

## Original Research Article

### **EVALUATION OF DIFFERENT APPROACHES OF NUTRIENT APPLICATION ON YIELD, NUTRIENT UPTAKE, NUTRIENT USE EFFICIENCY AND ECONOMICS OF CARROT**

#### **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, nutrient uptake and nutrient use efficiency by carrot. The experiment was conducted using randomized complete block design replicated thrice with eight treatments comprising T<sub>1</sub> (STCR target 20 t ha<sup>-1</sup> through inorganics), T<sub>2</sub> (STCR target 20 t ha<sup>-1</sup> through integrated), T<sub>3</sub> (STCR target 25 t ha<sup>-1</sup> through inorganics), T<sub>4</sub> (STCR target 25 t ha<sup>-1</sup> through integrated), T<sub>5</sub> (RDF (75: 63: 50) N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + FYM), T<sub>6</sub> (LMH /STL + FYM), T<sub>7</sub> (Farmers practice (92.6:159:0) N, P<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup> + FYM), T<sub>8</sub> (Absolute control). The results revealed that significantly higher root (27.51 t ha<sup>-1</sup>) and shoot (16.48 t ha<sup>-1</sup>) yield were recorded in STCR target of 25 t ha<sup>-1</sup> through integrated approach. Similarly, higher total uptake of nitrogen, phosphorus and potassium (297.07 kg, 57.48 kg and 253.81 kg ha<sup>-1</sup> respectively) by carrot crop and the higher apparent recovery efficiency (0.35, 0.08 and 0.58 kg kg<sup>-1</sup> of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively) and agronomic nutrient use efficiency (26.10, 12.37 and 48.25 kg kg<sup>-1</sup> of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively) were recorded in the same STCR target of 25 t ha<sup>-1</sup> through integrated approach. However, the better profit was recorded (value cost ratio: 43.30) in STCR target of 25 t ha<sup>-1</sup> through inorganics.

**Key words:** STCR, carrot, nutrient use efficiency, VCR

#### **1. Introduction**

The agricultural scenario of India is been completely changing due to modern intensive agricultural practices viz., use of higher doses of fertilizer nutrients, high yielding varieties of crops etc. However, use of these 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 (Anitha and Chikkaramappa, 2021).

Soil fertility evaluation helps the farmers to use fertilizer nutrients according to the need of the crop. Therefore, soil testing is now accepted as a tool for the recommendation of doses and kind of fertilizer nutrients. Among the various methods of fertilizer recommendations the soil test crop response (STCR) targeted yield approach is unique in the sense that, this method not only indicates the soil test-based fertilizer dose but also the level of yield the farmer can hope to achieve if good agronomic practices are adopted in crop cultivation (Kanwar, 1971).

Carrot (*Daucus carota* L.) is a popular cool season root vegetable of umbelliferae family. It is cultivated in temperate countries during spring, summer and autumn season while in tropical and subtropical regions during winter season. 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 82000 hectare with production of 1338000 metric tonnes and productivity of 16.3 t ha<sup>-1</sup>. The main carrot growing states are Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana (Anon, 2015).

Currently, general recommendation of 75:63:50 kg N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O ha<sup>-1</sup>, respectively is being followed for carrot crop along with FYM @ 25 t ha<sup>-1</sup> in Karnataka. Fertilization based on blanket recommendation results in either over use or under use of fertilizers, so balanced fertilization is must for realizing higher efficiency and economy of fertilizer use in addition to better yields.

## **2. Material and methods**

A Field experiment entitled “Evaluation of different approaches of nutrient application on yield, nutrient uptake and nutrient use efficiency by carrot” was conducted during *kharif* 2017 at Devanahalli village, Bengaluru rural district located in Eastern Dry Zone of Karnataka at 13° 24' 41.1" N latitude, 78° 60' 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<sup>-1</sup> with organic carbon content ranged from 0.62 - 0.77 %. Available nitrogen was medium (268.65 – 289.56 kg N ha<sup>-1</sup>), phosphorus was high (913.10 - 985.74 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) and potassium was medium (173.20 – 202.00 kg K<sub>2</sub>O ha<sup>-1</sup>). The experiment was laid out in randomized complete block design (RCBD) with eight treatments replicated thrice comprising T<sub>1</sub> (STCR target 20 tha<sup>-1</sup> through inorganics), T<sub>2</sub> (STCR target 20 tha<sup>-1</sup> through integrated), T<sub>3</sub> (STCR target 25 tha<sup>-1</sup> through inorganics), T<sub>4</sub> (STCR

target 25 t ha<sup>-1</sup> through integrated), T<sub>5</sub> (RDF (75: 63: 50) N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup> + FYM), T<sub>6</sub> (LMH /STL + FYM), T<sub>7</sub> (Farmers practice (92.6:159:0) N, P<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup> + FYM), T<sub>8</sub> (Absolute control).

Chart 1. The following STCR fertilizer adjustment equation developed by AICRP on STCR, UAS, Bengaluru centre for Zone-5 was used for fertilizer application to 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 <sub>2</sub> O <sub>5</sub> = 0.49 T - 0.43 STV-P <sub>2</sub> O <sub>5</sub>	F.P <sub>2</sub> O <sub>5</sub> = 0.49 T - 0.43 STV-P <sub>2</sub> O <sub>5</sub> - 0.14 OM
F.K <sub>2</sub> O = 0.87 T - 0.66 STV-K <sub>2</sub> O	F.K <sub>2</sub> O = 0.87 T - 0.66 STV-K <sub>2</sub> O - 0.51 OM

Where, T = Targeted yield (q ha<sup>-1</sup>), FN= Fertilizer nitrogen (kg ha<sup>-1</sup>), FP<sub>2</sub>O<sub>5</sub>= Fertilizer phosphorus (kg ha<sup>-1</sup>), FK<sub>2</sub>O = Fertilizer potassium (kg ha<sup>-1</sup>), STV- N, STV- P<sub>2</sub>O<sub>5</sub> and STV- K<sub>2</sub>O are initial available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O kg ha<sup>-1</sup> 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 for specific yield target 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<sup>-1</sup>. At harvest randomly labelled root and shoot samples were collected, dried, powdered and used for analysing the concentration of NPK by adopting the standard procedures (Piper, 1966). Soil samples collected from the experimental plots after harvest were processed and analysed for available nitrogen, phosphorus and potassium by following standard procedures (Jackson 1973). After analysing the major nutrient concentrations in root and shoot samples, nutrient uptake, apparent recovery efficiency (ARE) and agronomic nutrient use efficiency (ANUE) of these nutrients by carrot and value-cost ratio (VCR) were computed by using the standard formulae as shown below

$$\text{Uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Biomass (kg ha}^{-1}\text{)}}{100}$$

$$\text{ARE (kg kg}^{-1}\text{)} = \frac{\text{Nutrient uptake in treated plot - Nutrient uptake in control plot}}{\text{(kg ha}^{-1}\text{)} \quad \text{(kg ha}^{-1}\text{)}}$$

$$\text{ANUE (kg kg}^{-1}\text{)} = \frac{\text{Fertilizer nutrient applied (kg ha}^{-1}\text{)} + \text{Soil available nutrient (kg ha}^{-1}\text{)}}{\text{Root yield in treated plot (kg ha}^{-1}\text{)} - \text{Root yield in control plot (kg ha}^{-1}\text{)}}$$

$$\text{VCR} = \frac{\frac{(\text{Yield in treated plot (t ha}^{-1}\text{)} - \text{Yield in control plot (t ha}^{-1}\text{)}) \times \text{cost t}^{-1} \text{ of roots (Rs)}}{\text{Cost of fertilizers and FYM applied to treated plot (Rs)}}$$

**Table 1: Soil test values and quantity of nutrients and FYM applied for different approaches as per the treatments.**

Treatments	Soil test values			FYM applied	Fertilizer nutrient applied		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O		N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	kg ha <sup>-1</sup>			t ha <sup>-1</sup>	kg ha <sup>-1</sup>		
T <sub>1</sub>	269.69	931.88	186.80	0	101.19	0.00	50.71
T <sub>2</sub>	268.65	882.29	196.40	25	92.45	0.00	31.61
T <sub>3</sub>	289.56	1013.10	202.00	0	150.60	0.00	84.16
T <sub>4</sub>	269.69	951.54	173.20	25	151.60	0.00	90.42
T <sub>5</sub>	249.83	933.16	178.40	25	75.00	63.00	50.00
T <sub>6</sub>	279.10	982.75	195.20	25	80.56	50.50	50.00
T <sub>7</sub>	282.24	985.74	195.20	30	92.60	159.00	0.00
T <sub>8</sub>	276.99	919.05	189.20	0	0.00	0.00	0.00

(75: 63: 50) N,  $P_2O_5$ ,  $K_2O$  kg ha<sup>-1</sup>+ FYM), T<sub>6</sub> (LMH /STL + FYM), T<sub>7</sub> (Farmers practice (92.6:159:0) N,  $P_2O_5$  kg ha<sup>-1</sup> + FYM), T<sub>8</sub> (Absolute control).

### 3. 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<sup>-1</sup>) was recorded in STCR target of 25 t ha<sup>-1</sup> through integrated approach (T<sub>4</sub>) compared to all other treatments except STCR target 25 t ha<sup>-1</sup> through inorganics (T<sub>3</sub>) (15.35 t ha<sup>-1</sup>) and STCR target of 20 t ha<sup>-1</sup> through integrated (T<sub>2</sub>) (14.40 t ha<sup>-1</sup>) which were on par. Significantly higher root yield (27.51 t ha<sup>-1</sup>) was recorded in STCR target of 25 t ha<sup>-1</sup> through integrated approach (T<sub>4</sub>) which was superior than all the other treatments. The root yield in STCR targeted yield approach treatments were found to be superior over LMH (19.39 t ha<sup>-1</sup>), RDF (19.28 t ha<sup>-1</sup>) and Farmer's practice (19.18 t ha<sup>-1</sup>). The STCR-integrated approach at both the targets (20 and 25 t ha<sup>-1</sup>) 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 favorable complementary influence of organics and inorganics on chemical, physical and biological properties of soil under STCR integrated approach would have resulted in higher yield (Santhi *et al.*, 2002, Prabhakar *et al.*, 2017).

The higher value cost ratio (VCR) (Table. 2) of 43.30 was recorded where fertilizer nutrients were applied through STCR inorganic approach for a yield target of 25 t ha<sup>-1</sup> (T<sub>3</sub>) followed by 34.91 in STCR target of 20 t ha<sup>-1</sup> through inorganics (T<sub>1</sub>). The lower value cost ratio of 1.78 was recorded in Farmer's practice (T<sub>7</sub>). This higher VCR in STCR inorganic treatments could be mainly due to no P fertilizer and no FYM application associated with higher yields. Even though higher yields were recorded in STCR integrated approach, the VCR was lower mainly due to high cost of FYM applied to these treatments. These results are in conformity with Basavaraja *et al.* (2017) in finger millet crop, who reported higher VCR in STCR inorganic approach over integrated approach due to high cost of FYM, even though yield were higher in STCR integrated approach.

The uptake (Table.2) of nitrogen by carrot crop was significantly higher ( $297.07 \text{ kg ha}^{-1}$ ) in treatment receiving NPK fertilizers along with FYM for a targeted yield of  $25 \text{ t ha}^{-1}$  ( $T_4$ ) compared to all other treatments and significantly higher uptake of phosphorus ( $57.48 \text{ kg ha}^{-1}$ ) was recorded in targeted yield of  $25 \text{ t ha}^{-1}$  through integrated approach compared to all other treatments except targeted yield of  $25 \text{ t ha}^{-1}$  through inorganics ( $49.28 \text{ kg ha}^{-1}$ ) which was on par. Similarly, the uptake of potassium by carrot was significantly higher ( $253.81 \text{ kg ha}^{-1}$ ) in  $T_4$  treatment compared to all other treatments except  $T_3$  (STCR target  $25 \text{ t ha}^{-1}$  through inorganics) ( $234.00 \text{ kg ha}^{-1}$ ) and  $T_2$  (STCR target  $20 \text{ t ha}^{-1}$  through integrated) ( $220.85 \text{ kg ha}^{-1}$ ) and  $T_6$  (LMH/STL approach) ( $217.60 \text{ kg ha}^{-1}$ ) which were on par whereas the lower uptake of NPK ( $105.66 \text{ kg ha}^{-1}$ ,  $25.97 \text{ kg ha}^{-1}$ ,  $125.44 \text{ kg ha}^{-1}$ , respectively) was recorded absolute control ( $T_8$ ). The increase in uptake of nitrogen was due to higher root and shoot yield in that treatments and also due to application of more nitrogen fertilizers based on the soil test values and crop requirement.

**Table. 2 Influence of different approaches of nutrient application on yield, nutrient uptake and VCR of carrot crop**

Treatment	Shoot yield	Root yield	Nutrient uptake ( $\text{kg ha}^{-1}$ )			VCR
	( $\text{t ha}^{-1}$ )		N	P	K	
$T_1$	12.81	19.68	214.28	41.59	198.47	34.91
$T_2$	14.40	21.66	239.39	47.27	220.85	3.88
$T_3$	15.35	24.91	250.79	49.28	234.00	43.3
$T_4$	16.48	27.51	297.07	57.48	253.81	6.74
$T_5$	13.50	19.28	185.44	45.13	186.77	2.30
$T_6$	13.95	19.39	203.53	47.55	217.60	2.40
$T_7$	12.80	19.18	148.82	41.95	143.83	1.78
$T_8$	9.91	14.75	105.66	25.97	125.44	-
<b>SEm<math>\pm</math></b>	<b>0.68</b>	<b>0.77</b>	<b>15.58</b>	<b>2.99</b>	<b>19.19</b>	-
<b>CD @ 5%</b>	<b>2.08</b>	<b>2.35</b>	<b>47.27</b>	<b>9.08</b>	<b>45.47</b>	-

The higher uptake of phosphorus was recorded in STCR approach even without application of phosphatic fertilizers which was superior over LMH and RDF due to more biomass production and better uptake of native soil phosphorus and higher K uptake compared to LMH approach and RDF was due to higher dose of potassium ( $86.67 \text{ kg K}_2\text{O ha}^{-1}$ ) application

in STCR approach which has resulted in higher uptake due to higher biomass production. Basavaraja *et al.*, (2017) concluded that significantly higher NPK uptake was recorded in STCR-targeted yield with IPNS approach (30 q ha<sup>-1</sup>) which was on par with package of practice (POP) approach. They also concluded that the increased NPK uptake under POP and STCR-targeted (30 q ha<sup>-1</sup>) yield approach with purely inorganic approach could be due to application of required quantity of nutrients through inorganic fertilizers in STCR approach. Similar results were also reported by Sinchana and Subbarayappa (2021).

The higher apparent recovery efficiency (Table. 3) of nitrogen (0.35 kg kg<sup>-1</sup>), phosphorus (0.08 kg kg<sup>-1</sup>) and potassium (0.58 kg kg<sup>-1</sup>) was recorded in STCR target of 25 t ha<sup>-1</sup> through integrated approach (T<sub>4</sub>). Similarly, the agronomic nutrient use efficiency (Table. 3) of nitrogen (26.10 kg kg<sup>-1</sup>), phosphorus (12.37 kg kg<sup>-1</sup>) and potassium (48.25 kg kg<sup>-1</sup>) was higher in the same treatment. Among STCR targeted yield treatments, these efficiencies were higher in integrated approach than in inorganics which was due to combined use of organics and inorganics which helped in effective use of applied/soil nutrients for higher production and reduced the loss of the applied fertilizer nutrients. The efficiency of P was found to decrease with increase in the doses of P. The lower efficiency of fertilizer P at higher P application could be due to higher P losses through soil fixation. The similar results (Ashwini 2007) of higher nutrient use efficiency of N, P and K was observed when nutrients were applied as per POP (Package of practice) followed by STCR targeted yield of 50 q ha<sup>-1</sup> for ragi crop through both organic and inorganic sources of nutrients. Similarly, Basavaraja *et al.* (2016) reported that NPK uptake and nutrient use efficiency in aerobic paddy was significantly higher in the treatment where nutrients were applied through integrated approach for a yield target of 75 q ha<sup>-1</sup>.

**Table 3: Apparent recovery efficiency and Agronomic nutrient use efficiency of NPK as influenced by different approaches of nutrient application**

Treatments	ARE (kg kg <sup>-1</sup> )			ANUE (kg kg <sup>-1</sup> )		
	N	P	K	N	P	K
T <sub>1</sub>	0.18	0.04	0.37	13.25	5.32	20.77
T <sub>2</sub>	0.25	0.05	0.50	17.49	7.19	30.23
T <sub>3</sub>	0.24	0.06	0.46	23.19	10.09	35.72

T <sub>4</sub>	0.35	0.08	0.58	26.10	12.37	48.25
T <sub>5</sub>	0.17	0.04	0.32	10.24	4.52	20.15
T <sub>6</sub>	0.15	0.05	0.45	11.09	4.27	19.07
T <sub>7</sub>	0.12	0.03	0.11	9.99	3.87	22.39
T <sub>8</sub>	-	-	-	-	-	-

## Conclusion

Based on this study, it can be concluded that the STCR targeted yield equations developed for carrot crop is most suitable for zone-5 of Karnataka for getting higher carrot yield compared to all other approaches of fertilizer nutrient recommendation.

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