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Development of fertilizer prescription targeted yield-equation for carrot crop based on soil test values

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ABSTRACT

A field experiment was conducted on red soils (*Kandic paleustalfs*) of Zonal Agricultural Research Station, GKVK, Bangalore during *kharif* 2008-09 to develop a targeted yield equation for carrot crop. After developing three levels of fertility gradient with respect to available NPK in soil, the main experiment was conducted by taking carrot as a test crop. Initial soil data, carrot root yield and NPK uptake by carrot crop were used for obtaining four important basic parameters, viz., nutrients required to produce a quintal of carrot roots (NR%), contribution of nutrients from fertilizers (CF%), contribution of nutrients from soil (CS%) and contribution of nutrients from organic matter (%C-OM). These parameters were used for developing fertilizer-adjustment targeted yield equation. Comparison of the present soil testing laboratory method with Soil Test Crop Response approach of fertilizer recommendation clearly indicated superiority of STCR targeted yield approach for efficient and economic use of fertilizers to attain the required yield target.

Key words: Carrot, red soils, basic parameters, targeted yield equation

INTRODUCTION

Efficient use of plant nutrients through chemical fertilizers and organic manures is a good means for increasing agriculture productivity and profitability. Cost of fertilizers has gone up and, hence, their optional use in required quantity mainly depends on resources available to farmers. Imbalanced use of chemical fertilizers results in lower nutrient use efficiency and restricts utilization of the genetic potential of a crop to its maximum. The most comprehensive approach of fertilizer application by incorporating soil test values, nutrient requirement of the crop, contribution of nutrients from soil manures fertilizers and fixing yield-targets is possible only through Soil Test Crop Response (STCR) approach. Therefore, this study was undertaken to develop targeted yield equations for carrot crop in red soils of Gandhi Krishi Vignyan Kendra (GKVK), Bangalore.

MATERIAL AND METHODS

A field experiment was conducted on carrot crop during *kharif* 2008-09 under red soils (*Kandic paleustalfs*) of Zonal Agricultural Research Station (ZARS), GKVK, Bangalore to develop targeted yield equations following the procedure of Ramamoorthy *et al* (1967). Three strips of fertility gradients, viz., low, medium and high (with respect to available nitrogen, phosphorus and potassium) were developed taking fodder maize as the exhaustive crop. Thereafter the main experiment was conducted by dividing each strip into three blocks of FYM taking seven different NPK combinations + 1 Absolute Control. So thus, a total of 21 treatments of NPK combinations and 3 Controls were imposed in each strip. Similarly, the same NPK treatment groups in each FYM block were randomized in the other two gradient strips to a total of 72 treatments. The following NPK and FYM levels in different combinations were tested in this experiment.

Nutrient levels tested

FYM (tha^{-1})	N	P_2O_5	K_20
		kgha^{-1}	
0	**0**	**0**	**0**
25	**50**	**32**	**25**
30	**75**	**64**	**50**
-	**100**	**96**	**75**

Before applying FYM and NPK, soil samples (0-20 cm deep) from all the 72 plots were collected and analyzed for available nitrogen, by the alkaline permanganate method (Subbaiah and Asija, 1956); for available phosphorus, by Bray's method and for available potassium, by the ammonium acetate method (Hanway and Heidal, 1952) as described by Jackson (1973). After imposing all the treatments, carrot crop was sown at 22.5cm x 10cm spacing and recommended package of practices were followed.

Carrot root and leaf yield were recorded separately, and samples were taken for estimation of NPK uptake by the crop (which was computed using plant analysis as well as yield data). Initial soil data, yield and uptake were used for obtaining NR (Nutrient Required to produce a quintal of carrot roots), %CS (Contribution of nutrients from Soil), %CF (Contribution of nutrients from Fertilizers) and C–OM (Contribution of nutrients from Organic Matter), as illustrated below (Ramamoorthy *et al*, 1967)

$$\text{NR (kg q}^{-1}) = \frac{\text{Nutrient uptake (NPK) (kgha}^{-1}\text{) by grain + straw}}{\text{Grain yield or any economic produce (q ha}^{-1})}$$

$$\%\text{CS} = \frac{\text{Nutrient uptake (kgha}^{-1}\text{) by grain + straw in Control plot}}{\text{Soil test values (Av. NPK) in Control plot (kgha}^{-1})} \text{ X 100}$$

$$\%\text{CF} = \frac{\left\{\begin{array}{c}\text{Nutrient uptake by}\\ \text{grain + straw in}\\ \text{treated plot}\end{array}\right\} - \left\{\begin{array}{c}\text{Soil test values}\\ \text{in treated plot}\end{array}\right\} \text{ X } \left\{\begin{array}{c}\text{\%Contribution}\\ \text{(NPK) from soil}\end{array}\right\}}{\text{Nutrient dose applied in treated plot (kg ha}^{-1})} \text{ X 10}$$

$$\%\text{C-OM} = \frac{\left\{\begin{array}{c}\text{[Nutrient uptake by}\\ \text{grain + straw in}\\ \text{OM plot]}\end{array}\right\} - \left\{\begin{array}{c}\text{[Soil test values}\\ \text{in OM plot]}\end{array} \text{ X } \begin{array}{c}\text{[Mean \% Contribution}\\ \text{(NPK) from soil]}\end{array}\right\}}{\text{Amount of nutrients (NPK) added through OM}}$$

These basic parameters were transformed into simple, workable fertilizer adjustment equations for calculating any yield target based on soil test values following the procedure of Ramamoorthy *et al* (1967).

RESULTS AND DISCUSSION

Highest carrot root yield of 132.47q ha^{-1} was recorded in the high-fertility strip (L_3), where 2-2-2 levels of NPK were applied along with 25t ha^{-1} FYM (F_2). In the low-fertility strip (L_1) higher root yield of 118.53q ha^{-1} was obtained in 3-1-1 levels of NPK without FYM (F_1), whereas, in the medium-fertility strip (L_2), higher yield of carrot root (115.58 q ha^{-1}) was noticed in 3-2-3 levels of NPK along with 30t ha^{-1} of FYM (F_3).

In Control plots, the highest root yield of 93.51q ha^{-1} was recorded in the high-fertility strip (L_3) in which 25t ha^{-1} FYM (F_2) had been applied; whereas, the lowest yield of 51.08q ha^{-1} was obtained in low-fertility strip (L_1) where no FYM (F_1) had been applied (Table 2).

The basic data, when computed, clearly indicated that nutrients required to produce a quintal of carrot root are: 0.76 kg nitrogen, 0.42 kg phosphorus and 0.78 kg potassium (Table 1).

Nutrient-contribution from fertilizer was maximum (72.37% N, 84.24% P_2O_5 and 90.24% K_2O) for attaining maximum yield of carrot, whereas, contribution from soil was slightly lower (28.55% N, 36.56% P_2O_5 and 59.29% K_2O). Contribution from organic matter was very low (0.16% N, 0.12% P_2O_5 and 0.46% K_2O). These findings are in close conformity with those reported by Velayutham (1979) and Santhi *et al* (1999). By using these basic parameters, targeted yield equation for carrot crop was developed with respect to fertilizer nitrogen, phosphorus and potassium requirement (kg ha^{-1}). The equations are as follows:

$$\text{F.N.}^{*} = 1.04\ \text{T}^{**} - 0.39\ \text{STV}^{***}\text{-N} - 0.23\ \text{OM}$$

$$\text{F.P}_2\text{O}_5 = 0.49\ \text{T} - 0.43\ \text{STV-P}_2\text{O}_5 - 0.14\ \text{OM}$$

$$\text{F.K}_2\text{O} = 0.87\ \text{T} - 0.66\ \text{STV-K}_2\text{O} - 0.51\ \text{OM}$$

* F.N. = Fertilizer Nitrogen (kg ha^{-1}); F.P_2O_5 = Fertilizer Phosphorus (kg ha^{-1});

F.K_2O = Fertilizer Potassium (kg ha^{-1})

** T = Yield target (t ha^{-1})

*** STV = Soil test values (kg ha^{-1})

Using these equations, a farmer-friendly ready-reckoner was developed (following the procedure of Ramamoorthy *et al*, 1967), which clearly indicates the quantity of fertilizer nitrogen, phosphorus and potassium needed to be applied to get a fixed yield-target based on soil test values.

Table 1. Basic data on nutrient requirement of carrot crop and contribution of nutrients from different sources

	N	P_2O_5	K_2O
NR (kgq^{-1})	0.76	0.42	0.78
CS (%)	28.55	36.56	59.29
CF (%)	72.37	84.24	90.24
C-OM (%)	0.16	0.12	0.46

Table 2 indicates the amount of fertilizer nitrogen, phosphorus and potassium required, along with 10t ha^{-1} FYM or without FYM for a fixed yield target of 20t ha^{-1}, based on soil test values. If this yield target is modified, the amount of fertilizer nutrient required will change. Similarly, if the soil test values change, the amount of NPK required to attain a fixed-target will also get modified.

If the soil test value with respect to available nitrogen is 290kg ha^{-1}, the amount of fertilizer nitrogen required to obtain carrot root yield of 20tha^{-1} is 72kg ha^{-1} with 10t ha^{-1} RYM (Table 2). However, for the same soil-test values and the same yield target, 94.7kg ha^{-1} of fertilizer nitrogen is required when no FYM is applied. Similarly, if the available phosphorus content of soil is 23kg P_2O_5ha^{-1}, the amount of phosphatic fertilizer required for the same yield-target (20t ha^{-1}) is 74.5kg P_2O_5ha^{-1} and 88.9kg P_2O_5ha^{-1} with and without FYM application, respectively. If the soil test value for potassium is 160kg ha^{-1}, the amount of fertilizer potassium required for a target yield of 20t ha^{-1} without FYM is 69.0kg ha^{-1}, whereas, with FYM just 18.3kg of fertilizer potassium is required.

Fertilizer use following these equations is more economical and environment friendly. For example, to obtain yield target of 20t ha^{-1} carrot roots, fertilizer nitrogen required is only 75.0kg ha^{-1} even if the soil test value ranges from 260kg N ha^{-1} to 580kg N ha^{-1}, as per soil testing laboratory (STL) recommendation (Table 3); whereas, in STCR approach, fertilizer N required for the same yield-target (20t ha^{-1}) at lower soil nitrogen level (260kg N ha $^{-1}$) is 106.5kg fertilizer nitrogen. At higher soil test value of 480kg soil nitrogen, just 19.7kg of fertilizer nitrogen is needed to achieve the same yield target.

Similarly, for soil test values of 23.0kg P_2O_5ha^{-1} to 52.0kg P_2O_5ha^{-1}, amount of fertilizer phosphorus recommended as per STL is 63.0kg ha^{-1};. But, in the STCR approach, 88.9kg of fertilizer phosphorus is recommended (Table 3) when soil test value is 23.0kg P_2O_5ha^{-1}; whereas, at 52.0kg ha $^{-1}$ of available phosphorus, 76.3kg of fertilizer phosphorus is required to get a yield target of 20t ha^{-1} carrot roots. Similarly, 50.0kg ha^{-1} potassium fertilizer is required to produce 20t ha^{-1} of carrot root, when the soil test values ranges from 125kg K_2O ha^{-1} to 300kg K_2O ha^{-1}, as per STL recommendations. However, if one follows the STCR approach of fertilizer application, 92.0kg ha^{-1} of potassic fertilizer needs to be added when the soil test value is 125kg K_2O ha^{-1}. But, when the soil test value is 300kg K_2O ha^{-1}, no potassium fertilizer is needed to achieve the yield target of 20t ha^{-1}.

Table 2. STCR fertilizer prescription ready-reckoner for carrot root yield target of 20t ha^{-1}*

STV $KMnO_4$ - N	Only inorganics F. N Req.	FYM (10t ha^{-1}) F. N Req.	STV Bray's P_2O_5	Only Inorganics F. P_2O_5 Req.	FYM (10t ha^{-1}) F. P_2O_5 Req.	STV K_2O	Only inorganics F. K_2O Req.	FYM (10t ha^{-1}) F. K_2O Req.
(kg ha^{-1})								
250	110.4	87.7	15.0	92.4	78.0	110	101.8	51.2
260	106.5	83.8	17.0	91.5	77.1	120	95.2	44.6
280	98.6	75.9	19.0	90.6	76.2	125	92.0	41.3
290	94.7	72.0	21.0	89.8	75.3	130	88.7	38.0
300	90.7	68.0	23.0	88.9	74.5	140	82.1	31.5
320	82.8	60.1	25.0	88.0	73.6	150	75.5	24.9
340	74.9	52.2	30.0	85.8	71.4	160	69.0	18.3
400	51.3	28.6	32.0	85.0	70.6	170	62.4	11.7
440	35.5	12.8	35.0	83.7	69.3	180	55.8	5.2
480	19.7	0.0	38.0	82.4	68.0	200	42.7	0.0
520	3.9	0.0	41.0	81.1	66.7	220	29.5	0.0
560	0.0	0.0	44.0	79.8	65.4	240	16.4	0.0
600	0.0	0.0	46.0	78.9	64.5	260	3.3	0.0
			47.0	78.5	64.1	280	0.0	0.0
			50.0	77.2	62.8	300	0.0	0.0
			52.0	76.3	61.9	320	0.0	0.0
			54.0	75.4	61.0	340	0.0	0.0
			58.0	73.7	59.3	440	0.0	0.0
			62.0	72.0	57.5			

*****To increase or decrease yield target by one q ha^{-1},variations to be made in fertilizer recommendations are as follows:
N = $\pm$ 1.05kg P_2O_5 = $\pm$ 0.49kg K_2O = $\pm$ 0.87kg

Table 3. STCR fertilizer prescription ready-reckoner along with STL method of fertilizer application for carrot root yield target of 20tha^{-1}

STV $KMnO_4$	STCR F. N Req.	STL F. N Req.	STV Bray's P_2O_5	STCR F. P_2O_5 Req.	STL F. P_2O_5 Req.	STV K_2O	STCR F. K_2O Req.	STL F. K_2O Req.
250	110.4	90.0	15.0	92.3	73.0	110	101.8	65.0
260	106.5	90.0	17.0	91.5	73.0	120	95.2	65.0
280	98.6	90.0	19.0	90.6	73.0	125	92.0	50.0
290	94.7	75.0	21.0	89.7	73.0	130	88.7	50.0
300	90.7	75.0	23.0	88.9	63.0	140	82.1	50.0
320	82.8	75.0	25.0	88.0	63.0	150	75.5	50.0
340	74.9	75.0	30.0	85.8	63.0	160	69.0	50.0
400	51.3	75.0	32.0	85.0	63.0	170	62.4	50.0
440	35.5	75.0	35.0	83.7	63.0	180	55.8	50.0
480	19.7	75.0	38.0	82.4	63.0	200	42.7	50.0
520	3.9	75.0	41.0	81.1	63.0	220	29.5	50.0
560	0.0	75.0	44.0	79.8	63.0	240	16.4	50.0
600	0.0	60.0	46.0	78.9	63.0	260	3.3	50.0
			47.0	78.5	63.0	280	0.0	50.0
			50.0	77.2	63.0	300	0.0	50.0
			52.0	76.3	63.0	320	0.0	35.0
			54.0	75.4	53.0	340	0.0	35.0
			58.0	73.7	53.0	440	0.0	35.0
			62.0	71.9	53.0			

In comparison to the current soil testing laboratory (STL) recommendations followed in Karnataka, the STCR approach of fertilizer application is superior for efficient use of costly fertilizer nutrients in a balanced way without accruing any wastage, thereby helping sustaining the soil productivity for longer period.

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