals that Treatment T_6 significantly enhanced soil available nitrogen (287.16 kg ha^{-1}), followed by treatment T_8 (284.15 kg ha^{-1}), T_7 (283.61) and then T_9 (281.84).Similarly maximum available phosphorous (28.91 kg ha^{-1}) with the treatment T_6 followed by treatment T_8 (26.97), T_7 (26.69), T_9 (25.70), available potassium status (229.03 kg ha^{-1}) maximum in T_6 followed by T_8 (226.18), T_7 (225.77) and then T_9 (224.80) respectively over to treatments which do not received bio-fertilizers. The enhancement in available nitrogen content may be attributed to more nitrogen content of vermicompost and *Azospirillum* population which might have non-symbiotically fixed atmospheric nitrogen and caused more nitrogen solubilisation in soil. The enhancement in available phosphorous content in soil in case of vermicompost + bio-fertilizer inoculation could be due to better and efficient decomposition, mineralization, solubilization of phosphorus found in complex, fixed and unavailable form in soil brought by the action of phosphorus solubilising bacteria by producing various acids and enzymes like phosphatase. These results are in conformity with the findings of Parthasarathi *et al.* (2007) [8], Narayanamma *et al.* (2005) [7] and (Han *et al.* 2006) [4].

The decrese in soil pH (6.96), increase in organic carbon content (1.35%) and electrical conductivity (0.122 dS m^{-1}) was found with treatment T_6 (vermicompost @3.0 t ha^{-1}+ Biofertilizers @ 5.0 kg ha^{-1}). The decrease in soil pH could be ascribed to acidifying effect of organic acids like humic acid produced during decomposition of organic manures. Decrease in pH results in increased electrical conductivity. Increase in organic carbon content of soil can be attributed to narrow C/N ratio, leading to more decomposition, more microbial population, enhanced biological conservation and thus high built up of organic carbon. Similar trend has also been reported by other research workers (Taiwo *et al*., 2002; Jaipal *et al.* 2011 and Sharma *et al*., 2003) [5, 9].

Seed Yield Parameters

Table1 showed that among sole application of organic manures significantly maximum seed yield per plot (0.437 kg), seed yield per hectare (11.02 q) and 100 seed weight (1.93 g) was recorded in treatment T_2. Minimum seed yield per plot (0.245 kg), seed yield per hectare (6.45 q) and 100 seed weight (1.47 g) was recorded in T_5. Among the treatment combinations wherein the biofertilizers were added significantly maximum seed yield per plot (0.633 kg), seed yield per hectare (15.88 kg) and 100 seed weight (2.33 g) was recorded in treatment T_6. Minimum seed yield per plot (0.401 kg), seed yield per hectare (10.12 q) and 100 seed weight (1.84 g) was recorded in T_9.This may be attributed primarily to the beneficial effect of vermicompost on overall physical condition of the soil. Since, the vermicompost being a store house of almost all the plant nutrients required for proper growth and development of plants, its addition in soil enhanced availability of these nutrients. These results are in agreement with Khan *et al*., (2013) [6].

Table 1: Effect of organic manures and biofertilizers on seed yield and soil nutrient status after harvest of spinach beet

Treatments	Seed yield $plot^{-1}$ (kg)	Seed yield $hectare^{-1}$ (q)	100 seed weight (g)	Available nitrogen (Kg ha^{-1})
T_1	0.358	8.90	1.56	258.16
T_2	0.437	11.02	1.93	244.68
T_3	0.410	10.71	1.77	242.39
T_4	0.423	10.79	1.86	243.95
T_5	0.245	6.45	1.47	240.73
T_6	0.633	15.88	2.33	287.16
T_7	0.505	12.56	2.08	283.61
T_8	0.557	13.87	1.97	284.15
T_9	0.401	10.12	1.84	281.84
C.D($p \leq 0.05$)	0.03	0.35	0.15	1.82

Table 2

Treatments	Available phosphorous (Kg ha^{-1})	Available potassium (Kg ha^{-1})	Electrical conductivity (dS m^{-1})	Organic carbon (%)	pH
T_1	21.43	212.44	0.100	1.03	7.08
T_2	22.96	214.60	0.120	1.33	6.94
T_3	21.89	212.00	0.100	1.27	7.05
T_4	22.29	213.74	0.111	1.30	7.02

T_5	19.88	209.61	0.115	1.30	7.05
T_6	28.91	229.03	0.122	1.35	6.96
T_7	26.69	225.77	0.111	1.27	6.82
T_8	26.97	226.18	0.115	1.29	6.84
T_9	25.70	224.80	0.119	1.32	6.84
C.D($p \leq 0.05$)	0.80	0.79	0.009	0.08	0.13

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