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Effects of vermicompost, FYM and Phosphate solubilizing bacteria (PSB) on Growth, leaf yield and quality of spinach (*Spinacia oleracea*) Cv. All green

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Abstract
Experiment titled Effects of vermicompost, FYM and phosphate soluble bacteria (PSB) on growth, leaf yield and quality of spinach (*Spinacia oleracea*) cv. All Green during Rabi Season 2020-2021 on research farm of the Department Horticulture, AKS University, Satna (MP). The experiment was placed in a randomized block design with three repeated 12 treatments *viz.*, T_1: VC@0 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_2: VC@2 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_3: VC@4 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_4: VC@6 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_5: VC@0 t/ha.+ FYM @5 t/ha.+ PSB@4 kg/ha, T_6: VC@2 t/ha+ FYM @5 t/ha.+ PSB@4 kg/ha, T_7: VC@4 t/ha.+ FYM @5 t/ha.+ PSB@4 kg/ha, T_8: VC@6 t/ha.+ FYM @5 t/ha.+ PSB@4 kg/ha, T_9: VC@0 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha, T_{10}: VC@2 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha, T_{11}: VC@4 t/ha+ FYM @10 t/ha.+ PSB@4 kg/ha, T_{12}: VC@6 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha. The results reveal that increase in Vermicompost, FYM and phosphate solubilizing bacteria level had significant response on vegetative growth yield and quality of Spinach. The treatment T_{12} - VC@6 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha was found to be the best treatment among the different treatments with growth, yield and quality for Spinach under satna condition.

Keywords: Spinach, PSB, FYM, vermicompost

Introduction
Spinach is the most important leafy vegetable grown in the Indian subcontinent, USA, Canada and. Europe. It is rich in nutrients like minerals, carbohydrates, vitamins A and C, riboflavin, nicotinic acid and thiamine. Application of fertilizers not only affects the yield but also affects the nutritional properties of the product. The nutritional quality induced by various fertilizers is related to the chemical constituents of the fertilizer: Of these nitrogen plays a major role. A combination of organic and inorganic fertilizers has been found to affect quality to the maximum extent. This may be due to the fact that decomposing organic matter increases the solubility of mineral nutrients, thus increasing their availability to the plants and affecting the nutritional qualities of the vegetables. Low production of spinach in India may be due to the influence of several factors, including poor farmers' attention to land preparation, timing of sowing, improper use of cultural practices including weeding, irrigation and non-judicious use of chemical fertilisers. Spinach farming. Fertilizer application to plants greatly affects their growth, production and plant components. Nitrogen strongly stimulates growth, expansion of crop canopy and inhibition of solar radiation. Nitrogen is an essential macronutrient required for all plants to thrive. It is an important component of many structural, genetic and metabolic compounds in entire plant cells. Increasing nitrogen levels during the vegetative stage can strengthen and support plant roots, allowing plants to take up more water and nutrients; and allows a plant to grow more quickly and produce larger quantities of succulent, green leaves, which in tum can produce larger yields, tastier vegetables, and a crop that is resistant to pests, diseases, and other unfavorable conditions. is resistant. is resistant. is resistant. is sensitive. is resistant. Application of Vermicompost and Phosphate Solubilizing Bacteria (PSB) have essential roles in the development of crop yield and product quality. Farmers have increased the application of nitrogen fertilizers on their land from year to year without considering nutrient rates and the response of different species to their forms. Adequate supply of fertilizers can promote plant growth and increase crop production, but excessive and improper use of chemical fertilizers leads to the accumulation of compounds in food products that have

harmful effects on human health, environmental pollution and cause economic loss.

Materials and Methods

Experiment titled "Effects of vermicompost, FYM and phosphate soluble bacteria (PSB) on growth, leaf yield and quality of spinach (*Spinacia oleracea*) cv. All Green" was conducted during Rabi season of the year 2020-2021 on experimental farm of Department of Horticulture, AKS University, Satna (MLP.). The experiment was laid out in a randomized block design with three replicated 12 treatments *viz*., T_1: VC@0 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_2: VC@2 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_3: VC@4 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_4: VC@6 t/ha.+ FYM @0 t/ha.+ PSB@4 kg/ha, T_5: VC@0 t/ha.+ FYM @5 t/ha.+ PSB@4 kg/ha, T_6: VC@2 t/ha+ FYM @5 t/ha.+ PSB@4 kg/ha, T_7: VC@4 t/ha.+ FYM @5 t/ha.+ PSB@4 kg/ha, T_8: VC@6 t/ha.+ FYM @5 t/ha.+ PSB@4 kg/ha, T_9: VC@0 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha, T_{10}: VC@2 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha, T_{11}: VC@4 t/ha+ FYM @10 t/ha.+ PSB@4 kg/ha, T_{12}: VC@6 t/ha.+ FYM @10 t/ha.+ PSB@4 kg/ha. Spinach seeds were sown on 23 November 2020, germination started and was completed on 2 December, recording observations were made 15 days after sowing and subsequent readings were recorded after every 15 days interval. The spinach crop was harvested on 9 January 2021. All facilities required for farming including labor were provided in the department. Well rotten FYM @ 250 q ha-1 was applied at the time of field preparation. The field was fertilized with 60 kg ha-1 phosphorus and 50 kg ha-1 potash to supply nitrogen at the rate of 120 kg ha-1. Add urea in three equal amounts. Apply first dose of urea at the time of sowing with single superphosphate and full dose of muriate of potash. Apply light irrigation after sowing the seeds. The observations were made at 30, 60 and 90 days after sowing. The data recorded during the investigation were subjected to statistical analysis according to the method of analysis of variance (Panse and Sukhatme, 1967). Significance and non-significance of treatment effect were assessed with the help of the 'F' variance ratio test. The calculated 'F' value (variance ratio) was compared with the table value of F' at the 5% significance level. If the calculated value is greater than the table value, the effect was considered significant. Significant differences between means were tested against significant differences at the 5% significance level. Data mentioned in table 1 clearly revealed that the optimum levels of nutrients were found to significantly improve plant height at all the growth stages. The significantly higher plant Insight of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 19.98, 28.45 and 32.30cm at growth stage of 20, 40 and at harvest, respectively. These results closely match with the findings of Mahmoud *et al.* (2009) [6], Kumar *et al.* (2016) [4] and Islam *et al.* (2020) [3]. The optimum levels of nutrients were found to significantly improve length of leaves (cm). The significantly higher length of leaves (cm) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 24.85 cm proved significantly superior to rest of the treatments. The optimum levels of nutrients were found to significantly improve leaf width (cm), The significantly higher leaf width (cm) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 14.98 cm proved significantly superior to rest of the treatments. The optimum levels of nutrients were found to significantly improve Leaf area (cm^2). The significantly higher Leaf area (cm^2) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 47.80 cm proved significantly superior to rest of the treatments. The results of present study are almost matched with the findings of Biemond (2004) [2], Telhan Thakaral (2008) [12], Shelvakumar *et al.* (2012) [11] and Pandey *et al.* (2019) [9]. The optimum levels of nutrients 'were found significantly maximum Root length (cm). The significantly Root length (cm) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 7.8l cm proved significantly superior to ret of the treatments. The optimum levels of nutrients were found to significantly improve on juice (%) in green leaf. The significantly higher juice (%) in green leaf of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 69.12 proved significantly superior to rest of the treatments. The optimum levels of nutrients were found to significantly improve on fresh weight of leaves/Plant. The significantly higher on fresh weight of leaves/Plant of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 491.80 g proved significantly superior to rest of the treatments. The optimum levels of nutrients were found to significantly improve on yield per plot (kg). The significantly higher on yield per plot (kg) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 4.91kg proved significantly superior to rest of the treatments. The optimum levels of nutrients were found to significantly improve on yield (kg/ha). The significantly higher on yield (kg/ha) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 6383.52 kg /ha proved significantly superior to rest of the treatments. The optimum levels of nutrients were found to significantly improve on chlorophyll (mg/100g). The significantly higher on chlorophyll (mg/100g) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 128.44 mg/100g kg proved significantly superior to rest of the treatments. Results related to fresh weight (g) of Spinach found to be close agreement with that of Kumar *et al.* (2006) [5], Mehta *et al.* (2010) [7], Bharad *et al.* (2013) [1], Nayak and Maji (2018) [8] and Reda *et al.* (2020) [10]. The optimum levels of nutrients were found to significantly improve on Ascorbic Acid (mg/100g). The significantly higher on Ascorbic Acid (mg/100g) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 28.76 smg/100g proven to be much better than other treatments. The optimum levels of nutrients were found to significantly improve on Fibre (%). The significantly lower on Fibre (%) of Spinach was recorded under T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha with the respective values of 227% proved significantly superior to rest of the treatments. From the present investigation it is concluded that treatment T_{12} - VC@6 t/ha+ FYM @10 t/ha+ PSB@4 kg/ha was found to be the best treatment among the different treatments with growth, yield and quality of Spinach.

Table 1: Effects of vermicompost, FYM and phosphate soluble bacteria (PSB) on growth, leaf yield and quality of spinach

Treatments	Plant high (cm)	Number of leaves /plant	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	*Juice (%)* in green leaf	Fresh weight of leaves/Plant (g)	Yield per plot (kg)	Yield (kg /ha)	Chlorophyll (mg/100g)	Ascorbic Acid (mg/100g)	Fibre (%)
T_1	16.21	10.65	14.36	09.22	40.85	48.35	287.11	2.87	3731.83	86.41	23.14	1.82
T_2	17.41	11.78	16.41	10.17	42.53	51.77	321.34	3.21	4173.15	92.35	23.90	1.97
T_3	20.13	13.21	20.33	12.65	44.76	56.54	333.58	3.33	4329.43	101.66	24.88	2.03
T_4	24.52	15.21	21.16	12.75	45.53	59.69	353.12	3.53	4589.77	109.15	25.07	2.05
T_5	18.09	12.91	19.04	12.26	45.14	53.52	328.25	3.28	4264.10	97.36	24.31	2.03
T_6	26.72	16.31	21.52	13.44	46.27	62.05	360.98	3.60	4680.57	117.52	25.79	2.09
T_7	28.04	16.97	21.90	13.42	46.82	63.26	365.77	3.65	4745.42	120.93	26.44	2.13
T_8	29.55	17.38	22.31	13.70	46.96	65.44	372.45	3.72	4836.03	122.78	27.23	2.17
T_9	26.14	15.86	21.24	12.78	45.55	60.33	359.20	3.59	4667.51	113.29	25.31	2.07
T_{10}	30.05	18.11	23.17	13.86	46.72	65.51	393.36	3.93	5109.96	125.08	27.45	2.20
T_{11}	31.67	18.84	23.42	14.25	47.33	67.37	424.61	4.24	5512.70	127.21	28.10	2.24
T_{12}	32.30	19.32	24.85	14.98	47.80	69.12	491.80	4.91	6383.52	128.44	28.76	2.27
S.Ed(±)	0.13	0.41	0.24	0.03	0.24	2.34	2.42	4.55	2.51	0.24	0.06	0.36
CD at 5%	0.27	0.85	0.49	0.07	0.49	4.86	5.03	9.43	5.20	0.49	0.12	0.67

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