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Soil test based fertilizer prescriptions under integrated plant nutrient management system for carrot in an Inceptisol

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ABSTRACT

A field experiment was conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi in an Inceptisol during *rabi* 2020-21 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 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). It was found that 0.65, 0.11 and 0.83 kg of N, P_2O_5 and K_2O, respectively were required for producing one quintal carrot yield. The per cent contribution of nutrients from soil, fertilizer and FYM were 45.33, 65.91 and 67.26 for N; 58.45, 67.86 and 108.12 for P_2O_5 and 5.54, 3.35 and 10.53 for K_2O, respectively. The ready reckoner for fertilizer doses with NPK alone and integrated use of NPK and FYM was also made using developed basic parameters for varying soil test values and desired yield targets of carrot yield.

Key words: Carrot, alluvial soils, basic parameters, targeted yield equation and STCR

INTRODUCTION

Carrot (*Daucus carota* L.) belongs to the *Umbelliferae* family. It is native of area extending from Europe and southwestern Asia. India has 12th rank in the world in respect of area and production of carrot. 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 optimal use is required. The quantity of fertilizers 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 alluvial soils (Inceptisol) at different soil fertility levels to ensure maximum fertilizer use efficiency.

MATERIAL AND METHODS

A field experiment was conducted on carrot crop during *rabi* 2020-21on alluvial soil (Inceptisol) of Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 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 sorghum as the exhaustive crop. Thereafter the main experiment by carrot (Variety- CH-1) was grown as test crop during *rabi* 2020-21 in the same field in which the fertility gradient stabilizing experiment was conducted. Each strip (made in the fertility gradient stabilizing experiment in the previous season) was divided into 24 plots (21 treated and 3 control plots) equal sized (5 m x 4 m) plots having total of 72 (24 x 3) plots. Three blocks (A, B, C) comprising of 8 treatments were made within each strip randomized with farm yard manure levels. Treatments of N, P_2O_5, K_2O and FYM (0.7, 0.4 and 0.6 per cent of N, P and K, respectively were used as shown in Table 1. The urea, single super phosphate and muriate of potash fertilizers were used for supplying N,

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P_2O_5 and K_2O, respectively. The NPK and FYM levels in different combinations were tested in this experiment. Before applying FYM and NPK, soil samples (0-15cm deep) from all the 72 plots were collected and analyzed for available nitrogen, by the alkaline permanganate method (Subbaiah and Asija, 1956); available P by Olsen *et al.* (1954) and available K by ammonium acetate method (Hanway and Heidal, 1952). After imposing all the treatments, carrot crop was sown at 25 cm x 12cm spacing and recommended package of practices were followed. Carrot and straw 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 Org. Matter), as illustrated below (Ramamoorthy *et al.* 1967).

Table 1: Levels of nitrogen, phosphorus, potassium and FYM used in experiment

N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	FYM (t ha^{-1})
0	0	0	0
40	25	30	5
80	50	60	10
120	75	90	-

RESULTS AND DISCUSSION

The range and mean values of available nutrients in soil and yield of carrot in treated and control plots are presented in Table 2. In the NPK treated plots (plots that received NPK alone or NPK + FYM), $KMnO_4$-N increased from 213.3 kg ha^{-1} in strip I to 307.3 kg ha^{-1} in strip III with a mean value of 260.3 kg ha^{-1}. The Olsen-P ranged from 17.2 kg ha^{-1} in strip I to 34.5 kg ha^{-1} in strip III with a mean value of 28.8 kg ha^{-1}, while the NH_4OAc -K status varied from 205.1 kg ha^{-1} in strip I to 281.8 kg ha^{-1} in strip III with a mean value of 243.5 kg ha^{-1}.

Table 2: Available nutrients in pre-sowing surface soil and yield of carrot

Parameters	NPK treated plots		Control plots	
	Range	Mean SEm±	Range	Mean SEm±
$KMnO_4$-N (kg ha^{-1})	213.3 –307.3	260.3 ± 3.23	212.1 – 247.6	229.9 ± 0.95
Olsen-P_2O_5 (kg ha^{-1})	17.2 – 34.5	28.8 ± 0.61	16.5 – 28.8	22.7 ± 1.05
NH_4OAc-K_2O (kg ha^{-1})	205.1 – 281.8	243.5 ± 2.60	204.0 – 237.0	220.5 ± 0.64
Carrot yield (q ha^{-1})	208.0 – 270.0	239.0 ± 1.97	205.0 – 255.0	230.0 ± 1.46

In the NPK treated plots (that received NPK alone or NPK +FYM), the yield of carrot ranged from 208 to 270 q ha^{-1} with a mean value 239 q ha^{-1}. In the overall control plots, the carrot yield ranged from 205 to 255 q ha^{-1} with a mean value of 230 q ha^{-1}. In the overall control plot of three fertility gradients (Table 2), the $KMnO_4$ -N in soil ranged from 212.1 to 247.6 kg ha^{-1} with a mean of 229.9 kg ha^{-1}, Olsen-P_2O_5 ranged from 16.5 to 28.8 kg ha^{-1} with a mean value of 22.7 kg ha^{-1}, and the NH_4OAc -K_2O varied from 204 to 237 kg ha^{-1} with a mean value of 220.5 kg ha^{-1}. Soils are low in nitrogen and medium in phosphorus and potassium. Almost similar results were found by Basavaraja *et al.* (2011) for on-farm evaluation of soil test based site specific nutrient management in carrot on red soils.

The above data clearly indicate the existence of operational range of soil test values for available N, P and K and yield of treated and control plots, which is a prerequisite for calculating the basic parameters and fertilizer prescription equations for calibrating the fertilizer doses for specific yield targets. The equations are:

NPK Alone

FN = 1.11* T – 0.78* SN

FP_2O_5 = 0.16* T – 0.97* S P_2O_5

FK_2O =0.77* T – 0.62* SK_2O

NPK + FYM

FN = 1.11* T – 0.78* SN – 0.09* SN

FP_2O_5 = 0.16* T – 0.97* S P_2O_5 - 0.05* S P_2O_5

FK_2O =0.77* T – 0.62* SK_2O – 0.10*O K_2O

FN = Fertilizer N (kg ha^{-1}),

FP_2O_5 = Fertilizer P_2O_5 (kg ha^{-1})

FK_2O = Fertilizer K_2O (kg ha^{-1}),

T = Carrot yield target (q ha^{-1})

Where: SN, SP_2O_5 and SK_2O, respectively are alkaline $KMnO_4$ -N, Olsen-P_2O_5

and NH_4OAc -K_2O in kg ha^{-1} and ON, OP_2O_5 and OK_2O are the quantities of N, P_2O_5 and K_2O in kg ha^{-1} supplied through FYM, respectively.

Basic parameters

The basic data viz., nutrient requirement for producing one quintal of carrot, per cent contribution of nutrients from soil (%CS), fertilizer (%CF) and FYM (%CFYM) have been calculated (Table 3). These basic parameters were used for developing the fertilizer prescription equations under NPK alone and NPK plus FYM. The nutrient requirement of N, P_2O_5 and K_2O were 0.65, 0.11 and 0.83 kg q^{-1} of carrot, respectively. The % CS and % CF were found to be 45.33 and 65.91 for N, 67.26 and 58.45 for P_2O_5 and 67.86 and 108.12 for K_2O. Similarly, the per cent contribution of N, P_2O_5 and K_2O from FYM was 5.54, 3.35 and 10.53, respectively.

Table 3: Basic data and fertilizer adjustment equations of carrot (*var.CH-1*) in Inceptisol

Basic Data	N	P_2O_5	K_2O
Nutrient requirement (kg q^{-1})	0.65	0.11	0.83
Soil efficiency (%) or (%CS)	45.33	65.91	67.26
Fertilizer efficiency (%) or (%CF)	58.45	67.86	108.12
Organic efficiency (%) or (%CFYM)	5.54	3.35	10.53

It calculated (Table 3). These basic parameters were used for developing the fertilizer prescription equations under NPK alone and NPK plus FYM. The nutrient requirement of N, P2O5 and K2O were 0.65, 0.11 and 0.83 kg q^{-1} of carrot, respectively. The % CS and % CF were found to be 45.33 and 65.91 for N, 67.26 and 58.45 for P_2O_5 and 67.86 and 108.12 for K_2O. Similarly, the per cent contribution of N, P_2O_5 and K_2O from FYM was 5.54, 3.35 and 10.53, respectively. It was noted that contribution of potassium from fertilizer for carrot was higher as compared to soil. This high value of potassium could be due to the interaction effect of higher doses of N, P coupled with priming effect of starter K doses in the treated plots, which might have caused the release of soil potassium, resulting in the higher uptake from the native soil sources by the crop (Chatterjee *et al.* 2000). Contribution of nutrients from FYM is low which might be due to lower mineralization rate of FYM (Singh *et al.* 2015). However, in the case of P_2O_5, the contribution was more from soil than from fertilizer.

Table 4: Estimation of soil test based fertilizer recommendation for 240 q ha^{-1} yield target of carrot

Soil test values (kg ha^{-1})			Fertilizer doses (kg ha^{-1}) under NPK alone			Fertilizer dose (kg ha^{-1}) under NPK+ FYM @ 10 t ha^{-1}		
SN	SP_2O_5	SK_2O	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O
200	10.0	160	110.4	28.7	85.6	105.9	27.2	81.6
220	15.0	180	94.8	23.9	73.2	90.3	22.4	69.2
240	20.0	200	79.2	19.00	60.8	74.7	17.5	56.8
260	25.0	220	63.6	14.2	48.4	59.1	12.7	44.4
280	30.0	240	48.0	9.3	36.0	43.5	7.8	32.0

An assessment of fertilizer doses were prepared based on these equations for a range of soil test values and for carrot yield target of 240 q ha^{-1} of carrot (Table 4). For achieving this target (240 q ha^{-1}) with soil test values of 200:10:160 kg ha^{-1} of $KMnO_4$-N, Olsen-P and NH_4OAc -K, the required fertilizer doses of N, P_2O_5 and K_2O were110.4, 28.7 and 85.6 kg ha^{-1}, respectively. When FYM was applied @10 t ha^{-1} along with NPK, the required fertilizer doses of, N, P_2O_5 and K_2O were 105.90, 27.20 and 81.60 kg ha^{-1}, respectively. Under IPNMS, the required dose of fertilizer is low due to nutrient availability increased by addition of FYM through mineralization. It has also been reported (Singh *et al.* 2018) that fertilizer doses are reduced to achieve the desired target yield under integrated nutrient management system.

Fertilizer prescription equations were transformed into ready reckoner for obtaining requirements of fertilizer, say for yield target of 240 q ha^{-1} of carrot on soils with varying soil test value for both NPK applied with and without FYM. The finding revealed that with the variation in soil test values, the rate of fertilizer recommendations varied for the same level of crop production. Hence, balanced fertilization through soil testing becomes essential for increasing crop production. Similar results were also recorded by various workers in different crops like cauliflower and carrot (Thilagam *et al.*, 2009 and Basavaraja *et al.,* 2011). It was obvious from these findings that there was net saving of fertilizers in each target and ultimately the reduction in cost of cultivation of crops.

Prediction of post-harvest soil available nutrients (N, P and K)

A post-harvest prediction equation of soil test value can be used to make a fertilizer recommendation for entire cropping scheme. This is very useful because the soil of farmers' field under intensive farming cannot be tested for each crop for practical reasons. The interactions among the post-harvest soil test values, fertilizer applied doses, initial soil test values and carrot yield from the treated plots for carrot crop are obtained through multiple regression analysis (Table 5).

Table 5: Prediction equations for post-harvest soil test value for carrot

Nutrient	R^2	Multiple regression equation
N	0.95**	54.40682-0.47256 RY**+1.284646SN**+0.058177 FN*
P	0.87**	-0.54608+0.065642RY*+0.540745SP**0.012392 FP**
K	0.99**	5.493011-0.008781RY**+1.004908SK**-0.002 FK

Significant at 1 % level: Here PHN, PHP and PHK stand for the post-harvest soil test values of N, P and K (kg ha^{-1}); RY is the carrot yield of crop (q ha^{-1}), SN, SP and SK represent the initial soil test values of N, P and K (kg ha^{-1}) and FN, FP and FK represent the fertilizer doses of N, P_2O_5 and K_2O kg ha^{-1} applied, respectively

It is evident that higher R^2 values (significant at 1%) were obtained for these equations (Table 5). This suggests that such regression equations can be applied with confidence for the prediction of available N, P, and K after carrot for making soil test based fertilizer recommendation for succeeding crops. Similar significances for N, P and K with respect to post harvest soil values were also reported by Singh *et al.* (2018).

Fertilizer adjustment equations for obtaining economic yield have specific advantage because the fertilizer recommendations in this approach take into account the soil test values, response to applied nutrients as well as relative prices of fertilizer nutrients and carrot. This provides liberty to the farmers to choose yield target according to their resources and management conditions.

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