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Effect of inorganic and organic fertilizers on growth, yield and nutrient uptake in beetroot (*Beta vulgaris* L.) under shade-net conditions

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Abstract

An experiment was conducted to find the effect of inorganic and organic fertilizers application on growth, yield and nutrient uptake of beetroot (*Beta vulgaris* L.) under shade net condition. Fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost treatment (T_7) showed the best performance in almost all the parameters studied in both the crops (I and II) with the highest mean plant height (16.76, 45.50 and 43.22 cm), leaf area (260.23, 1929.95 and 1101.46 $cm^{2)}$ and dry matter production (419.40, 2008.17 and 2338.62 kg ha^{-1}) on 30, 60 and 90 DAS. The highest uptake of NPK also recorded in T_7 treatment with the highest mean nitrogen (11.60, 61.90 and 76.76 kg ha^{-1}), phosphorus (1.36, 7.21 and 12.75 kg ha^{-1}) and potassium uptake (11.60, 55.30 and 69.27 kg ha^{-1}) on 30, 60 and 90 DAS. Highest yield $hectare^{-1}$ was also observed in the same treatment with the value of 37.97 and 34.52 t ha^{-1} in crop I and II, respectively.

Keywords: Beetroot, NPK uptake, Fertigation, Liquid biofertilizer, Vermicompost

Introduction

Beetroot (*Beta vulgaris* L, 2n=2x=18) is an important root vegetable grown mainly for its fleshy enlarged roots and belongs to the family Chenopodiaceae (Thompson 2001). Nutrient management has an important role in production and productivity. In agriculture, water and nutrients are the two most critical inputs and their efficient management is important not only for higher productivity but also for maintaining environmental quality Ram et al. (2011). Fertilizers applied under traditional methods are generally not utilized efficiently by the crop. Generally, crop response to fertilizer application through drip irrigation has been excellent and frequent nutrient application has improved the fertilizer use efficiency (Malik et al. 1994). Since beetroot is a root crop, it is a heavy feeder of nutrients especially phosphorous. Farmers are applying water-soluble fertilizers in large quantities through fertigation without adequate knowledge. Since water-soluble fertilizers are costly, there is need to reduce the usage of water-soluble fertilizers without yield reduction. Integrated nutrient management is one of the suitable methods to get higher yield with high benefit cost ratio with limited use of fertilizers. It is a better approach for supplying nutrition or food to the crop with organic and inorganic sources of nutrients (Arora 2008). Keeping the facts in view, the present investigation was planned to find out the appropriate combination of inorganic sources of nutrients along with organic and biofertilizers (Phosphobacteria) for improving the growth, yield and N, P and K uptake of beetroot.

Materials and Methods

Field experiments were conducted at the College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during October - January (2014) and February - May (2015) to study the effect of fertigation on the nutrient uptake of beetroot. The experiment was laid out in randomized block design (RBD) having 10 treatments, including control and all the treatments were replicated thrice. The treatments consist of T_1 (soil application with straight fertilizers at 100 % RDF), T_2 (fertigation with water soluble fertilizers at 100 % RDF), T_3 (soil application with SF at 75 % RDF + fertigation with water soluble fertilizers at 25% RDF), T_4 (soil application with SF at 50 % RDF + fertigation with water soluble fertilizers at 50% RDF), T_5 (soil application with SF at 25 % RDF + fertigation with water soluble fertilizers at 75% RDF), T_6 (T_1 + liquid bio fertilizer (phosphobacteria) + vermicompost), T_7 (T_2 + liquid biofertilizer (phosphobacteria) +

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vermicompost), T_8 (T_3 + liquid biofertilizer (phosphobacteria) + vermicompost), T_9 (T_4 + liquid biofertilizer (phosphobacteria) + vermicompost and T_{10} (T_5 + liquid biofertilizer (phosphobacteria) + vermicompost). The hybrid 'Beet Hero' was used for conducting the experiment.

The water soluble fertilizesr used were Urea, Mono ammonium phosphate and Sulphate of potash. Straight fertilizers were applied in soil with half dose of N and full dose of P and K as basal, remaining half of N applied as top dressing. In all the Water-Soluble Fertilizer treatments, 75% of the RDF of P was applied as basal and remaining 25% was applied in the form of mono ammonium phosphate through drip fertigation. Likewise, full dose of N and K were applied through drip fertigation in the form of urea and sulphate of potash. Fertigation was scheduled once in six days from fifteen days after sowing. Vermicompost at the rate of 2.5 tonnes per hectare and liquid phosphobacteria at the rate of 200 ml per acre at 30 days after sowing through drip irrigation was also applied. All other cultural practices were adopted to raise the crop as per recommendation. The data in respect of nutrient uptake *viz.,* nitrogen, phosphorus, urea, potash was recorded and statistically analyzed for the test of significance following the method of Panse and Sukhatme (1978).

Results and Discussion

Plant height: Fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T‡) recorded significantly highest mean plant height i.e. 16.76, 45.50 and 43.22 cm at 30, 60 and 90 DAS respectively (Table 1) which was on par with soil application of SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost (T_{10}). The lowest mean plant height of 10.64, 28.15 and 24.32 cm was recorded by T_1 (soil application with straight fertilizers at 100 % RDF). The reason for highest plant height might be due to the application of water-soluble fertilizers through drip fertigation and soil application of vermicompost. In drip fertigation most of the nutrients placed to active root zone so that crop nutrient requirements are met out accurately and in vermicompost most of the nutrients present in the form that are readily taken up by the plants for the growth. This result is closely related to Dominguez (2004).

Dry matter production: Highest dry matter production of 450.34 and 388.45 kg ha^{-1} at 30 DAS, 2163.40 and 1852.93 kg ha^{-1} at 60 DAS, 2434.74 and 2242.49 kg ha^{-1} at 90 DAS in crop I and II respectively (Table 2) was recorded by fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7). The reason for higher dry matter production might be due to the integration of inorganic, organic and bio fertilizers sources of nutrients that might have improved the physio - chemical conditions of soil and nutrient availability to the plants. Better use of added nutrients in the process of photosynthesis and other physiological activities might have increased the plant height, number of leaves and higher leaf area leading to more dry matter production. This result is in conformity with the findings of Patil et al. (2003) who reported that application of organic manures such as FYM, vermicompost and crop residue enhanced the soil available NPK as compared to recommended dose of fertilizers. The lowest dry matter production was recorded with soil application of straight fertilizers at 100 per cent RDF (T_1) in all growth stages of the crops.

Table 1: Effect of fertigation on plant height (cm) at different growth stages of beetroot hybrid 'Beet Hero' under shade net

Treatments	30 DAS			60 Das			90 DAS		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	12.62	8.65	10.64	31.98	24.31	28.15	25.42	23.21	24.32
T_2	13.19	11.87	12.53	33.87	27.26	30.56	29.87	26.47	28.17
T_3	13.09	9.02	11.06	33.42	26.32	29.87	26.31	24.31	25.31
T_4	13.73	9.12	11.42	33.37	26.56	29.96	26.45	24.57	25.51
T_5	13.83	8.79	11.31	33.05	26.43	29.74	29.21	26.31	27.76
T_6	14.75	11.04	12.89	38.23	33.67	35.95	32.61	32.54	32.58
T_7	18.20	15.32	16.76	49.21	41.79	45.50	46.09	40.35	43.22
T_8	15.36	12.75	14.06	40.34	34.36	37.35	38.05	33.38	35.72
T_9	15.97	12.78	14.37	41.26	35.11	38.19	38.83	34.02	36.43
T_{10}	17.10	14.35	15.73	46.74	38.21	42.48	43.69	37.24	40.47
SEd	1.43	0.96	1.20	3.75	3.10	3.43	2.61	2.79	2.7
CD (0.05%)	3.01	2.02	2.52	7.88	6.51	7.19	5.48	5.87	5.67

T_1 – Control - Soil application with Straight Fertilizers at 100 % RDF.
T_2 – Fertigation with Water Soluble Fertilizers at 100 % RDF.
T_3 - Soil application with SF at 75 % RDF + Fertigation with WSF at 25% RDF.
T_4 – Soil application with SF at 50 % RDF + Fertigation with WSF at50% RDF.
T_5 - Soil application with SF at 25 % RDF + Fertigation with WSF at 75% RDF.
T_6 – T_1 + Liquid Bio Fertilizer (Phosphobacteria) + Vermicompost.
T_7 – T_2 + Liquid Bio Fertilizer (Phosphobacteria) + Vermicompost.
T_8 – T_3 + Liquid Bio Fertilizer (Phosphobacteria) + Vermicompost.
T_9 – T_4 + Liquid Bio Fertilizer (Phosphobacteria) + Vermicompost.
T_{10} – T_5 + Liquid Bio Fertilizer (Phosphobacteria) + Vermicompost.

Table 2: Effect of fertigation on dry matter production (kg ha^{-1}) at different growth stages of beetroot hybrid 'Beet Hero' under shade net

Treatments	Dry matter production (kg ha^{-1})								
	30 DAS			60 DAS			90 DAS		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	237.80	186.52	212.16	1164.80	993.42	1079.11	1335.41	1320.43	1327.92
T_2	293.50	256.37	274.94	1342.10	1163.72	1252.91	1564.38	1526.58	1545.48
T_3	255.70	206.42	231.06	1234.57	1074.36	1154.47	1442.36	1394.27	1418.32
T_4	249.41	224.73	237.07	1254.63	1096.16	1175.39	1451.30	1414.40	1432.85
T_5	263.10	241.73	252.42	1287.63	1110.37	1199.00	1503.24	1430.61	1466.93
T_6	338.49	298.46	318.48	1585.60	1285.42	1435.51	1797.52	1686.73	1742.13
T_7	450.34	388.45	419.40	2163.40	1852.93	2008.17	2434.74	2242.49	2338.62
T_8	372.47	303.82	338.15	1657.83	1407.55	1532.69	1925.83	1775.82	1850.83
T_9	378.65	324.37	351.51	1795.30	1584.39	1689.85	2020.92	1887.59	1954.26
T_{10}	432.59	345.78	389.19	2054.00	1762.75	1908.38	2342.42	2163.25	2252.84
SEd	31.31	27.92	29.615	156.94	134.98	145.96	179.65	168.31	173.98
CD(0.05)	65.78	58.66	62.22	329.74	283.59	306.66	377.43	353.62	365.52

Table 3: Effect of fertigation on nitrogen uptake (kg ha^{-1}) at different growth stages of beetroot hybrid 'Beet Hero' under shade net

Treatments	Nitrogen uptake (kg ha^{-1})								
	30 DAS			60 DAS			90 DAS		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	4.7	3.6	4.1	22.4	19.7	21.0	22.3	25.0	23.6
T_2	4.52	3.90	4.21	21.74	18.62	20.18	29.57	28.39	28.98
T_3	3.09	2.46	2.77	14.81	13.21	14.03	26.68	24.96	25.81
T_4	3.74	3.30	3.52	18.69	14.25	16.47	25.83	24.89	25.36
T_5	3.95	3.58	3.76	20.09	17.10	18.59	25.10	23.46	24.28
T_6	7.14	6.21	6.68	34.88	28.02	31.45	41.52	38.63	40.07
T_7	12.52	10.68	11.60	67.28	56.51	61.90	83.27	76.24	79.76
T_8	8.68	7.02	7.85	40.95	34.20	37.58	53.15	48.66	50.91
T_9	9.28	7.85	8.56	45.96	40.09	43.02	60.02	55.68	57.85
T_{10}	11.42	9.02	10.22	59.57	49.89	54.73	75.89	69.44	72.67
SEd	0.79	0.65	0.72	4.05	3.41	3.73	5.17	4.76	4.96
CD (0.05%)	1.67	1.37	1.52	8.51	7.17	7.84	10.86	9.99	10.43

Table 4: Effect of fertigation on phosphorus uptake (kg ha^{-1}) at different growth stages of beetroot hybrid 'Beet Hero' under shade net

Treatments	Phosphorus uptake (kg ha^{-1})								
	30 DAS I			60 DAS			90 DAS		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	0.45	0.35	0.40	2.33	2.28	2.31	5.88	5.68	5.78
T_2	0.70	0.64	0.67	3.36	3.14	3.25	7.67	7.33	7.50
T_3	0.51	0.43	0.47	2.59	2.58	2.59	6.52	6.27	6.40
T_4	0.52	0.52	0.52	2.76	2.74	2.75	6.68	6.22	6.45
T_5	0.58	0.58	0.58	3.09	2.89	2.99	7.22	6.72	6.97
T_6	1.05	0.90	0.97	4.76	4.11	4.44	8.99	8.26	8.63
T_7	1.49	1.24	1.36	7.57	6.86	7.21	13.39	12.11	12.75
T_8	1.08	0.85	0.97	5.14	4.79	4.96	9.82	8.88	9.35
T_9	1.14	0.94	1.04	5.74	5.70	5.72	10.51	9.63	10.07
T_{10}	1.38	1.07	1.23	6.98	6.35	6.66	12.65	11.47	12.06
SEd	0.09	0.08	0.09	0.49	0.45	0.47	0.93	0.85	0.89
CD(0.05%)	0.21	0.17	0.19	1.03	0.95	0.99	1.95	1.79	1.87

Nitrogen uptake: The treatment under fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7) recorded the highest nitrogen uptake of 12.52, 67.28 and 83.27 kg ha^{-1} and 10.68, 56.51 and 76.24 kg ha^{-1} at 30, 60 and 90 DAS in crop I and II respectively (Table 3). This could be due to reduction of nitrogen losses and favourable distribution of N in the vicinity of the plant roots resulting in better utilization of applied nitrogen. Li et al. (2003) reported that No_3^- N ion is very mobile in the soil under fertigation and it is maintained at higher concentration at shallow depth. Increased N uptake with the fertigation was also observed by Badr et al. (2011) in potato. The lowest nitrogen uptake was recorded in soil application with straight fertilizers at 100 per cent RDF (T_1) in crop I (4.7, 22.4 and 22.3 kg ha^{-1}) and crop II (3.60, 19.70 and 25.00 kg ha^{-1}).

Table 5: Effect of fertigation on potassium uptake (kg ha^{-1}) at different growth stages of beetroot hybrid 'Beet Hero' under shade net

Treatments	Potassium uptake (kg ha^{-1})								
	30 DAS			60 DAS			90 DAS		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	2.45	1.88	2.17	25.98	21.95	23.96	32.72	32.09	32.40
T_2	4.52	3.90	4.21	30.60	26.30	28.45	41.30	40.00	40.65
T_3	3.09	2.46	2.78	27.90	24.07	25.98	36.64	35.00	35.82
T_4	3.74	3.30	3.52	28.23	24.66	26.45	37.59	36.35	36.97
T_5	3.95	3.58	3.76	29.23	25.09	27.16	39.38	37.20	38.29
T_6	7.14	6.21	6.68	35.17	28.66	31.92	47.99	44.70	46.35
T_7	12.52	10.68	11.60	59.84	50.77	55.30	73.29	65.26	69.27
T_8	8.68	7.02	7.85	37.83	32.66	35.24	53.54	48.66	51.10
T_9	9.28	7.85	8.56	42.48	37.07	39.78	58.00	53.42	55.71
T_{10}	11.42	9.02	10.22	51.72	43.19	47.45	69.10	62.95	66.03
SEd	0.79	0.65	0.72	3.82	3.25	3.53	5.09	4.68	4.88
CD (0.05%)	1.67	1.37	1.52	8.03	6.84	7.44	10.69	9.83	10.26

Table 6: Effect of fertigation on yield (t ha^{-1}) and BCR of beetroot hybrid 'Beet Hero' under shade net

Treatments	Yield per ha (t)				
	Crop I	Crop II	Mean	Crop I	Crop II
T_1	18.47	16.46	17.47	0.99	0.88
T_2	23.52	21.12	22.32	1.66	1.04
T_3	19.84	17.48	18.66	1.04	0.91
T_4	21.32	18.86	20.09	1.09	0.97
T_5	24.25	20.34	22.30	1.27	1.06
T_6	29.35	26.64	28.00	1.51	1.37
T_7	37.97	34.52	36.25	1.81	1.64
T_8	31.84	27.53	29.69	1.60	1.39
T_9	31.24	27.02	29.13	1.54	1.33
T_{10}	36.58	33.31	34.94	1.84	1.68
SEd	2.79	2.35	2.57	-	-
CD (0.05%)	5.81	4.95	5.38	-	-

Phosphorus uptake: Significant differences were noticed among the treatments for phosphorus in both the crops (Table 4). Among the treatments, fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7) recorded the highest phosphorus uptake of 1.49, 7.57 and 13.39 kg ha^{-1} in crop I and 1.24, 6.86,

12.11 kg ha^{-1} in crop II at 30, 60 and 90 DAS, respectively. This might be due to accumulation of P at shallow depth was tended to be higher in fertigation treatments because of frequency of fertigation and complete solubility of phosphoric acid compared to soil application. This is in accordance with the findings of Shedeed et al. (2009) who reported that mobility of P can be increased when they are applied *via* fertigation. Soil application with straight fertilizers at 100 per cent RDF (T_1) recorded the least uptake in crop I (0.45, 2.33 and 5.88 kg ha^{-1}) and II (0.35, 2.28, and 5.68 kg ha^{-1}) at 30, 60 and 90 DAS, respectively.

Potassium uptake: The influence of different combinations of nutrients on potassium uptake is presented in the Table 5. Among the treatments, T_7 recorded the highest potassium uptake of 12.52 and 10.68 kg ha^{-1} at 30 DAS, 59.84 and 50.77 Kg ha^{-1} at 60 DAS and 73.29 and 65.26 kg ha^{-1} at 90 DAS in crop I and II, respectively. Increased K uptake might be due to integrated system of nutrient application with water soluble fertilizers through drip fertigation along with liquid phophobacteria and soil application of vermicompost. This is in line with the findings of Kattimani (2004) who reported that vermicompost besides being a rich source of micronutrients which act as chelating agent and regulating the availability of micronutrients to the plant growth and yield and increases the plant uptake of nutrients like N, P, K, S and Ca by providing nutrients in the available form. The lowest potassium uptake of 2.45, 25.98 and 32.72 kg ha^{-1} in crop I and 1.88, 21.95 and 32.09 kg ha^{-1} in crop II at 30, 60 and 90 DAS were recorded in the treatment T_1 (soil application with straight fertilizers at 100 per cent RDF).

Yield: Treatment combinations of fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7) recorded the highest yield per hectare in crop I (37.97 t ha^{-1}) and II (34.52 t ha^{-1}) which was on par with soil application of SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost (T_{10}) with 36.58 and 33.31 t ha^{-1}in crop I and II, respectively (Table 6). The lowest yield per hectare was recorded under soil application with straight fertilizers at 100 per cent RDF (T_1) in crop I (18.47 t ha^{-1}) and II (16.46 t ha^{-1}). The reason for higher yield might be due to integrated application of nutrients as water soluble fertilizers, liquid phosphobaceteria and vermicompost which prevents the volatilization and leaching by binding of nutrients and release with passage of time. Hence, the increase in the growth and yield of beetroot could be attributed to enhanced nutrient use efficiency in the presence of organic fertilizers being excellent sources of macro - and micro nutrients. This might have increased the leaf area, resulting higher photosynthetic surface, leading to higher carbohydrate synthesis and translocation to the sink, coupled with total soluble sugars. This result is in line with the findings of Sasani et al. (2006) in potato. Lowest yield was recorded in the treatment of soil application with straight fertilizers at 100 % RDF (T_1). This might be due to non-availability of nutrients to the crop by volatilization and fixation of nutrients in soil by soil application. This result is closely related to the findings of Asghar et al. (2006) in radish.

Cost economics: The highest benefit cost ratio of 1.84 and 1.68 in crop I and II were registered with soil application of SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost (T_{10}), which was closely followed by fertigation with WSF at 100% RDF along with liquid phosphobacteria and vermicompost (T_7). The lowest benefit cost ratio of 0.99 and 0.88 in crop I and crop II were recorded with soil application of straight fertilizers at 100 per cent RDF (T_1).

Conclusion

From the above results, it could be concluded that, the highest N, P and K uptake by the crop were recorded under fertigation with 100 per cent recommended dose of water-soluble fertilizers along with liquid phosphobacteria and vermicompost followed by soil application with straight fertilizers at 25 % RDF + fertigation with water soluble fertilizers at 75% RDF along with liquid phosphobacteria and vermicompost.

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सारांश

छायादार जाली दशा में चुकन्दर (*बिटा बुल्गेरिस*) के वृद्धि, उपज एवं पोषक तत्वों के ग्रहण करने के प्रभाव को अकार्बनिक तथा कार्बनिक स्थिति में ज्ञात करने के लिये प्रयोग किया गया। जल विलेय उर्वरकों को 10 प्रतिशत आर.डी.एफ. के साथ तरल फास्फोबैक्ट्रिया एवं वर्मी कम्पोस्ट शोधन (टी–7) से स्पष्ट हुआ कि अध्ययन में प्रयुक्त लगभग सभी प्राचालों को दोनों फसल दशाओं (I एवं II) में अधिकतम मध्य विस्तार पौध ऊँचाई (16.76, 45.50 व 43.22 सेंमी.), पत्ती क्षेत्रफल (260.23, 1929.95 तथा 1101.46 वर्ग सेंमी.), शुष्क पदार्थ उत्पादन (419.40, 2008.17 व 2338.62 किग्रा./हे.) क्रमशः बीज बुआई के 30, 60 तथा 90 दिनों उपरान्त पाया गया। नत्रजन, फास्फोरस तथा पोटाश के अधिकतम ग्रहण करने की प्रवष्त्ति शोधन टी–7 में अधिकतम मध्य विस्तार नत्रजन (11.60, 61.90 व 76.76 किग्रा./हे.), फास्फोरस (1.36, 7.21 व 12.75 किग्रा./हे.) एवं पोटाश (11. 60, 55.30 व 69.27 किग्रा./हे.) बीज बुआई के 30, 60 व 90 दिनों उपरान्त क्रमशः पाया गया। अधिकतम उपज प्रति हेक्टयर इसी शोधन में पाया गया जिसका मूल्य 37.97 तथा 35.52 टन/हे. दोनों प्रक्षेत्र दशा I व II क्रमशः पाया गया।

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