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Quality of carrot as influenced by different approaches on nutrient recommendations

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Abstract
A field experiment was conducted during *kharif* 2017 at Devanahalli village, Bengaluru rural district to study the influence of different approaches of nutrient application on yield and quality of carrot. The results revealed that significantly higher root (27. 51 t ha^{-1}) and shoot (16.48 t ha^{-1}) yield were recorded in STCR target of 25 t ha^{-1} through integrated approach. Similarly, the quality parameters of carrot *viz.*, TSS (9.70 ºBrix), beta-carotene (9.81 mg 100g^{-1}) and reducing sugars (5.07 mg 100g^{-1}) were significantly higher where nutrients were applied through STCR integrated approach for targeted yield of 25 t ha^{-1}. However, non-reducing sugars and total sugars were found to be non significant.

Keywords: STCR, carrot, yield, quality, per cent deviation

Introduction
Use of fertilizers by the farmers in the fields without information on soil fertility status and nutrient requirement by crop causes adverse effects on soil and crop regarding nutrient toxicity and deficiency either by excess quantity or under dosing [1]. Soil test based application of plant nutrients helps to realize higher response to nutrients used in proportion to the magnitude of the deficiency of a particular nutrient and correction of the nutrients imbalance in soil which helps to harness the synergistic effects of balanced fertilization [2].

Among the various methods of fertilizer recommendations the soil test crop response (STCR) targeted yield approach is a novel approach where in fertilizer recommendations are made by considering nutrient use efficiency of the crop and nutrient contribution of the soil. In addition to this fertilizer recommendations are made based on the yield target. This approach is site specific and situation specific. Therefore, in order to extrapolate to other situations (Zones), one should evaluate the STCR equation for its suitability.

Carrot (*Daucus carota* L.) is a popular cool season root vegetable of umbelliferae family. The cultivated forms of carrots are derived from South Western Asia probably in the hills of Punjab and Kashmir. In India carrot is cultivated in an area of 82,000 hectare with production of 1,33,8000 metric tonnes and productivity of 16.3 t ha^{-1}. The main carrot growing states are Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana [3].

Carrot roots are rich in nutrients with moisture 86 g, protein 0.9 g, carbohydrate 10.6 g, fat 0.2 g, fiber 1.2 g, energy 48 kilo calorie, mineral 1.1 g, iron 2.2 mg, beta carotene 9.81 mg, thiamine 0.04 mg, riboflavin 0.02 mg, niacin 0.5 mg, vitamin-C 3 mg, folic acid 15 mg, calcium 14 mg and phosphorus 19.8 mg per 100 g of edible portion [4]. Essential oils extracted from carrots may be used as a body purifier which has the potential to boost the functions of liver and digestive system, and also assist in the formation of red blood corpuscles and slowing down ageing process. It improves eyesight as well as skin health due to its rich source of beta-carotene.

Material and Methods
A Field experiment entitled "Evaluation of different approaches of nutrient application on yield and quality of carrot" was conducted during *kharif*, 2017 Devanahalli village, Bengaluru rural district located in Eastern Dry Zone of Karnataka at 13° 24' 41.1" N latitude, 78° 08' 01.9" E longitude with an altitude of 880 meters above mean sea level (MSL). The soil of the experimental site was sandy loam in texture and acidic in reaction (pH, 5.48 - 5.58). Electrical conductivity was 0.13 to 0.15 dSm^{-1} with organic carbon content ranged from 0.62 - 0.77%. Available nitrogen was medium to high (268.65 – 289.56 kg N ha^{-1}), phosphorus was high.

(913.10 - 985.74 kg P_2O_5 ha^{-1}) and potassium was medium (173.20 – 202.00 kg K_2O ha^{-1}). The experiment was laid out in randomized complete block design (RCBD) with eight treatments replicated thrice comprising T_1 (STCR target 20 tha^{-1} through inorganics), T_2 (STCR target 20 tha^{-1} through integrated), T_3 (STCR target 25 tha^{-1} through inorganics), T_4 (STCR target 25 tha^{-1} through integrated), T_5 (RDF (75: 63: 50) N, P_2O_5, K_2O kg ha^{-1}+ FYM), T_6 (LMH /STL + FYM), T_7 (Farmers practice (92.6:159:0) N, P_2O_5 kg ha^{-1} + FYM), T_8 (Absolute control).

The following STCR fertilizer adjustment equation developed by AICRP on STCR, UAS, Bengaluru centre for Zone-5 was used for fertilizer application for STCR treatments.

STCR equation for inorganics	STCR equation for IPNS
F.N. = 1.04 T - 0.39 STV-N	F.N. = 1.04 T - 0.39 STV-N - 0.23 OM
F.P_2O_5 = 0.49 T - 0.43 STV-P_2O_5	F.P_2O_5 = 0.49 T - 0.43 STV-P_2O_5 - 0.14 OM
F.K_2O = 0.87 T - 0.66 STV-K_2O	F.K_2O = 0.87 T - 0.66 STV-K_2O - 0.51 OM

Where, T = Targeted yield (q ha^{-1}), FN= Fertilizer nitrogen (kg ha^{-1}), FP_2O_5= Fertilizer phosphorus (kg ha^{-1}), FK_2O = Fertilizer potassium (kg ha^{-1}), STV- N, STV- P_2O_5 and STV-K_2O are initial available N, P_2O_5 and K_2O kg ha^{-1} respectively.

A composite soil sample was collected from each plot after laying out the plan from 0-15 cm depth before the start of experiment. Based on the soil test values NPK fertilizers were applied in STCR and LMH approach. The quantity of nutrients applied per hectare through different approaches as per the treatments are presented in Table 1. Fifty per cent of nitrogen recommended for each treatment was applied through urea and entire quantity of phosphorus through SSP (single super phosphate) and potassium through MoP (muriate of potash) were supplied at the time of sowing as basal dose to each plot and remaining 50 per cent of nitrogen was applied at 30 days after sowing. At harvest the root and shoot yield was computed from the net plot and expressed in tonnes ha^{-1}.

Fresh root samples from five randomly selected plants from each treatments were used for determining the quality parameters. Total soluble solids (TSS) was measured using refractometer and expressed in °Brix. Beta- carotene content was estimated according to the method advocated by Association of Official Analytical Chemists [5], total sugars by the method outlined by Dubios [6] and reducing sugars by Nelson-Somogyi's method [7]. The non-reducing sugar was calculated by deducting reducing sugars from total sugars estimated.

The data collected were subjected to statistical analysis. The level of significance used in F and t-test was P= 0.05. Critical difference (CD) values were calculated for P= 0.05 whenever F-test was found significant.

Results and Discussion

The root and shoot yield of carrot crop differed significantly due to different approaches of nutrient application (Table 2). Significantly higher shoot yield (16.48 t ha^{-1}) was recorded in STCR target 25 tha^{-1} through integrated approach (T_4) compared to all other treatments except STCR target 25 tha^{-1} through inorganics (T_3) (15.35 t ha^{-1}) and STCR target 20 tha^{-1} through integrated (T_2) (14.40 t ha^{-1}) which were on par. Significantly higher root yield (27.51 t ha^{-1}) was recorded in STCR target of 25 t ha^{-1} through integrated approach (T_4) which was superior than all the other treatments. The root yield of STCR targeted yield approach treatments were found to be superior over LMH (19.39 t ha^{-1}), RDF (19.28 t ha^{-1}) and Farmer's practice (19.18 t ha^{-1}). The STCR-integrated approach at both the targets (20 and 25 t ha^{-1}) have recorded the yield more than the target fixed and was higher compared to STCR - inorganic approach. The enhanced nutrient uptake and increased nutrient use efficiency under STCR approach over LMH, RDF and Farmer's practice, resulted in positive effect on growth and yield attributes that have enabled higher root yield of carrot. The results are in conformity with Goudappa [8] who reported that The increase in bulb yield owing to STCR approach might be due to balanced application of nutrients which is based on soil analysis and takes into account of the amount of nutrient removed by the crops, initial levels of soil fertility, efficiency of nutrients present in the soil and added through the fertilizers. These factors might have provided the optimum nutrients at optimum time for better uptake and ultimately resulted in higher dry matter and yield [9, 10].

The total soluble solids (TSS) in carrot roots was significantly higher in T_4 (9.70 ° Brix) compared to all other treatments. However, it was on par with all other STCR treatments *viz.*, T_3 (9.03 ° Brix), T_2 (9.07 ° Brix), T_1 (9.03 ° Brix) and (T_6) LMH approach (8.83 ° Brix). Similarly, higher beta carotene in carrot roots was recorded in T_4 (9.81 mg $100g^{-1}$) compared to all other treatments. Significantly higher reducing sugar content (5.07 mg $100g^{-1}$) in carrot roots was noticed in STCR target of 25 t ha^{-1} through integrated approach (T_4) compared to all the other treatments including control except STCR target of 25 t ha^{-1} through inorganics (T_3) (4.83 mg $100g^{-1}$) and STCR target of 20 t ha^{-1} through integrated approach (T_2) (4.60 mg $100g^{-1}$) which were on par. Significantly lower reducing sugar content (3.71 mg $100g^{-1}$) was recorded in absolute control (T_8) that was found to be on par with STCR target of 20 t ha^{-1} through inorganics (T_1) (4.16 mg $100g^{-1}$), RDF (T_5) (4.13 mg $100g^{-1}$), LMH (T_6) (4.16 mg $100g^{-1}$) and Farmer's practice (T_7) (4.09 mg $100g^{-1}$). However, non-reducing sugars and total sugars were found to be non-significant. This improvement in quality parameters of carrot in the present study was due to better availability and uptake of nitrogen and other nutrients with the application of FYM which might have lead to increased activity of plant metabolism. Also, the increment might be brought about by more assimilates produced by the increased number of leaves and larger roots recorded in this study.

Table 1: Quantity of nutrients applied per hectare through different approaches as per the treatments

Treatments	Soil test values			FYM	Fertilizer nutrient applied		
	N	P_2O_5	K_2O	Applied	N	P_2O_5	K_2O
	kg ha^{-1}			t ha^{-1}	kg ha^{-1}		
T_1	269.69	931.88	186.80	0	101.19	0.00	50.71
T_2	268.65	882.29	196.40	25	92.45	0.00	31.61
T_3	289.56	1013.10	202.00	0	150.60	0.00	84.16
T_4	269.69	951.54	173.20	25	151.60	0.00	90.42

T_5	249.83	933.16	178.40	25	75.00	63.00	50.00
T_6	279.10	982.75	195.20	25	80.56	50.50	50.00
T_7	282.24	985.74	195.20	30	92.60	159.00	0.00
T_8	276.99	919.05	189.20	0	0.00	0.00	0.00

T_1 (STCR target 20 tha^{-1} through inorganics), T_2 (STCR target 20 tha^{-1} through integrated), T_3 (STCR target 25 tha^{-1} through inorganics), T_4 (STCR target 25 tha^{-1} through integrated), T_5 (RDF (75: 63: 50) N, P_2O_5, K_2O kg ha^{-1}+ FYM), T_6 (LMH /STL + FYM), T_7 (Farmers practice (92.6:159:0) N, P_2O_5 kg ha^{-1} + FYM), T_8 (Absolute control).

Table 2: Influence of different approaches of nutrient application on yield and quality parameters of carrot crop

Treatment	Shoot yield	Root yield	TSS	Beta- carotene	Reducing sugars	Non-reducing sugars	Total sugars
	(t ha^{-1})		(º Brix)	(mg 100g-1)			
T1	12.81	19.68	9.03	8.63	4.16	2.02	6.18
T2	14.4	21.66	9.07	8.78	4.6	1.67	6.26
T3	15.35	24.91	9.03	8.92	4.83	1.46	6.3
T4	16.48	27.51	9.7	9.81	5.07	1.41	6.48
T5	13.5	19.28	8.67	8.6	4.13	2.03	6.16
T6	13.95	19.39	8.83	8.62	4.16	1.7	5.86
T7	12.8	19.18	8.3	8.33	4.09	2.05	6.14
T8	9.91	14.75	6.17	5.93	3.71	2.1	5.81
S.Em±	0.68	0.77	0.31	0.27	0.18	0.27	0.23
CD @ 5%	2.08	2.35	0.93	0.82	0.54	NS	NS

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