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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 5689-5693

www.thepharmajournal.com
Received: 01-10-2022
Accepted: 04-11-2022

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Studies on the effect of organic and inorganic nutrient management on yield and quality of beetroot (*Beta vulgaris* L.) cv. Detroit dark red

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Abstract

The present investigation entitled "Studies on the effect of organic and inorganic nutrient management on yield and quality of beetroot (*Beta vulgaris* L.) cv. Detroit Dark Red" was carried out during *Rabi* season of the year 2021-22 at College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. The experiment was laid out in Randomized Block Design (RBD) with thirteen treatments and three replications. Treatments consisted of T_1-Control (100% RDF), T_2-90% RDF + Vermicompost (2.5 t/ha), T_3-90% RDF + Azotobacter (10 kg/ha), T_4-90% RDF + Phosphorous solubilising bacteria (10 kg/ha), T_5-90% RDF + Azospirillum (10 kg/ha), T_6-70% RDF + Vermicompost (2.5 t/ha), T_7-70% RDF + Azotobacter (10 kg/ha), T_8-70% RDF + Phosphorous solubilising bacteria (10 kg/ha), T_9-70% RDF + Azospirillum (10 kg/ha), T_{10}-50% RDF + Vermicompost (2.5 t/ha), T_{11}-50% RDF + Azotobacter (10 kg/ha), T_{12}-50% RDF + Phosphorous solubilising bacteria (10 kg/ha), T_{13}-50% RDF + Azospirillum (10 kg/ha). Different have a significant influence on the yield and quality parameters of Beetroot. The yield parameters of beetroot were significantly affected due to different organic and inorganic nutrient management treatments. Application of recommended dose of fertilizers through combination of fertilizer and organic manures significantly increased the crop yield i.e., T_2 treatment (90% RDF + Vermicompost (2.5 t/ha) recorded higher values of yield attributes *viz*., root length (18.51 cm), root girth (9.17 cm), root weight per plant (189.93 gms), root yield per plot (11.58 kg) and root yield (28.95 t/ha). The quality of the beetroot root was significantly affected with different organic and inorganic nutrient management treatments. Application of recommended dose of fertilizers through combination of fertilizer and organic manures significantly increased the quality of the crop i.e., T_2 treatment (90% RDF + Vermicompost (2.5 t/ha)) recorded higher values of total soluble solids content in root (10.70 ºBrix), reducing sugars (1.75%), ascorbic acid content (4.82 mg 100 g fresh weight^{-1}) and recorded lowest percentage of root rotting (0.04%), percentage of root forking (3.41%) where minimum root cracking observed in T12 treatment (50% RDF + phosphorous solubilising bacteria (10 kg/ha).

Keywords: Beetroot, yield, quality, Detroit dark red, organic and inorganic

Introduction

One of the important root vegetable crop is beetroot (*Beta vulgaris* L.) having chromosome number (2n=18) which is commonly known as chukander. It belongs to the family Chenopodiaceae and shares similar chromosome number with swiss chard, parsley, spinach, palak and celery. A plant with origin throughout the coast of Western Europe and North Africa where they were grown to feed both humans and livestock. It produces green swollen top roots that are used as vegetable and salad. Beetroot is grown for food (pickles, salad, juice) rather than for sugar production.

Beetroot is valued for its juice, medicinal properties and known by several common names like beet, chard, spinach beet (Yashwant, 2015) [22]. Roots are rich source of proteins (1.7 g), carbohydrates (8.8 g), calcium (18 mg), phosphorous (55 mg), vit-c (10 mg) and 87.7 percent of the root has water (Aykroyd, 1963) [1].

Beetroot is now a days grown in many countries worldwide and consumed routinely as part of a normal diet. It is also frequently used in food processing as the food colouring agent E 162 (Clifford *et al.* 2015) [3].

In India major beetroot growing states are Haryana, Himachal Pradesh, West Bengal, Uttar Pradesh and Maharashtra. Beetroot is produced annually over an area of 0.079 lakh hectares nationwide, where Telangana contributing 425 hectares and an annual production of 11,132 million tonnes (HAPIS portal database, 2017-2018) [7].

Composting, vermicomposting, using biofertilizers, NPK consortium either alone or in combination with chemical fertilizers and other organic and inorganic nutrient management techniques not only help to reduce the amount of chemicals in the soil but also enhance the physical condition of the soil and increase microbial activity, which increases the potential for sustainable yields.

Material and Methods

The current research was carried out at the PG students research farm at College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Hyderabad. The area is characterised by a semi-arid tropical zone with average rainfall and average maximum and minimum temperatures 30.6 °C and 17.3 °C respectively. The experiment was laid out in Randomized Block Design with three replications and thirteen treatments. To achieve fine tilth, the experimental site was ploughed and harrowed three to four times. Next, a basal dose of well-decomposed FYM @ 25 t/ha was applied. 39 plots of 2 m × 2 m each were created from the experimental plot after it had been levelled. To ensure better germination, seeds of beetroot were soaked in water for 12 hours. The seeds were mixed with sand and sown by using the dibbling method. Seeds were sown at a spacing of 45 x 10 cm at a depth of 1.5 cm in rows as per the treatment. The field was irrigated immediately after sowing, by taking utmost care so that the seeds were not disturbed with flow of water. To prevent the spread of disease and pests, preventative plant measures were implemented on a regular basis. Dithane M-45 @ 3gm/lit was sprayed to guard against Cercospora leaf spot. Chlorpyriphos was sprayed on the crop at a rate of 5 ml per litre to prevent pest attack including aphids, jassids, and leaf miners. The data was analysed statistically by following the analysis of variance (ANOVA) technique as asserted by Panse and Sukhatme (1985) [16].

Application of manures and fertilizers

Farmyard manure was applied at 25 tonnes per hectare at the time of plots preparation and recommended dose of NPK (70:110:70 kg/ha) was applied in the form of Urea, Single super phosphate (SSP) and Muriate of potash (MOP). Nitrogen 50 kg/ha was applied in two splits, half dose of nitrogen was applied at the time of sowing and the rest at one month after sowing. The recommended dose of Phosphorus (40 kg/ha) and Potassium (50 kg/ha) were applied as a basal.

Application of Bio-fertilizers

Phosphorous Solubilizing Bacteria, *Azotobacter*, and *Azospirillum* were each applied at a rate of 10 kg/ha. These three biofertilizers are first taken in a container and mixed with FYM and water in a container before being covered with a wet gunny sack cloth. In order to promote the growth and multiplication of the bacteria, it was kept moist by routinely moistening the cloth. These are mixed into the main field in accordance with the treatments after one week.

Results and Discussion

Yield parameters

Yield parameters are represented in Table 1.

Root length (cm)

Among different organic and inorganic nutrient management treatments significantly maximum root length of (18.51 cm) was recorded under the treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)). It was found significantly superior over other treatments and is statistically on par with treatment T_6 (70% RDF + Vermicompost (2.5 t/ha)) with root length of (18.03 cm). While minimum root length of (14.73 cm) was observed with the treatment T_{11} (50% RDF + *Azotobacter* (10 kg/ha)) and it is found comparable to treatment T_{13} (50% RDF + *Azospirillum* (10 kg/ha)) with root length of (15.11cm). Maximum root length recorded under the treatment T_2 (90% RDF + Vermicompost (2.5t/ha)) is due to the application of organic manures to the soil which improves the soil physical state because the soil particles will aggregate more efficiently. and their controlled release coinciding with the stage of root growth, fertilizers are more effective and provides all the required nutrients in a balanced amount, which may indicate the positive effect of applying organic manure (vermicompost) and fertilizer together (Kumar *et al.* 2014) [10]. Similar increase in root length have been reported by kushwah *et al.* (2019) [12] Sunandarani and Mallareddy (2010) [21] and Kumar *et al.* (2014) [10] in carrot.

Root girth (cm)

Among different organic and inorganic nutrient management treatments. Significantly maximum root girth of (9.17 cm) was recorded under the treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)). It was found significantly superior over other treatments and which is found statistically on par with treatment T_6 (70% RDF + Vermicompost (2.5 t/ha)) with root girth of (8.95 cm) and minimum root girth of (7.18 cm) was observed under the treatment T_{11} (50% RDF + *Azotobacter* (10 kg/ha)) and it is comparable with T_{13} (50% RDF + *Azospirillum* (10 kg/ha)) with root girth of (7.23 cm). Maximum root girth recorded under treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)) is due to the positive effect of combined application of organic manure (vermicompost) and fertiliser. This is because inorganic fertilisers are more effective and provide all the essential nutrients in a balanced amount because their release is controlled which will coincide with the stage of root growth (Kumar *et al*. 2014) [10]. Similar findings have been reported by kushwah *et al.* (2019) [12] Sunandarani and Mallareddy (2010) [21] and Kumar *et al.* (2014) [11] in carrot.

Root weight per plant (gms)

Significant differences were noticed among different treatments with respect to root weight at harvesting stage, significantly maximum root weight per plant of (189.93 gms) was recorded in treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)) which is found statistically on par with treatment T6 (70% RDF + Vermicompost (2.5 t/ha)) with root weight of (186.23 gms/plant), T4 (90% RDF + Phosphorous solubilising bacteria (10 kg/ha) with root weight of (184.26 gms/plant) and treatment T5 (90% RDF + *Azotobacter* (10 kg/ha) with root weight of 181.29 gms/plant. The minimum root weight of (162.52 gms/plant) was observed in T11 (50% RDF + *Azotobacter* (10 kg/ha)). Maximum root weight (189.93gms/plant) was recorded in treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)) which might be due to solubilizing effect of plant nutrients by the addition of vermicompost leading to increased uptake of NPK. As a source of all essential macro and micronutrients in forms that are available during mineralization, organic manures directly contribute to plant growth by enhancing the physical and physiological properties of soil. Similar results have been reported by Kushwah *et al.* (2019) [12], Kumar *et al.* (2014) [10] in relation to carrot and Kumar *et al.* (2014) [11] in relation to radish.

Root yield (kg/plot)

Among different organic and inorganic nutrient management treatment combinations, significantly maximum root yield of (11.58 kg/plot) was recorded with the treatment T_2 (90% RDF + Vermicompost (2.5 t/ha))which was found significantly superior over all other treatments under study and it is found statistically on par with treatment T_6 (70% RDF + Vermicompost (2.5 t/ha)) with root yield of (11.19 kg/plot),while minimum root yield of (9.07 kg/plot) was observed under the treatment T_{11} (50% RDF + *Azotobacter* (10 kg/ha) and it is comparable to treatment T_{13} (50% RDF + *Azospirillum* (10 kg/ha) with root yield of (9.36 kg/plot).Root yield of beetroot was significantly affected by the various combinations of treatments. The maximum root yield recorded under the treatment T_6 (90% RDF + Vermicompost (2.5 t/ha)) is mainly due to an essential characteristic of vermicompost is that when earthworms consume a variety of organic wastes, many of the nutrients it contains are changed into forms that are more readily available. and efficiently utilised by plants, which results in maximum root thickness and ultimately root production (Degwale, 2016) [4]. Similar results pertaining to root yield have been reported by Mahorkar *et al.* (2007) [13] and Kumar *et al.* (2014) [10] in relation to radish, Kumar *et al.* (2014) [11] in relation to carrot, Rao *et al.* (2009) [17] in relation to onion, Singh *et al.* (2014) [19] and Narayan *et al.* (2014) [15] in relation to potato.

Root yield (t/ha)

Among different organic and inorganic nutrient management treatments, significantly maximum root yield recorded under the treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)) with (28.95 t/ha) root yield and it was found statistically on par with treatment T_6 (70% RDF + Vermicompost (2.5 t/ha)) with root yield of (27.99 t/ha). While the minimum root yield was observed with treatment T_{11} (50% RDF + *Azotobacter* (10 kg/ha)) with root yield of (22.67 t/ha) and it is comparable with treatment T_{13} (50% RDF + *Azospirillum* (10 kg/ha)) with a root yield of (23.42 t/ha). Root yield of beetroot was significantly affected by various combinations of treatments. The maximum root yield recorded under the treatment T_6 (90% RDF + Vermicompost (2.5 t/ha)) may due to vermicompost may have a positive impact on yield and yield-attributing traits because it provides enhanced supply of macro-and micronutrients during the entire growing season. vermicompost had a noticeable impact on yield, which was mostly due to improved growth and consequent increase in many yield parameters. Vermicompost may have improved the effectiveness of chemical fertilizers applied to the soil, nitrogen-fixing bacterial activity and humification rate, which enhances the availability of both native and added nutrients in the soil, hence enhancing yield and yield-attributing attributes (Shreeniwas *et al.* 2000) [18]. Similar results pertaining to root yield have been reported by Mahorkar *et al.* (2007) [13] and Kumar *et al.* (2014) [10] in radish, Kumar *et al.* (2014) [11] in carrot, Rao *et al.* (2009) [17] in onion, Singh *et al.* (2014) [20] and Narayan *et al.* (2014) [15] in potato.

Quality parameters

Quality parameters are represented in Table 2 & 3.

Total soluble solids (⁰Brix)

The differences among the different organic and inorganic nutrient management treatments was found to be significant with respect to total soluble solids, significantly maximum total soluble solids content (10.7 ⁰Brix) was determined in treatment T2 (90% RDF + Vermicompost (2.5 t/ha)) and it is found statistically on par with treatment T6 (70% RDF + Vermicompost (2.5 t/ha)) with total soluble solid content of (10.37 cm). Minimum total soluble solid content of (8.12 ⁰Brix) was found in treatment T12 (50% RDF + Phosphorous solubilizing bacteria (10 kg/ha)) and it is comparable with treatment T11 (50% RDF + *Azotobacter* (10 kg/ha)) with total soluble solids content of (8.14⁰ Brix). Maximum total soluble solids content (10.7⁰ Brix) was determined with treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)) may be due to the increased carbohydrate production resulted in improved physiological and biochemical activities of plant system. The current findings may be comparable with that of Sentiyangla *et al.* (2010) [21] in relation to radish and Singh *et al.* (2017) [19] in relation to carrot. Similar findings pertaining to total soluble solids content have been reported by Kushwah *et al.* (2019) [12], Kumar *et al.* (2014) [10] in radish and Kumar *et al.* (2014) [11] in carrot.

Reducing sugars (%)

The differences observed among the different organic and inorganic nutrient management treatments were found to be significant with respect to reducing sugars, significantly maximum reducing sugars content (1.75%) was determined in treatment T2 (90% RDF + Vermicompost (2.5 t/ha)) and it was found statistically on par with treatment T6 (70% RDF + Vermicompost (2.5 t/ha)) with (1.7%) reducing sugars content. Minimum reducing sugars content (1.03%) was found in treatment T12 (50% RDF + phosphorous solubilising bacteria (10 kg/ha)) and it is comparable to treatment T11 (50% RDF + *Azotobacter* (10 kg/ha)) with (1.16%) reducing sugar content. The response of 90% RDF + Vermicompost (2.5 t/ha) with an increase in sugar content may be brought on by the application of organic nutrient sources. The better availability and absorption of nutrients in combination with manures may be responsible for the improvement in nutrient quality attributes, which may have resulted in a balanced C/N ratio and more active plant metabolism. Similar findings pertaining to reducing sugars have been reported by Kushwah *et al.* (2019) [12], Kumar *et al.* (2014) [10] in carrot and Kumar *et al.* (2014) [11] in radish.

Ascorbic acid content (mg/100 g fresh weight)

The differences observed among different organic and inorganic nutrient management treatments were found to be significant with respect to ascorbic acid, significantly maximum ascorbic acid (4.82 mg/100 g) was found with treatment T2 (90% RDF + Vermicompost (2.5 t/ha)) which was found significantly superior over other treatments and it is found to be statistically on par with treatment T6 (70% RDF + Vermicompost (2.5 t/ha)) with (4.68 mg/100 g) ascorbic acid content and minimum ascorbic acid content (2.08 mg/100 g) was found in T12 (50% RDF + Phosphorous solubilising bacteria (10 kg/ha)) and it is comparable to treatment T11 (50% RDF + *Azotobacter* (10 kg/ha)) with (2.35 mg/100 g) ascorbic acid content. Treatments exhibited significant effect on ascorbic acid content whereas, maximum ascorbic acid content has been recorded in treatment T2 (90% RDF + Vermicompost (2.5 t/ha)). In addition to nitrogen and phosphate fertilisers, the addition of manures may have enhanced the ascorbic acid content of beetroot, which may have improved fresh bio mass production of root through higher nutrient absorption by the plant. Similar results pertaining to increase in ascorbic acid content of root was also reported by Kandil *et al.* (2011) [9], Islam *et al.* (2013) [8], Chatterjee *et al.* (2008) [2], Fatideh and Asil (2012) [5], Hailu *et al.*, (2008) [6].

Percentage of Root cracking (%)

The minimum percentage of root cracking was recorded in treatment T12 (50% RDF + Phosphorous solubilising bacteria (10 kg/ha)) (1.03%) while it was maximum in treatment T1 (100% RDF-control) (1.75%) might be due to low availability of nitrogen and thus resulted in less incidence of splitting and it was found to be increased when the soil nitrogen increased. The results regarding root cracking percentage are in accordance with that of Mehedi *et al.* (2012) [14] in carrot.

Percentage of root rotting (%)

The differences observed among different organic and inorganic nutrient management treatments were found to be non-significant with respect to percentage of root rotting. The minimum root rotting percent was recorded in treatment T2 (90% RDF + Vermicompost (2.5 t/ha)) (0.04%) while it was found maximum in T11 treatment (50% RDF + *Azotobacter* (10 kg/ha)) (0.82%). The data on root rotting per cent (table 4.3.5) revealed that organic and inorganic nutrient management treatments showed non-significant differences during the course of study.

Percentage of root forking (%)

The maximum root forking per cent was recorded in treatment T_{12} (50% RDF + Vermicompost (2.5 t/ha)) (8.01%) while it was found minimum in treatment T_2 (90% RDF + Vermicompost (2.5 t/ha)) (0.82%). The results on root forking percent indicated that treatment T_2 (90% RDF + Vermicompost (2.5t/ha)) recorded less root forking percent. This was due to the increased levels of nitrogen through organic manures could be attributed to lower availability of nitrogen at rhizosphere. Similar results were reported by Kumar *et al*. (2014) [11] in carrot**.**

Table 1: Effect of organic and inorganic nutrient management on root length, root girth, root weight per plant, root yield of beetroot cv. Detroit Dark Red

Treatments	Root length (cm)	Root girth (cm)	Root weight per plant (gm)	Root yield (kg /plot)	Root yield (t/ha)
T1	17.12	8.31	178.38	10.59	26.47
T2	18.51	9.17	189.93	11.58	28.95
T3	17.33	8.42	179.45	10.75	26.88
T4	17.66	8.75	184.26	10.96	27.42
T5	17.49	8.61	181.29	10.92	27.30
T6	18.03	8.95	186.23	11.19	27.99
T7	16.18	7.73	169.65	9.97	24.94
T8	16.48	8.20	173.36	10.16	25.40
T9	16.37	8.13	170.70	10.12	25.29
T10	16.64	8.26	175.34	10.24	25.59
T11	14.73	7.18	162.52	9.07	22.67
T12	15.28	7.56	166.42	9.86	24.65
T13	15.11	7.23	164.60	9.36	23.42
S.Em ±	0.25	0.13	2.99	0.17	0.40
CD at 5%	0.73	0.37	8.73	0.51	1.18

Table 2: Effect of organic and inorganic nutrient management on TSS, Reducing sugars, Ascorbic acid of beetroot cv. Detroit Dark Red

Treatments	TSS	Reducing sugars	Ascorbic acid
T1	9.30	1.47	3.41
T2	10.70	1.75	4.82
T3	9.79	1.58	3.85
T4	9.55	1.53	3.64
T5	9.67	1.61	4.09
T6	10.37	1.70	4.68
T7	9.35	1.30	2.88
T8	9.20	1.26	2.71
T9	9.42	1.38	3.09
T10	9.50	1.45	3.25
T11	8.14	1.16	2.35
T12	8.12	1.03	2.08
T13	8.16	1.23	2.69
S.Em ±	0.15	0.03	0.05
CD at 5%	0.44	0.08	0.15

Table 3: Effect of organic and inorganic nutrient management on Percentage of root cracking, rotting, forking of beetroot cv. Detroit Dark Red

Treatments	Percentage of root cracking	Percentage of root rotting	Percentage of root forking
T1	1.75	0.21	6.04
T2	1.58	0.04	3.41
T3	1.61	0.13	5.74
T4	1.45	0.11	5.09
T5	1.70	0.12	5.37
T6	1.53	0.06	4.18
T7	1.30	0.27	6.79
T8	1.26	0.22	6.37
T9	1.38	0.24	6.62
T10	1.47	0.22	6.29
T11	1.19	0.82	7.89
T12	1.03	0.57	8.01
T13	1.23	0.77	7.07
S.Em ±	0.02	0.06	0.10
CD at 5%	0.06	NS	0.30

Conclusion

Among the different organic and inorganic nutrient management source of treatments, T_2-90% RDF + Vermicompost (2.5 t/ha)) was found to be the effective fertilizer dose with the combination of fertilizer and organic manures affecting the yield and quality of the roots of beetroot cv. Detroit Dark Red.

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