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Effect of fertigation on growth and yield of beetroot (*Beta vulgaris* L.) under shade net condition

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Abstract
Field experiments were conducted to find the effect of fertigation on growth and yield of beetroot (*Beta vulgaris* L.) under shade net condition in the College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during winter (October - January 2015) and summer (February – May 2016) seasons. Fertigation with Water Soluble Fertilizers at 100% RDF along with liquid phosphobacteria and vermicompost treatment showed the best performance in all the growth and yield parameters of the crop. The highest plant height of 16.76, 45.50 and 43.22 cm with leaf area of 260.23, 1929.95 and 1101.46 cm^2 on 30, 60 and 90 DAS respectively were observed in beet root hybrid 'Beet Hero' in the fertigation treatment with Water Soluble Fertilizers at 100% RDF along with liquid phosphobacteria and vermicompost The highest root volume (464.80 and 390.52 cc), fresh weight of root (254.37 and 252.82 g), yield per plot (50.63 and 45.67 kg) and yield per hectare (37.97 and 34.52 t ha^{-1})in winter and summer season crops respectively were also reported in the same treatment. But the highest benefit cost ratio of 1.84 and 1.68 was registered by soil application with Straight Fertilisers at 25% RDF + Fertigation with Water Soluble Fertilisers at 75% RDF along with liquid phosphobacteria and vermicompost in winter and summer season crops. Control plots applied with Straight Fertilisers at 100% RDF by soil application showed the least performance in all the growth and yield parameters compared to all other fertigation treatments.

Keywords: Beetroot, fertigation, water soluble fertilizers, straight fertilisers and phosphobacteria

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) [8]. In India beetroot is mainly cultivated in Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal and Maharashtra. The total cultivable area of beet root in Tamil Nadu during 2011-12 was 1116 hectares. Beet root is essentially a cool weather crop. It grows best in winter with bit warm climate in the plains of India. But good quality roots, rich in sugar and intense red colour are obtained always in cool weather with a temperature range 18.3 °C to 21.1 °C. At a temperature range below 10 °C, plants start wilting before attaining marketable root size (Sandhu, 1986) [6]. Under warm condition, beetroot shows alternate white and colour circles when sliced called zoning. It reduces the marketability. Hence the crop was raised under shade net in this study. Integrated nutrient management is one of the suitable method to get higher yield with high benefit cost ratio with limited use of fertilizers.

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 (2015) and February - May (2016). The experiment was laid out in randomized block design (RBD) having 10 treatments, including control and all the treatments were replicated thrice. The hybrid 'Beet Hero' was tried as a test crop. 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) + 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 water soluble fertilizers used were Urea, Mono ammonium phosphate and Sulphate of potash and straight fertilizers are Urea, Single superphosphate and Muriate 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 topdressing. In all the Water Soluble Fertilizer treatments, 75% of the RDF of P was applied as basal and remaining 25% 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. All other cultural practices were adopted to raise the crop as per recommendation. The data in respect to crop growth and yield attributing characters were recorded which were then statistically analyzed for the test of significance following the method of Panse and Sukhatme (1978) [4].

Results and Discussion

Plant height

Fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7) recorded significantly highest mean plant height in both the crops with 16.76, 45.50 and 43.22 cm at 30, 60 and 90 DAS respectively, 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) [2].

Leaf area

There was significant response to leaf area by fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7) in both the crops with the mean values of 260.23, 1929.95 and 1101.46 cm^2 at 30, 60 and 90 DAS respectively (Table 1). This might be due to drip fertigation that gives needed flexibility of fertilization which enables the specific nutritional requirements of the crop to be met at different stages of its growth. The effect of nitrogen in enhancing the leaf area was well established and increased optimum levels usually had positive relationship with greater leaf area which aids the plant to synthesize more metabolites exhibiting high photosynthetic rate during the period of growth and development. High available soil moisture and nutrients may contribute to promoting the role of enough watering for cell division, expansion and enlargement and consequently increasing the leaf area. This result is in agreement with the findings of Saidi *et al*., 2010 [5] in potato.

Root volume

The highest root volume in crop I (464.80 cc) and crop II (390.52 cc) were obtained from fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7), which was on par with T_{10} with 350.21 and 320.74cm in crop I and II respectively. The lowest root volume was recorded with soil application of straight fertilizers at 100 per cent RDF (T_1) in crop I (122.67 cc) and II (106.32 cc).

Fresh weight of root

Highest root weight of 254.37 and 252.82 g in crop I and II respectively were obtained from the treatment T_7 (fertigation of water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost) which was on par with soil application with SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost (T_{10}) with 245.36 in and 243.78 g in crop I and II respectively. The lowest root weight was recorded in T_1 (soil application of straight fertilizers with 100 per cent RDF) with 130.21 g in crop I and 128.46 g crop II. The reason might be fertigation with higher rates of water soluble fertilizers resulted in higher availability of nutrient ions in soil solution, which obviously would have led to increased plant growth, higher uptake of nutrients, better photo assimilation and better translocation of assimilates from source to sink leading to increased root weight. Phosphobacteria would have caused more mobilization and solubilization of insoluble P in the soil and improved the availability of P to plants and more P are translocated to roots might also increased the root weight. This result is closely related to the findings of Janat, (2007) [3] in potato.

Yield per plot

Increased in root yield was observed in the integrated nutrient management treatments. Fertigation with water soluble fertilizers at 100 % RDF along with liquid phosphobacteria and vermicompost (T_7) recorded the highest root yield per plot in crop I (50.63 kg) and II (45.67 kg) which was on par with T_{10} (soil application of SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost) with 48.78 kg in crop I and 44.38 kg crop II. The lowest yield per plot was recorded in T_1 (soil application of straight fertilizers with 100 per cent RDF) with 26.07 and 24.02 kg in crop I and II respectively.

Yield per hectare

Treatment combination 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. 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 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 may increase higher 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 [7] in potato. Less 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 releated to the findings of Asghar *et al*., 2006 [1] in radish.

Cost economics

The highest benefit cost ratio of 1.84 and 1.68 were registered in soil application with SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost (T_{10}) in season I and II, 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 was recorded in soil application with straight fertilizers at 100 per cent RDF (T_1).

From the above results, it could be concluded that soil application with SF at 25 % RDF + fertigation with WSF at 75% RDF along with liquid phosphobacteria and vermicompost (T_{10}) is highly profitable and economically viable integrated nutrient management practice for cultivation of beetroot, which can be recommended for adaption by the farmers.

Table 1: Effect of fertigation on plant height (cm), fresh weight of root (g), yield per plot (kg), yield per ha (t), root volume (cc) and leaf area (cm^2) at different growth stages of beetroot hybrid 'Beet Hero' under shade net

	Plant height (cm)			Leaf area (cm^2)			Root volume (cc)	Fresh weight of root (g)	Yield per plot (kg)	Yield per ha (t)
Treatments	30 DAS	60 Das	90 DAS	30 DAS	60 Das	90 DAS				
T_1	10.64	28.15	24.32	97.58	569.76	445.59	114.50	129.34	25.05	17.47
T_2	12.53	30.56	28.17	105.75	1097.58	600.36	166.26	167.96	33.91	22.32
T_3	11.06	29.87	25.31	79.09	847.90	538.48	127.10	131.28	25.49	18.66
T_4	11.42	29.96	25.51	74.17	778.63	553.11	128.84	132.85	25.82	20.09
T_5	11.31	29.74	27.76	67.53	929.95	553.80	137.89	168.51	32.56	22.30
T_6	12.89	35.95	32.58	170.22	1312.99	643.13	203.24	196.59	37.65	28.00
T_7	16.76	45.50	43.22	260.23	1929.95	1101.46	427.66	253.60	48.15	36.25
T_8	14.06	37.35	35.72	178.39	1453.66	704.62	213.25	206.48	39.90	29.69
T_9	14.37	38.19	36.43	197.95	1630.15	817.81	243.09	207.19	40.17	29.13
T_{10}	15.73	42.48	40.47	240.83	1850.65	1078.39	335.48	244.57	46.58	34.94
SEd	1.20	3.43	2.7	16.98	134.93	73.49	23.62	16.67	3.46	2.57
CD (0.05%)	2.52	7.19	5.67	35.67	283.47	154.37	49.62	35.01	7.26	5.38

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.

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