Original Research Article

EFFECTOF 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 of Karnataka to evaluate theeffect of different approaches of nutrient application on yield, nutrient uptake and use efficiency by carrot(*Daucus carota* L.). The experiment was laid out inrandomized complete block design replicated thrice with eight treatments comprisingT_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).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, higher total uptake of nitrogen, phosphorus and potassium (297.07 kg, 57.48 kg and 253.81 kg ha^{-1}, respectively) by carrot and the higher apparent recovery efficiency (0.35, 0.08 and 0.58 kg kg^{-1} of N, P_2O_5 and K_2O, respectively) and agronomic nutrient use efficiency (26.10, 12.37 and 48.25 kg kg^{-1} of N, P_2O_5 and K_2O, respectively) were recorded in the same STCR target of 25 t ha^{-1} through integrated approach. However, the better profit was recorded (value cost ratio: 43.30) in STCR target of 25 t ha^{-1} through inorganics.The STCR target of 25 t ha^{-1} through integrated approach had the most positive effect for the carrot cultivation.

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

1. Introduction

The current agricultural scenario of India is been completely changing due to modern intensive agricultural practices *viz.,*use of highdoses of fertilizers, high yielding varieties of crops etc. Farmers are generally used the fertilizers in the fields without information ofsoil fertility status and nutrient requirement by the crops causesadverse effects on soil and crop regarding nutrient toxicity and deficiency (Anitha and Chikkaramappa, 2021).

Soil fertility assessment helps the farmers to use fertilizer nutrients according to the requirement of the crop. Therefore, soil testing is now accepted as a tool for the recommendation of fertilizer 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). Soil testing would become a useful tool when it is based on close information of soil-crop-variety-fertilizer-climate and management practices interaction for a given situation (Basavaraja et al., 2017).

Carrot (*Daucus carota* L.) is a short duration and popular cool season root vegetable under umbelliferae family. It is cultivated in temperate countries during spring, summer and autumn season while in tropical and subtropical regions during winter season(Afrin et al., 2019). It contains appreciable amount of carotene, thiamin, riboflavin, iron, calcium and phosphorus. It is used as salad and as cooked vegetable in soups, stews, curries, etc. and also used for the preparation of pickles, jam, and sweet dishes (Afrin et al.,2019). The cultivated forms of carrots are derived from South Western Asia probably in the hills of Punjab and Kashmir (Baranska, 2005). In India carrot is cultivated in an area of 82000 hectare with production of 1338000 metric tonnes and the productivity is 16.3 t ha^{-1}. The main carrot growing states are Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana (Anonymous, 2015).

Bengaluru of Karnataka state is eastern dry zone, general recommendation for carrot crop of 75:63:50 kg N, P_2O_5, and K_2O ha^{-1}, respectively is being followed along with FYM @ 25 t ha^{-1}.Fertilization based on comprehensive recommendation results in either over use or under use of fertilizers. This dry ecosystem of Karnataka canbe achieved best crop productivity by adopting a holistic approach in whichsoil and water conservation measures are implementedalong with sound nutrient management options (Waniet al., 2003).

STCR-targeted yield approach can be used for individual field situation and is a better estimation for planning the requirement of fertilizers on the area basis for a given level of crop production. Fertilizer is a costly input hence, the scientific and efficient utilization of this input is essential. Input utilization of STCR approach plays a vital role as a comprehensive approach of fertilizer utilization where fertilizer is applied based on yield target, site specification, crop specification and soil test values. However there is a need to evaluate the STCR-targeted yield approach in comparison with the other approaches for yield variation, nutrient uptake, nutrient use efficiency and economics. Therefore, the present study was undertaken to find out the suitable approaches of nutrient application on yield maximization, nutrient uptake and use efficiency and economics of carrot.

2. Material and methods

A Field experiment 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^{-1} with organic carbon content ranged from 0.62 - 0.77 %. Available nitrogen was medium (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).

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_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 for specific yield target in STCR and LMH approach.Thequantity 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.

Carrot seeds were sown in line sowing in 22.5 cm rows at a depth of about 2 cm in the soil on 31st July 2017 in experimental plot of 4.0 m × 3.6 m. Basal dose of fertilizer nutrients (1/2 of N and 100 % P_2O_5 and K_2O) were applied in seed rows and mixed with soil and line sowing was done. The recommended seed rate of 5 kg ha^{-1} was adopted. Thinning was done at 15 days after sowing and retained only one seedling per hill at 10 cm spacing. The uniform stand of crop was maintained at a spacing of 22.5 cm between the rows and 10 cm between the plants in a row. In order to keep the soil porus and also free from weeds, hand weeding was done at 30 and 50 days after sowing. For the better establishment of the crop, first light irrigation was given through sprinklers immediately after sowing. Then subsequent irrigations were given at different intervals as per the crop requirement through sprinklers. The crop was well managed as per the package of practice.

At harvest the root and shoot yield was computed from the net plot and expressed in tonnes ha^{-1}. At harvest randomly labeled 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

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

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

$$\text{ANUE (kg kg}^{-1}\text{)} = \frac{\text{Root yield in treated plot (kg ha}^{-1}\text{) – Root yield in control plot (kg ha}^{-1}\text{)}}{}$$

$$\text{Fertilizer nutrient applied (kg ha}^{-1}\text{) + Soil available nutrient (kg ha}^{-1}\text{)}$$

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

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_2O_5	K_2O		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).

3. Results and discussion

3.1 Root and Shoot yield of carrot

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 of 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 of 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 to all the other treatments. The root yields in 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 approaches 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 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).

3.2 Value cost ratio (VCR)

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^{-1} (T_3) followed by 34.91 in STCR target of 20 t ha^{-1} through inorganics (T_1). The lower value cost ratio of 1.78 was recorded in Farmer's practice (T_7). 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 STCRinorganic approach over integrated approach due to high cost of FYM, even though yield were higher in STCR integrated approach.

3.3 Nutrient uptake by carrot

The uptake (Table.2) of nitrogen by carrot crop was significantly higher (297.07 kg ha^{-1}) in treatment receiving NPK fertilizers along with FYM for a targeted yield of 25 t ha^{-1} (T_4)compared to all other treatments and significantly higher uptake of phosphorus (57.48 kg ha^{-1}) was recorded in targeted yield of 25 t ha^{-1} through integrated approach compared to all other treatments except targeted yield of 25 t ha^{-1} through inorganics (49.28 kg ha^{-1}) which was on par. Similarly, the uptake of potassium by carrot was significantly higher (253.81 kg ha^{-1}) in T_4 treatment compared to all other treatments except T_3 (STCR target 25 tha^{-1} through inorganics) (234.00 kg ha^{-1}) and T_2 (STCR target 20 tha^{-1} through integrated) (220.85 kg ha^{-1}) and T_6 (LMH/STL approach) (217.60 kg ha^{-1}) which were on par whereas the lower uptake of NPK (105.66 kg ha^{-1}, 25.97 kg ha^{-1},125.44 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 treatment 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 (kg ha^{-1})			VCR
	(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	-
SEm±	**0.68**	**0.77**	**15.58**	**2.99**	**19.19**	-
CD @ 5%	**2.08**	**2.35**	**47.27**	**9.08**	**45.47**	-

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 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 kg K_2O 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^{-1}) 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^{-1}) 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).

3.4 Nutrient use efficiency

The higher apparent recovery efficiency (Table. 3) of nitrogen (0.35 kg kg^{-1}), phosphorus (0.08 kg kg^{-1}) and potassium (0.58 kg kg^{-1}) was recorded in STCR target of 25 t ha^{-1} throughintegrated approach (T_4). Similarly, the agronomic nutrient use efficiency (Table. 3) of nitrogen (26.10 kg kg^{-1}), phosphorus (12.37 kg kg^{-1}) and potassium (48.25 kg kg^{-1}) 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^{-1} 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^{-1}.

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

Treatments	ARE (kg kg^{-1})			ANUE (kg kg^{-1})		
	N	P	K	N	P	K

T_1	0.18	0.04	0.37	13.25	5.32	20.77
T_2	0.25	0.05	0.50	17.49	7.19	30.23
T_3	0.24	0.06	0.46	23.19	10.09	35.72
T_4	0.35	0.08	0.58	26.10	12.37	48.25
T_5	0.17	0.04	0.32	10.24	4.52	20.15
T_6	0.15	0.05	0.45	11.09	4.27	19.07
T_7	0.12	0.03	0.11	9.99	3.87	22.39
T_8	-	-	-	-	-	-

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).

Conclusion

From the study it is clear that STCR approach of integrated fertilizer application is more suitable for achieving higher yield of carrot. This approach is also facilitated for maximum uptake of nutrient, higher apparent nutrient recovery and agronomic nutrient useefficiency by the test crop. The STCR target of 25 t ha^{-1} through integrated approach can support to increase the quantity of carrot for the experimental soil condition.

References

Afrin, A, Islam MA, Hossain MM, Hafiz MMH. Growth and yield of carrot influenced by organic and inorganic fertilizers with irrigation interval. J. Bangladesh Agril. Univ. 2019; 17(3): 338-343.

Anitha K. and Chikkaramappa T. Study on residual effect of fym and graded levels of inorganic fertilizers applied to proceeding crop of browntop millet on growth and yield of succeeding crop of field bean.*Mysore J. Agric. Sci.,*2021; 55(2): 62-70.

Anonymous.*National Horticulture Database*-2015. National Horticulture Board, Govt. of India, Gurgaon, India. www. nhb.gov.in.

Ashwini Y.Evaluation of STCR targeted yield approach on ragi crop yield, soil properties, nutrient uptake and nutrient use efficiency. *M.Sc (Agri.) Thesis,* University of Agricultural Sciences, Bangalore2007.

Baranska, Malgorzata, Schulz, Hartwig, Baranski, Rafal, Nothnagel, Thomas, Christensen, Lars P. In situ simultaneous analysis of polyacetylenes, carotenoids and polysaccharides in carrot roots. *J. Agricultural and Food Chemistry*, 2005;. **53**(17): 6565–6571.

Basavaraja PK. Mohamed Saqeebulla H. Dey P and Prakash SS. Fertilizer prescription equations for targeted yield of rice (*Oryza sativa* L.) and their validation under aerobic condition.*Int. J. Agric. Sci.,*2016; **8**: 1003-1008.

Basavaraja PK., Mohamed Saqeebulla H. Dey P and Sidharam P. Evaluation of different approaches of fertilizer recommendation on finger millet (*Eleusine coracana* L) yield, nutrient requirement and economics. *Int. J.Farm Sci.,*2017; **7**:102-107.

Jackson ML.*Soil Chemical Analysis*, Prentice Hall of India, Pvt. Ltd., New Delhi, 1973: p 498.

Kanwar JS.Soil testing service in India retrospect and prospect. *Proceedings of international symposium. on soil fertility evaluation*, held at New Dehli, on February, 1971, **91**, 1103 - 1133.

Piper CS.*Soil and Plant Analysis*. Hands Publishers, Bombay., 1966; 137- 153.

Prabhakar K. Munirathnam P. Balaji NS. Venkataramanamma K. Raghavendra T. Pulli Bai P. and Gopal Reddy B.Soil test based nutrient management for rabi sunflower (*Helianthus annuus* L.). *The J. Res. ANGRAU* 2017; **45**: 16-21.

Ray PK. Jana AK. Maitra DN. Saha MN. Chaudhury J. Saha S and Saha AR. Fertilizer prescriptions on soil test basis for jute, rice and wheat in *Typic ustochrept.J. Indian Society of SoilSci.*2000; **48:**79-84.

Santhi R. Natesan R. and Selvakumari G. Soil test based fertilizer recommendation under IPNS for aggregatum onion in *Inceptisols* of Tamil Nadu. *Agropedology,*2002; **12**: 141-147.

Sinchana S. and Subbarayappa CT. Soil and foliar application of zinc for different approaches of nutrients on soil properties, nutrient uptake, growth and yield of maize (*Zea mays* L.). *Mysore J. Agric. Sci.,*2021; **55**(3): 266.

Wani SP, Pathak P, Jangawad LS, Eswaran H, Singh P. Improved management of vertisols in the semiaridtropics for increased productivity and soil carbonsequestration. Soil Use Manag. 2003;19(3):217-222.