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Organic production of spinach beet (*Beta vulgaris* var. *bengalensis*) through the use of manures and biofertilizers

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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 growth and leaf yield 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 growth parameters like plant height (27.18, 27.44 and 27.48 cm), weight of leaf blade (1.13, 2.55 and 3.54 g), weight of leaf petiole (0.48, 0.50 and 0.63 g), seedling emergence per cent (97.68 %), seedling root length (9.09 cm), seedling shoot length (6.19 cm) and seedling vigour index (1492.55) were highest in the treatment in which vermicompost @ 3 tonnes ha^{-1} + biofertilizers @ 5 kg ha^{-1} was applied. Lowest values for growth parameters were recorded in treatment where mustard cake @ 1.2 tonnes ha^{-1} was applied. Yield parameters like number of leaves (10.97, 9.37 and 7.09), leaf area (20.10, 64.10 and 104.30 cm^2), leaf yield per plant (17.62, 29.27 and 29.26 g) and per hectare (58.73, 97.58 and 97.88 q) were also registered highest in vermicompost @ 3 tonnes ha^{-1} + biofertilizers @ 5 kg ha^{-1}. Treatment RFD (control) recorded the lowest values for yield parameters.

Keywords: Biofertilizers, growth, spinach beet, vermicompost, yield

Introduction
Spinach beet (*Beta vulgaris* var. *bengalensis*; 2n=2x=18), commonly known as 'Indian spinach' in English and 'Palak' in Hindi, originated from Indo-Chinese region (Nath, 1976) belongs to the genus *Beta*, specie *vulgaris* and family Chenopodiaceae. Leaves of this might have been first used in Bengal and hence known as var. *bengalensis*. It is also called as Beet leaf and Desi palak. It is closely related to beet root, sugar beet, and Swiss chard. Sea beet (*Beta vulgaris* var. *maritima*) is the ancestor of palak. It is commonly grown for its tender and soft succulent leaves.
Spinach beet needs a well-balanced nutrition for better growth and yield. Manures are the substances which provide nutrients for proper growth of plants. Manure is anything organic that has been added to the soil to increase its fertility and enhances plant growth and yield. 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) [3]. In view of the above facts the research was conducted with the following objective:
To assess the effect of organic manures and biofertilizers on growth and yield of spinach beet.

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 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 growth observations were recorded on plant height, weight of leaf blade, weight of leaf petiole, leaf blade petiole ratio, seedling emergence per cent, seedling root length, seedling shoot length and seedling vigour index. Seedling emergence per cent was recorded at 20 DAS while seedling root length, seedling shoot length and vigour index was recorded at 60 DAS.Yield observations were recorded on number of leaves, leaf area, yield plant^{-1} and yield hectare^{-1}. Other growth and leaf yield attributes were recorded at first, second and third cuttings respectively. Data was analyzed as per standard statistical procedures (Gomez and Gomez, 1984) [7].

Results and Discussion

The findings of the present study as well as relevant discussion have been summarized under following headings:

Seedling Parameters

Data presented in table 1 revealed that treatment T_6 resulted in maximum seedling emergence (97.68 %) followed by T_8 (94.00 %) and minimum was registered in T_5 (60.22 %). T_6 also exhibited higher seedling root length (9.09 cm), seedling shoot length (6.19 cm) and vigour index (1492.55). The increased seedling emergence and seedling length may be attributed to high levels of nutrients and organic matter in vermicompost (Sarma and Gogoi, 2015) [2]. These results are in accordance with Sharma and Agarwal (2014) [13] in palak for seedling emergence and (Edwards *et al*., 2004) for seedling root and shoot length.

Table 1: Effect of organic manures and biofertilizers on seedling parameters of spinach beet

Treatments	Seedling emergence (%)	Seedling root length (cm)	Seedling shoot length (cm)	Seedling vigour Index
T_1	76.43	5.38	6.04	872.83
T_2	90.97	6.31	5.97	1117.11
T_3	83.26	6.05	5.67	975.80
T_4	92.01	6.16	5.39	1062.71
T_5	60.22	5.37	3.71	546.79
T_6	97.68	9.09	6.19	1492.55
T_7	84.69	6.80	5.99	1083.18
T_8	94.00	7.12	5.88	1222.00
T_9	64.41	6.74	5.49	787.73
C.D($p \leq 0.05$)	0.14	1.19	0.82	108.15

Plant Height

Table 2 depicts that the maximum plant height was observed in treatment T_6 (27.18, 27.44 and 27.48 cm) followed by T_7 (25.38, 26.19 and 26.20 cm) Minimum plant height was registered in T_5 (20.36, 21.11 and 21.14 cm). The improvement in plant height could be due to increase in soil microbial biomass after vermicompost and biofertilizer application, leading to production of hormones or humates in the vermicompost acting as plant-growth regulators such as auxins, gibberellins and cytokinins which might have resulted in increased plant height through increased cell division and rapid cell elongation as reported by Canellas *et al*., (2000) [4] and Atiyeh *et al*., (2002) [1]. These results are in conformity with the findings of Gopinathan and Prakash (2014) [6] in tomato.

Table 2: Effect of organic manures and biofertilizers on growth parameters of spinach beet

Treatments	Plant height (cm)			weight of leaf blade (g)			weight of leaf petiole (g)			Leaf blade petiole ratio		
	Istcutting	2ndcutting	3rd cutting	Istcutting	2ndcutting	3rd cutting	Istcutting	2ndcutting	3rd cutting	Istcutting	2ndcutting	3rd cutting
T_1	24.54	25.47	25.68	1.06	1.47	2.71	0.41	0.44	0.50	2.59	3.34	5.42
T_2	25.00	25.41	25.55	1.05	2.33	3.46	0.38	0.42	0.58	2.77	5.55	5.96
T_3	24.08	25.21	25.26	1.05	1.56	3.01	0.29	0.35	0.48	3.62	4.46	6.27
T_4	20.95	21.75	21.79	1.06	1.61	3.10	0.35	0.38	0.51	3.02	4.24	6.07
T_5	20.36	21.11	21.14	1.03	1.49	2.86	0.18	0.29	0.39	5.72	5.14	7.33
T_6	27.18	27.44	27.48	1.13	2.55	3.54	0.48	0.54	0.65	2.35	4.72	5.44
T_7	25.38	26.19	26.20	1.09	1.83	3.02	0.44	0.50	0.63	2.48	3.27	4.79
T_8	23.85	24.08	24.11	1.11	2.47	3.51	0.40	0.48	0.61	2.78	5.15	5.75
T_9	21.38	22.31	22.47	1.04	1.66	2.99	0.37	0.45	0.61	2.81	3.68	4.90
C.D($p \leq$ 0.05)	1.23	1.18	1.13	0.04	0.10	0.05	0.02	0.03	0.07	0.26	0.53	0.69

Weight of leaf blade and petiole

Table 2 revealed that treatment T_6 produced significantly maximum weight of leaf blade (1.13, 2.55 and 3.54g) which was statistically at par with T_8 (1.11, 2.47 and 3.51g) and minimum was registered in T_1 (1.06, 1.47 and 2.71 g). Maximum weight of leaf petiole (0.48, 0.54 and 0.65g) was also registered in T_6 and minimum was recorded in T_5 (0.18, 0.29 and 0.39 g). Maximum weight of leaf blade and petiole in T_6 might be due to its rich content of macro and micronutrients, vitamins, growth hormones and micro flora (Bhawalkar, 1992) [2]. These results are in accordance with Sharma and Agarwal (2014) [13].

As regards to cutting, maximum plant height, weight of leaf blade, weight of leaf petiole and leaf blade-petiole ratio was recorded in third cutting (C_3), followed by second cutting (C_2) and minimum was recorded in first cutting (C_1). The better height of the plant, weight of leaf blade and petiole with respect to cutting might be due to better development and branching of roots which help in uptake of nutrients as well as more availability of nutrients.

Number of Leaves

Table 2 revealed that no. of leaves plant^{-1} was maximum under T_8 (11.43) which was found at par with T_6 (10.97) and minimum number of leaves inT_1 (6.60) in first cutting (C_1). In second cutting (C_2) maximum number of leaves were recorded in T_3 (12.96) and minimum in T_8 (9.27). In third cutting(C_3) maximum leaves under the treatment T_8 (7.53) and was at par with T_6 (7.09).Leaf number increased with response to cutting and with plant height and this could be due to availability of nutrients in higher level along with growth substances throughout crop growth period. Increase in leaf number was reported in palak (Jha and Jana, 2009). Minimum number of leaves in third cutting might be due to increased leaf area.

Leaf Area

Maximum leaf area was recorded with treatment T_6C_3 (104.30 cm^2), T_6C_2 (64.10 cm^2) and T_6C_1 (20.10 cm^2). Minimum leaf area was registered in T_5C_1 (17.09 cm^2), T_5C_2 (27.64 cm^2) and T_5C_1 (78.59 cm^2). Increase in leaf area in T_6 might be due to supply of adequate nitrogen and other nutrients which might have lead to higher metabolic activity in leaves, synthesis of carbohydrates and phytohormones which in turn might have contributed to increase in leaf area. These results are in line with the findings of Norman *et al.* (2005) [10]; Sharma and Agarwal (2014) [13].

Leaf yield per plant

Data presented in Table 3 indicated that there were significant differences in respect of yield per plant (17.62, 29.27 and 29.26 g) recorded in T_6 in first, second and third cuttings respectively which was statistically at par with T_8 (17.33, 27.16 and 27.57). Minimum yield plant^{-1} was recorded in T_1 (9.75, 20.69 and 21.51 g). Vermicompost acts as a chelating agent and regulates the availability of micronutrients for plants thereby increase the growth and yield by providing nutrients in available form. Similar results were also obtained by Yadav and Vijayakumari (2003) [14] in chilli.

Table 3: Effect of organic manures and biofertilizers on yield parameters of spinach beet

Treatments	No. of leaves plant^{-1}			Leaf area (cm^2)			Leaf yield plant^{-1} (g)			Leaf yield ha-^{1} (q)		
	Istcutting	2ndcutting	3rd cutting	Istcutting	2ndcutting	3rd cutting	Istcutting	2ndcutting	3rd cutting	Istcutting	2ndcutting	3rd cutting
T_1	6.60	10.92	6.61	18.80	35.88	77.93	9.75	20.69	21.51	32.41	68.96	71.69
T_2	10.00	10.01	6.87	18.23	59.64	99.23	14.08	27.52	27.91	46.93	91.73	93.04
T_3	9.32	12.96	7.03	18.11	39.18	82.45	12.50	24.91	24.51	41.67	83.04	81.41
T_4	8.95	11.08	6.72	18.83	47.86	86.72	12.61	22.99	24.80	42.05	76.64	82.51
T_5	7.86	12.23	7.26	17.09	27.64	78.59	9.52	21.79	23.46	31.74	72.64	78.19
T_6	10.97	9.39	7.09	20.10	64.10	104.30	17.62	29.27	29.26	58.73	97.58	97.88
T_7	8.06	11.39	7.49	19.57	41.75	82.65	12.83	26.66	27.03	42.77	88.87	90.10
T_8	11.43	9.27	7.53	19.96	57.34	100.49	17.33	27.16	27.57	57.77	90.53	91.89
T_9	8.30	11.30	6.44	17.72	31.96	81.97	11.66	23.31	23.94	38.86	77.69	79.79
C.D($p \leq 0.05$)	1.75	1.56	1.72	1.04	2.78	1.49	1.74	2.99	3.34	5.18	9.95	11.12

Leaf yield per hectare

The data presented in Table 3 revealed that maximum leaf yield ha^{-1} was recorded in treatment T_6C_1 (58.73 q), T_6C_2 (97.58 q) and T_6C_3 (97.88 q) which was at par with T_8 (57.77, 90.53 and 91.89 q). Minimum yield ha^{-1} was registered in T_1 (32.41, 68.96 and 71.69 q). Superiority of vermicompost can be attributed to its nutritional richness, quick mineralization, efficient microbial activity, improvement in soil physical conditions and finally leading to better yields. Similar results were obtained by Ranuma *et al*. (2012) [11] in mulberry. The increase in yield might be either due to increased leaf area or leaf number or both.

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