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Research Article

Integrated nutrient management approaches increased the growth and yield of carrot

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A B S T R A C T

To evaluate the influence of integrated use of nutrient on the development and production of carrot a research trial was executed at the Farm under Department of Horticulture, Bangladesh Agricultural University, Mymensingh from the month of November, 2021 to February, 2022. The factorial experiment involved two carrot varieties namely Shidur and New Kuroda and seven nutrient treatments *viz.* Control (No nutrient), 100% Poultry manure (PM) @ 5t/ha, 100% Vermicompost (VC) @ 6t/ha, 100% Recommended dose of fertilizer (RDF) @ 200kg urea+ 125 kg TSP+ 120 kg MP per hectare, 50% PM + 50% RDF, 50% VC + 50% RDF and 30% PM + 30% VC + 40% RDF. RCBD (Randomized Complete Block Design) was used to perform the experiment with three replications. In case of variety, growth and yield attributes such as plant height (38.81 cm), length (13.14 cm) and diameter (3.17 cm) of roots, root fresh weight in each plant (61.43 g), gross yield (27.47 t/ha) and commercial yield (24.78 t/ha) observed higher in Shidur than New Kuroda. Considering the nutrient treatments, 30% PM + 30% VC + 40% RDF treatment performed better than any other treatments in respect to plant height (49.79 cm), leaf number per plant (10.50), length (15.08 cm) and diameter (3.94 cm) of roots, fresh weight of root in each plant (87.36 g), gross (37.65 t/ha) and commercial yield (34.40 t/ha), while control treatment produced the minimum plant height (27.73 cm), leaf number per plant (8.23), length (10.56 cm) and diameter (2.11 cm) of roots, gross (17.52 t/ha) and marketable yield (15.08 t/ha). Considering the treatment combinations, Shidur with 30% PM + 30% VC + 40% RDF formed the tallest plant (50.96 cm), length of root (15.42 cm), diameter of root (4.18 cm), root weight per plant (88.56 g), gross yield (38.90 t/ha) and commercial yield (35.77 t/ha). The shortest plant (26.50 cm), minimum length (9.92 cm) and diameter (2.07 cm) of roots, root weight per plant (31.83 g), gross (16.33 t/ha) and commercial yield (13.73 t/ha) were observed from variety New Kuroda with control treatment combination. The study concludes that the treatment combination of Shidur with 30% PM + 30% VC + 40% RDF could be used for enhanced growth and production of carrot.

INTRODUCTION

Carrot (*Daucus carota* L.) is an important root crop which is a member of the family Apiaceae. It is originated from middle Asia and known as being Mediterranean native (Simon *et al.*, 2008). Carrot has high nutritive value like other vegetables and contains appreciable amount of carotene (l0mg/l00g), thiamine (0.04mg/100g), riboflavin (0.05mg/100g) (Yawalker, 1985). It is as well an outstanding source of different minerals, for instance phosphorus, iron, calcium, vitamin A, B and also contains sugar and folic acid. It is used in making various delicious foods like salad, soups, curries, halua, jam, etc. In Bangladesh, carrot production is currently limited due to lack of proper knowledge about cultivation technique and management of plant nutrients. According to the report of FAO (2017), the worldwide carrot cultivation area was 1125,805 hectares with the overall production of 40,316,041 MT. A report revealed that the

total carrot production was 11.87 MT/ha in our country during 2020-2021 fiscal year (BBS, 2022) and the mean yield of this root crop is about 12 MT/ha which is quite lower from main carrot cultivating nations like Belgium (67.25 t/ha), Sweden (64.16 t/ha) and the Netherlands (57.02 t/ha) (FAO, 2017). So, there are a lot of rooms for improvement.

For carrot production, most of the farmers use inorganic fertilizers as the key sources of nutrients to achieve maximum development and yield (Hochmuth *et al.*, 1999; Amjad *et al.*, 2005). However, imbalance and extended use of these chemical fertilizers result in lessening of soil fertility, microbial activity of soil, decreasing soil health and proportion of organic matter in the soil (Chen *et al.*, 2014). For this reason, applying the right combination of inorganic fertilizers and organic manures is essential to increase yield and for preserving soil health.

Vermicompost and poultry manure are the sources of organic fertilizer other than cowdung. Vermicompost is a prospective source of readily obtainable nutrients which contains N, P, K, Ca and Mg at the rate of 1.6%, 0.7%, 0.8%, 0.5% and 0.2% respectively (Theunissen *et al.*, 2010). It not only contains growth enhancing substances but also possess variable favorable micro-organisms such as P-solubilizing, N-fixing, and cellulose decaying organisms (Archana and Anubha, 2011; Amooaghaie and Golmohammadi, 2017). It also improves seed germination, root (edible part) size, color, shelf life and quality (Ansari, 2008). Poultry manure (PM) also contains a good amount of nutrients for better production of carrot (Kankam *et al.*, 2014) but the doses of poultry manure for growing this root crop has not been recognized. The implementation of combined nutrient management methods clenches the key in improving the production along with quality of crops in an eco-friendly mode. In light of these facts, the research trial was conducted to explore the diverse integrated nutrient management approaches in two carrot varieties to maximize the yield and production.

MATERIALS AND METHODS

The field trial was carried out at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh from November 2021 to, February 2022. The investigational land was medium high. The soil of the experimental area was non-calcareous dark grey sandy loam soil fits to the Old Brahmaputra Flood Plains Alluvial Tract (UNDP, 1988) under the Agro Ecological Zone 9 (AEZ 9). The selected area was fertile, having pH 6.8 and well drained. The region's subtropical climate is divided into three diverse seasons: winter from November to February, summer from March to April, and the rainy season from May to October.

The experiment consisted of two factors namely i) Two varieties (Shidur and New Kuroda: Both of the carrot varieties are imported from Japan and are open pollinated varieties.) and ii) Seven nutrient treatments {T_1= Control (without any nutrients), T_2 = 100% Poultry manure (PM, 5t/ha), T_3 = 100% Vermicompost (VC, 6t/ha), T_4 = 100% Recommended dose of fertilizer (RDF, 200kg urea+ 125 kg Tsp+ 120 kg MP for each hectare), T_5 = 50% PM + 50% RDF, T_6 = 50% VC + 50% RDF and T_7 = 30% PM + 30% VC + 40% RDF} which followed Randomized Complete Block Design (RCBD) and replicated thrice . There were 14 (2×7) treatment combinations and total number of plots was 42 (3×2×7). Size of every plot was 1.0 m x 1.0 m and the plots were alienated into three blocks. In each block, combinations of different varieties and levels of nutrients were assigned randomly. Distance between blocks was 1 m and 0.5 m distance was maintained between plot to plot to assist various intercultural operations.

For the cultivation purpose, land preparation was started on November, 2021 using a power tiller for three times subsequently laddering to acquire good tilth suitable for growing carrot. According to the guideline of FRG (2018), total amount of vermicompost, poultry manure, TSP and half doses of urea and MP were distributed as a basal dose at the time of final land preparation and the remaining amount of the urea and MP were used in two portions at 4 and 6 weeks after seed sowing as per treatments. Carrot seeds were seeded in the field on 18 November 2021. Before sowing, seeds were soaked in water overnight to facilitate quick germination. Furrows with a depth of 1.5 cm were created by maintaining a distance of 25 cm between the lines where seeds were sown and at that time the furrows were concealed with loose soil. The germination of seedlings was taking place after 7 days from the date of sowing. Thinning of the seedlings were performed two times to maintain the desirable spacing of 25 cm × 10 cm and different intercultural operations such as weed control, application of irrigation water, plant protection methods etc. were done when it was required.

Data collection and statistical analysis

Data were documented from the sample plants throughout the progress of trial on the growth and yield parameters i.e. plant height (cm), leaf number per plant, fresh weight of root per plant (g), length and diameter of roots (cm), core diameter (cm), percentage of damaged root, gross yield, marketable etc.

Statistical analysis of the collected data was performed after testing the F-variance using the MSTAT-C program to find out the variation(s) caused by the experimental treatments. The significance of the change between pairs of means was performed using the least significant difference (LSD) test at the 5% and 1% probability levels according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Impact of variety on development and yield of carrot

Variety is a vital factor considering the development and yield of carrot. Plant height and leaf number for each plant were recorded at diverse phases of growth i.e. 30, 40, 50, 60, 70 and 80 (DAS) and plant height varied considerably between the varieties at various DAS except at 40 DAS. At 80 days, the taller plant (38.81 cm) was measured in Shidur than New Kuroda (37.86 cm) (Table 1). This might be because of the genetic characteristics of the variety. In case of number of leaves, New Kuroda produced higher number of leaves per plant (9.50) than Shidur (8.91) at 80 DAS (Table 1). But at initial growth stage (30 and 40 DAS) number of leaves per plant observed higher in Shidur than New Kuroda. The difference in leave's number between two varieties was possibly because of the frequency of leaf

initiation which potentially an inherent attributes of the varieties (Kushwah *et al.*, 2019).

Root length, root diameter and core diameter in each plant were significantly influenced by the two carrot varieties. Shidur produced higher root length (13.14 cm), root diameter (3.17 cm) and core diameter (1.32 cm) than New Kuroda (12.67 cm, 2.92 cm and 1.26 cm, respectively). Fresh weight of root in each plant (61.43 g) was also higher in Shidur than New Kuroda (57.86 g). New Kuroda produced higher (3.93%) percentage of the damaged root than Shidur (3.33%) (Table 2) and the result of the experiment were found similar by the findings of Ferdause (2020). Shidur produced higher gross yield (27.47 t/ha) and marketable yield (24.78 t/ha) than New Kuroda (25.47 t/ha and 22.51 t/ha, respectively) (Table 2). Among the varieties which have given better yield have considerably extra number of healthy leaves on it and more plant height than the other variety, which could have produced additional food materials to supply to the root. That might be the reason of increasing the weight and diameter and eventually helped in getting greater yield of root (Ladumor *et al.*, 2020).

Table 1. Main influence of variety and nutrient treatments on plant height and leaf number of carrot.

Factors		Plant height (cm) at different DAS						No. of leaves/plant at different DAS					
		30	40	50	60	70	80	30	40	50	60	70	80
Variety	V_1	11.08	15.42	20.89	30.79	36.20	38.81	3.40	4.82	5.89	7.76	8.37	8.91
	V_2	10.42	15.55	20.07	29.70	35.00	37.86	3.23	4.69	6.07	7.92	8.93	9.50
	$LSD_{0.05}$	0.21	0.18	0.19	0.20	0.25	0.19	0.07	0.10	0.08	0.09	0.08	0.12
	$LSD_{0.01}$	0.28	0.24	0.25	0.26	0.33	0.25	0.10	0.13	0.11	0.12	0.10	0.16
	LS	**	NS	**	**	**	**	**	**	**	**	**	**
Nutrient treatments	T_1	9.28	12.90	16.51	22.18	25.95	27.73	2.94	3.76	4.88	6.39	7.64	8.23
	T_2	10.23	14.25	17.50	23.69	28.82	30.66	3.16	4.38	5.78	7.05	7.90	8.73
	T_3	10.51	14.29	18.03	24.49	28.29	31.25	3.27	4.49	5.48	7.23	7.99	8.77
	T_4	11.31	17.30	23.58	36.31	43.02	45.72	3.42	5.36	6.51	8.64	9.27	9.73
	T_5	11.15	15.98	20.95	34.22	39.84	43.26	3.27	4.57	6.16	8.36	8.92	9.30
	T_6	10.64	15.08	20.78	31.81	37.26	39.93	3.43	4.59	6.09	8.16	8.83	9.17
	T_7	12.15	18.63	26.02	38.99	46.05	49.79	3.70	6.13	6.95	9.07	10.01	10.50
	$LSD_{0.05}$	0.40	0.34	0.35	0.37	0.46	0.35	0.14	0.19	0.15	0.17	0.14	0.23
	$LSD_{0.01}$	0.53	0.45	0.46	0.48	0.61	0.46	0.18	0.25	0.20	0.23	0.19	0.30
	LS	**	**	**	**	**	**	**	**	**	**	**	**

Table 2. Main influence of variety and nutrient treatments on yield contributing parameters of carrot.

Factors		Root length (cm)	Root diameter (cm)	Core diameter (cm)	Root weight per plant (g)	% damaged root	Gross yield (t/ha)	Marketable yield (t/ha)
Variety	V_1	13.14	3.17	1.32	61.43	3.57	27.47	24.78
	V_2	12.67	2.92	1.26	57.86	3.93	25.47	22.51
	$LSD_{0.05}$	0.12	0.10	0.009	1.00	0.20	0.80	1.30
	$LSD_{0.01}$	0.16	0.13	0.012	1.32	0.27	1.05	1.72
	LS	**	**	**	**	**	**	**
Nutrient treatments	T_1	10.56	2.11	0.75	37.10	4.58	17.52	15.08
	T_2	11.52	2.73	0.97	44.10	2.92	20.23	16.82
	T_3	12.25	2.70	1.14	50.47	2.92	21.52	19.08
	T_4	13.23	3.10	1.59	59.61	7.09	26.13	22.15
	T_5	13.38	3.15	1.40	64.63	1.67	30.78	28.65
	T_6	14.32	3.59	1.64	74.26	2.09	31.47	29.32
	T_7	15.08	3.94	1.54	87.36	5.00	37.65	34.40
	$LSD_{0.05}$	0.23	0.19	0.017	1.86	0.38	1.49	2.43
	$LSD_{0.01}$	0.30	0.25	0.023	2.46	0.50	1.97	3.21
	LS	**	**	**	**	**	**	**

NS = Non-significant, LS = Level of significance. ** = Significant at 1% level of probability. V_1= Shidur, V_2 = New Kuroda; T_1 = Control, T_2 = 100% PM, T_3 = 100% VC, T_4 = 100% RDF, T_5 = 50% PM + 50% RDF, T_6 = 50% VC + 50% RDF, T_7 = 30% PM + 30% VC + 40% RDF

Influence of integrated nutrient management approach on development and yield of carrot

There were substantial dissimilarities among different nutritional treatments in plant height and number of leaves per plant. The tallest plant (49.79 cm) and maximum number of leaves (10.50) were recorded from T_7 (30% PM + 30% VC + 40% RDF) while the control treatment (T_1) produced shortest plant (27.73 cm) and minimum (8.23) number of leaves per plant at 80 DAS (Table 1). Similar results were found by Afrin *et al.* (2019) reported that the tallest plant (47.58 cm) was found when combined fertilization applied (1/3 inorganic fertilizer + 2/3 vermicompost) and the shortest height (35.08 cm) was produced by control treatment method.

A significant variation was observed in the parameters: root length and diameter, core diameter, and fresh weight of carrot for using different levels of nutrients. The highest root length (15.08 cm) and diameter (3.94 cm), core diameter (1.64 cm) and fresh weight of single root (87.36 g) were documented from T_7 (30% PM + 30% VC + 40% RDF) treatment and the lowest values (10.56 cm, 2.11, 0.75 cm and 37.10 g, respectively) were observed from control treatment

(Table 2) and the results appeared comparable with the results of Babul (2019) and Agbede *et al*. (2017).

Maximum damaged root per plot (7.09%) was recorded at T_4 (100% RDF) and minimum (1.67%) was found in T_5 (50% PM + 50% RDF) treatment (Table 2). The trend of damaged root percentage was indiscriminate in respect of different treatment levels. The outcome of the trial was supported by the results of Bose and Som (1990).

Maximum gross (37.65 t/ha) and commercial yield (34.40 t/ha) were observed from T_7 (30% PM + 30% VC + 40% RDF) treatment while control treatment (T_1) produced the minimum gross (17.52 t/ha) and commercial yield (15.08 t/ha) (Table 2) which is fairly concurring with the outcomes of Afrin *et al*. (2019) and Patil *et al*. (2016). The reasons for such findings may be caused by proper and timely obtainability of all kinds of nutrients for the crop.

Combined influence of varieties and integrated nutrient management approach on development and yield of carrot

Plant height and leaf number were significantly affected by various treatment combinations. The tallest plant (50.96 cm) was obtained from the treatment combination of V_1T_7 (Shidur and 30% PM + 30% VC + 40% RDF) and the shortest (26.50 cm) one was documented with V_2T_1 (New Kuroda with control) treatment combinations at maximum vegetative stage (Table 3). In contrast, maximum leaf number in each plant (11.12) was obtained from the V_2T_7 (New Kuroda with 30% PM + 30% VC + 40% RDF) treatment combination and the minimum leaf number in each plant (8.20) was noted from the treatment combination of V_2T_1 (New Kuroda variety with control) at 80 DAS (Table 3).

The maximum length (15.42 cm) and diameter (4.18 cm) of roots, core diameter (1.66 cm) and fresh weight of distinct root (88.56 g) were produced by the plants of Shidur variety that received 30% PM + 30% VC + 40% RDF treatment while the lowest root length (9.92 cm), root diameter (2.07 cm), core diameter (0.73 cm) and fresh weight of single root (31.83 g) were observed from V_2T_1 (New Kuroda with control) treatment combination (Table 4). These outcomes are aligned with the research findings of Merlin *et al*. (2020) and Babul (2019). Nevertheless, the maximum percentage of damaged root (7.50%) was recorded from variety New Kuroda with 100% RDF treatment (V_2T_4) which might be due to the improper supply of nutrients and the lowest (0.83%) was obtained from Shidur with 50% PM + 50% RDF treatment combination (V_1T_5) (Table 4).

Maximum gross yield (38.90 t/ha) and commercial yield (35.77 t/ha) were obtained from Shidur variety with combined inoculant 30% PM + 30% VC + 40% RDF (V_1T_7). On the other hand, the lowermost gross yield (16.33 t/ha) and commercial yield (13.73 t/ha) were found from the New Kuroda with control (V_2T_1) treatment combination (Figure 1 and Figure 2).

Table 3. Combined influence of variety and nutrient management on plant height and number of leaves of carrot.

Treatment combinations	Plant height (cm) at different DAS						No. of leaves/plant at different DAS					
	30	40	50	60	70	80	30	40	50	60	70	80
V_1T_1	9.63	13.32	17.61	23.46	27.40	28.95	3.13	4.14	5.17	6.72	7.60	8.26
V_1T_2	10.65	14.31	18.22	24.89	29.91	31.57	3.17	4.57	6.01	7.55	7.92	8.94
V_1T_3	10.36	14.00	18.47	24.62	28.71	30.63	3.29	4.39	5.25	7.31	7.58	8.33
V_1T_4	11.74	17.37	23.35	36.29	44.52	46.28	3.44	5.48	6.16	8.17	8.58	9.29
V_1T_5	11.50	15.55	21.15	34.74	40.24	43.73	3.24	4.47	5.66	8.06	8.66	8.87
V_1T_6	11.06	14.74	20.77	32.35	36.88	39.55	3.69	4.85	6.08	7.83	8.54	8.79
V_1T_7	12.63	18.67	26.67	39.17	45.76	50.96	3.83	5.82	6.88	8.71	9.72	9.89
V_2T_1	8.92	12.47	15.41	20.89	24.51	26.50	2.74	3.37	4.59	6.06	7.68	8.20
V_2T_2	9.80	14.19	16.77	22.49	27.73	29.74	3.15	4.18	5.55	6.55	7.88	8.53
V_2T_3	10.66	14.57	17.59	24.36	27.86	31.87	3.24	4.59	5.71	7.15	8.39	9.21
V_2T_4	10.87	17.24	23.82	36.33	41.52	45.16	3.40	5.23	6.86	9.12	9.96	10.17
V_2T_5	10.80	16.40	20.74	33.70	39.43	42.79	3.31	4.67	6.66	8.66	9.18	9.74
V_2T_6	10.21	15.42	20.79	31.27	37.64	40.32	3.17	4.32	6.10	8.48	9.12	9.55
V_2T_7	11.66	18.59	25.38	38.81	46.33	48.63	3.58	6.44	7.02	9.43	10.29	11.12
$LSD_{0.05}$	0.56	0.49	0.50	0.52	0.65	0.49	0.20	0.27	0.21	0.24	0.20	0.32
$LSD_{0.01}$	0.74	0.64	0.65	0.68	0.87	0.65	0.26	0.35	0.28	0.32	0.26	0.43
LS	*	**	**	**	**	**	**	**	**	**	**	**

LS = Level of significance. ** = Significant at 1% level of probability. * = Significant at 5% level of probability. V_1= Shidur, V_2 = New Kuroda; T_1 = Control, T_2 = 100% PM, T_3 = 100% VC, T_4 = 100% RDF, T_5 = 50% PM + 50% RDF, T_6 = 50% VC + 50% RDF, T_7 = 30% PM + 30% VC + 40% RDF

Table 4. Combined influence of variety and nutrient management on yield contributing parameters of carrot.

Treatment combinations	Root length (cm)	Root diameter (cm)	Core diameter (cm)	Root weight per plant (g)	% damaged root
V_1T_1	11.20	2.15	0.78	42.37	5.83
V_1T_2	11.79	2.67	1.02	51.12	3.33
V_1T_3	12.28	2.98	1.16	52.88	2.50
V_1T_4	13.30	3.33	1.61	57.62	6.67
V_1T_5	13.42	3.17	1.42	65.06	0.83
V_1T_6	14.55	3.68	1.66	72.40	2.50
V_1T_7	15.42	4.18	1.57	88.56	3.33
V_2T_1	9.92	2.07	0.73	31.83	3.33
V_2T_2	11.25	2.79	0.92	37.09	2.50

Treatment combinations	Root length (cm)	Root diameter (cm)	Core diameter (cm)	Root weight per plant (g)	% damaged root
V_2T_3	12.21	2.42	1.11	48.05	3.33
V_2T_4	13.17	2.87	1.56	61.61	7.50
V_2T_5	13.33	3.13	1.37	64.19	2.50
V_2T_6	14.08	3.49	1.62	76.13	1.67
V_2T_7	14.74	3.70	1.51	86.16	6.67
$LSD_{0.05}$	0.32	0.27	0.024	2.63	0.54
$LSD_{0.01}$	0.43	0.35	0.032	3.48	0.71
LS	**	**	**	**	**

LS = Level of significance. ** = Significant at 1% level of probability. V_1= Shidur, V_2 = New Kuroda; T_1 = Control, T_2 = 100% PM, T_3 = 100% VC, T_4 = 100% RDF, T_5 = 50% PM + 50% RDF, T_6 = 50% VC + 50% RDF, T_7 = 30% PM + 30% VC + 40% RDF

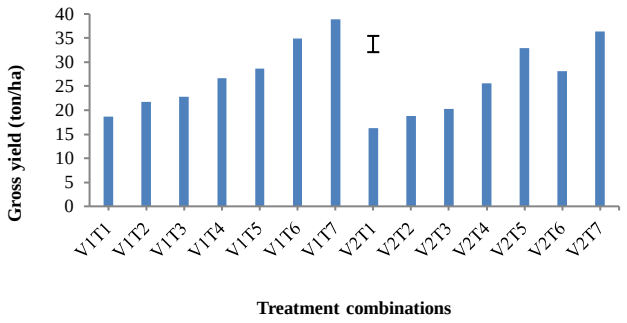

Figure 1: Combined effect of variety and nutrient management on gross yield of carrot. Vertical bar represents LSD at 1% level of significance. Here, V_1 = Shidur, V_2 = New Kuroda, T_1 = Control, T_2 = 100% PM, T_3 = 100% VC, T_4 = 100% RDF, T_5 = 50% PM + 50% RDF, T_6 = 50% VC + 50% RDF, T_7 = 30% PM + 30% VC + 40% RDF

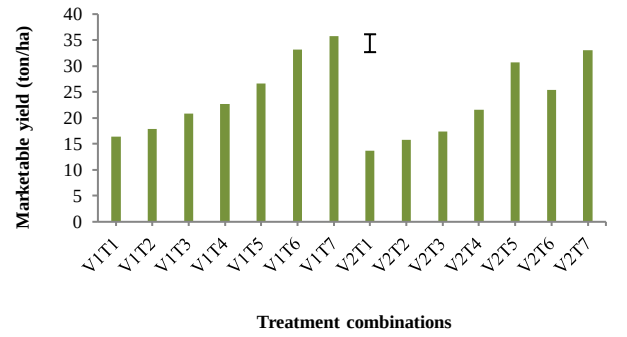

Figure 2: Combined influence of variety and nutrient management on marketable yield of carrot. Vertical bar denotes LSD at 1% level of significance. Here, V_1 = Shidur, V_2 = New Kuroda, T_1 = Control, T_2 = 100% PM, T_3 = 100% VC, T_4 = 100% RDF, T_5 = 50% PM + 50% RDF, T_6 = 50% VC + 50% RDF, T_7 = 30% PM + 30% VC + 40% RDF

CONCLUSION

Considering the above discussion, it can be concluded that, the growth and yield of carrot found best at V_1T_7 (Shidur with 30 % poultry manure + 30% vermicompost + 40% recommended dose of fertilizers) treatment combination as it produced the highest gross yield and commercial yield (38.90 t/ha and 35.77 t/ha) and the lowest result was found from V_2T_1 treatment combination

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Conflict of Interest

The Researchers announce that there is no encounter of interests about the publication of this paper.

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