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Original Research Article

Prediction of Post-Harvest Soil Test Values and Apparent Nutrient Balance for Turmeric (*Curcuma longa* L.) in Mollisol of Uttarakhand

Sarvesh Kumar*, Sobaran Singh, Poonam Gautam, Poonam Gangola and Vineet Kumar

Department of Soil Science, G.B.P.U.A. & T., Pantnagar 263 145, India
**Corresponding author*

Keywords

Turmeric, Mollisol, Prediction equation, Post-harvest soil test values

A B S T R A C T

A field experiment was conducted during the year 2013-14 and 2014-15 in a Aquic Hapludoll at D_7 block of Norman E. Borlogue Crop Research Centre of The G.B. Pant University of Agriculture and Technology, Pantnagar (29^0 N latitude and $79^029'$ E longitude), as per the technical programme of All India Coordinated Research Project on Soil Test Crop Response Correlation to develop PHSTVs prediction equations adopting Inductive cum Targeted yield model (Ramamoorthy *et al.*, 1967), with Turmeric (*Curcuma longa* L.). The experiment was laid out in a fractional factorial design comprising twenty four treatments (21 fertilizer treatments + three controls). Using pre-sowing soil test values, fertilizer doses and rhizome yield and/or NPK uptake by the crop as independent variables and post-harvest soil test values as dependent variable, PHSTVs prediction equations were developed. Significant R^2 values (>0.67) were recorded for prediction equations which showed that these equations could be used for the prediction of post-harvest $KMnO_4$-N, Olsen-P and NH_4OAc-K. Apparent N, P and K balances were found 7.22%, -6.92 and -8.25%, respectively noticed in turmeric. Using the predicted post-harvest soil test values of turmeric, soil test based fertilizer recommendation for desired yield targets of any succeeding crop could be prescribed.

Introduction

Soil test crop response (STCR) studies help to generate fertilizer adjustment equations and calibration charts for recommending fertilizers on the basis of soil tests and achieving targeted yield of crops (Singh and Biswas, 2000). Soil testing has to be rechristened as soil quality assessment and it has to assume a holistic role not limited to guide fertilizer recommendation for a crop based on soil test. The 'Soil testing for fertilizer recommendation' needs to be changed to 'Soil test for soil quality assessment and resource management options for production systems and variable soil uses'. Hence, the prediction of post-harvest soil fertility status using the pre-sowing soil test values, fertilizer doses and yield or uptake by the crop has much of practical significance. To apply soil test based fertilizer recommendations, the soils are to be tested after each crop. Which is not practicable, therefore it has become necessary to predict the soil test values after the harvest of the crop. It can be done by the development of prediction equations (Ramamoorthy *et al.*, 1971). Predicted soil test values can be utilized for recommending the fertilizer doses for the next crop.

The crop nutrient balance—the comparison of nutrients applied to cropland in relation to those removed by crops—is an important indicator of the sustainability performance of crop production. Deficits in the nutrient balance can limit crop yields and deplete soil fertility, and surpluses can cause economic waste and increase the risk of harm to water and air. In present study, a strong research support in term of calibration on soil test crop response was made to predict the post-harvest soil test values for turmeric and analysed apparent nutrient balance for next crop.

Materials and Methods

A field experiment was conducted as per the technical programme of AICRP on Soil Test Crop Response Correlation (STCR) at Norman E. Borlaug Crop Research Centre (CRC), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. The Soil of the experimental field is moderately well to well drained and sandy loam in texture. The initial soil pH, electrical conductivity, organic carbon, available alkaline potassium permanganate ($KMnO_4$) nitrogen (N), Olsen phosphorus (P) and ammonium acetate (NH_4OAc) potassium (K) were 6.75, 0.21 dSm^{-1}, 0.76 %, 150.44 kg ha^{-1}, 16.34 kg ha^{-1}, and 135.48 kg ha^{-1}, respectively. The P and K fixation capacity also analysed and found 81.26 % and 54.07 %, respectively. Field experiment was carried out in two phases *viz*., fertility gradient and test crop experiment as per the technical programme of STCR in fractional factorial design comprising twenty four treatments and the test crop experiment with turmeric was conducted with four levels of N (0, 50, 100 and 150 kg ha^{-1}), P_2O_5 (0, 50, 100 and 150 kg ha^{-1}) and K_2O (0, 50, 100 and 150 kg ha^{-1}) and three levels of Farm Yard Manure (FYM) (0, 10 and 20 t ha^{-1}) in turmeric. The pre-sowing and post-harvest soil samples were collected from each fertility strip after turmeric and analyzed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Olsen-P (Olsen *et al.*, 1954) and NH_4OAc-K (Hanway and Heidel, 1952). At digging of rhizome samples were collected, processed and analyzed for N, P and K contents and NPK uptake was computed. Crop was grown to maturity, harvested and plot wise rhizome and haulm yields were recorded.

Development of prediction equations for post-harvest soil test values

The post-harvest soil test values were taken as dependent variable and a function of the pre sowing soil test values and the related parameters like yield/uptake and fertilizer nutrient doses as independent variables. The functional relationship is given below:

PHS = f (F, ISTV, yield / nutrient uptake)

Where,

PHS = Post-harvest soil test value;

F = Applied fertilizer nutrient

ISTV =Initial soil test value of available N, P and K.

Mathematical form of equation is,

YPHS = a + b1F + b2ISTV + b3yield/uptake

Where,

a = Absolute constant and

b1, b2 and b3 = Respective regression co-efficient.

Using these regression equations, the post-harvest soil test values of nitrogen, phosphorus and potassium were predicted after turmeric.

An apparent nutrient balance sheet at the end of the experiment were calculated by subtracting the nutrient removed in the crops from those added in the fertilizer, crop residue, irrigation water and rainfall.

Results and Discussion

Following the methodology outlined by Ramamoorthy *et al.,* (1971), PHSTVs prediction equations were developed for the prediction of post-harvest soil test values after the digging of turmeric (Table 1). The results showed that when turmeric rhizome yield was used for predicting the extent of predictability for available nitrogen, phosphorus and potassium R^2 values were 82.50, 83.90 and 98.70 per cent, respectively, while, when uptake by haulm was considered the values were 81.70, 84.30 and 97.90 per cent.

Based on above prediction equations strip wise observed and predicted post-harvest soil test value ($KMnO_4$-N, Olsen-P and NH_4OAc-K kg ha^{-1}) can be calculated. The percentage deviation of the calculated post-harvest soil test values from the actual soil test values is given in Table 2. The observed and predicted post-harvest soil test values were compared by Paired t- Test. The results clearly show that the deviations were quite small/very negligible and both actual and predicted soil test values of available nitrogen, phosphorus and potassium were in good agreement with each other. This test shows that that predicted and observed value were non-significant. This clearly shows the validity of the postharvest soil test values. The soil test values generated through this predicting equation may be utilized for soil test based fertilizer recommendation for the next crop in the crop rotation. Similar result also found by Bera *et al.,* (2006). Prediction equations were also developed by Mishra *et al.,* (2015) for chickpea and Coumaravel *et al.,* (2016) for maize and Gangola *et al.,* (2017) for maize-chickpea sequence.

Apparent nutrient balance

An apparent nutrient balance was estimated by considering the amount of added nutrient through fertilizer and FYM, the amount of nutrient removed by crops. Calculate initial soil test value and post-harvest soil test value after digging of turmeric shown in Table 3.

Nitrogen of experimental field changed from 144.95 to 155.41 kg N ha^{-1} initial to post soil test value. Average Nitrogen in strip I changed from 140.60 to 147.91 kg N ha^{-1}. While in strip II the Nitrogen changed from 144.26 to 155.75 and average Nitrogen in strip III changed from 150.01 to 162.55 kg N ha^{-1}. Over all, Nitrogen increase from initial to post soil test value. Increase in available nitrogen with 100% NPK and FYM may be due to the direct addition of nitrogen through inorganic sources and FYM to the available pool of the soil. The decomposition of organic matter is accompanied by the release of appreciable quantities of carbon dioxide which, when dissolved in water, forms carbonic acid which is capable of weathering certain primary minerals. The increase in available N due to organic materials application might be also attributed to the greater multiplication of microbes caused by the addition of organic materials for the conversion of organically bound N to inorganic form. The favourable soil conditions under FYM addition might have helped in the mineralization of soil N leading to build up of higher available N. Similar result also found by Yanthan *et al.,* (2010).

Table.1 Prediction equation of postharvest soil nutrient based on yield and uptake of turmeric

S. No.	Prediction equation	R^2 Value
1.	Based on yield	
	PHN = 67.3461* + 0.6744 SN* + 0.0626 FN* - 0.0562 Y*	0.825**
	PHP = - 0.5282 + 0.8379 SP* - 0.0036 FP + 0.0127 Y*	0.839**
	PHK = 53.1182* + 0.4492 SK* + 0.1399 FK* - 0.0487 Y*	0.987**
2.	Based on uptake	
	PHN = 61.8054* + 0.6752 SN* + 0.0464 FN - 0.0294 UN	0.817**
	PHP = - 0.6286 + 0.8393 SP* - 0.0030 FP + 0.0893 UP*	0.843**
	PHK = 47.5535* + 0.4496 SK* + 0.1223 FK* - 0.0199 UK*	0.979**

**Significant at P = 0.05, ** Significant at P = 0.01*
FN, FP and FK = Fertilizer doses of N, P and K (kg ha^{-1}), respectively.
SN, SP and SK = Soil test values of N, P and K (kg ha^{-1}), respectively.
PHN, PHP and PHK = Post harvest soil test values of N, P and K (kg ha^{-1}), respectively;
Y= Yield (q ha^{-1});
UN, UP and UK = Total uptake of N, P and K (kg ha^{-1}), respectively.

Table.2 Predicted and observed value of post-harvest soil test value

Particulars	Strip I		% Deviation	Strip II		% Deviation	Strip III		% Deviation
	Observed	Predicted		Observed	Predicted		Observed	Predicted	
Available nitrogen (kg N ha^{-1})	147.91	155.35	3.68	155.75	157.48	1.11	162.55	159.66	-1.78
Available phosphorus (kg P ha^{-1})	19.05	20.58	7.43	24.45	23.88	-2.33	25.09	24.28	-3.23
Available potassium (kg K ha^{-1})	92.35	88.04	-4.67	101.97	101.89	-0.07	103.37	108.04	4.52

Table.3 Apparent nutrient balance during experiment

Particulars	Strip I		Strip II		Strip III		Whole field		Apparent Nutrient Balance %
	Initial	Post	Initial	Post	Initial	Post	Initial	Post	
Available nitrogen (kg N ha^{-1})	112.90-200.70 (140.60)	100.35-200.70 (147.91)	112.90-263.42 (144.26)	112.90-238.34 (155.75)	112.90-213.25 (150.01)	112.90-225.79 (162.55)	112.90-263.42 (144.95)	100.35-238.34 (155.41)	7.22
Available phosphorus (kg P ha^{-1})	18.24-26.30 (21.99)	15.80-24.29 (19.05)	22.48-28.85 (25.84)	21.99-26.40 (24.45)	16.97-29.27 (25.86)	19.16-28.52 (25.09)	16.97-29.27 (24.56)	15.80-28.52 (22.86)	-6.92
Available potassium (kg K ha^{-1})	58.24-126.56 (81.71)	69.44-115.36 (92.35)	58.24-189.28 (113.17)	73.92-170.24 (101.97)	84.00-189.28 (129.59)	71.68-171.48 (103.37)	58.24-189.28 (108.16)	69.44-171.48 (99.23)	-8.26

Phosphorus of experimental field changed from 24.56 to 22.86 kg P ha^{-1} initial to post soil test value. Average Phosphorus in strip I changed from 21.99 to 19.05 kg P ha^{-1}. While in strip II the Phosphorus changed from 25.84 to 24.45 and average Phosphorus in strip III changed from 25.86 to 25.06 kg P ha^{-1}may be due to high P fixation capacity of particular site characteristics.

Potassium of experimental field changed from 108.16 to 99.23 kg K ha^{-1} initial to post soil test value. Average Potassium in strip I changed from 81.71 to 92.35 kg K ha^{-1}. While in strip II the Potassium changed from 113.17 to 101.97 and average Potassium in strip III changed from 129.59 to 103.37 kg K ha^{-1}. Over all Potassium decreased from initial to post soil test value due to large amount of uptake K by rhizome and higher potassium fixation capacity of particular site characteristics.

In case of P and K, decreased from initial to post harvest soil test value because applied fertilizer is fully utilized by crops and some amount of P and K fix in the soil due to high P & K fixation capacity of particular soil but in case of Nitrogen slightly increased from initial to post harvest soil test value. On an average, well decomposed FYM contains 0.57% N, 0.32% P_2O_5 and 0.58%K_2O. When FYM is applied to soil about 100% of N, P_2O_5 and K_2O are available for the turmeric crop, depending upon the transformation of each nutrient element in the soil matrix. So that available nutrient in post-harvest soil is fewer amounts.

The data on $KMnO_4$-N, Olsen-P and NH_4OAc-K indicated the build-up and maintenance of soil fertility due to soil test based fertilizer recommendation under NPK with FYM. Despite higher removal of nutrients, the fertility status was maintained at higher level in NPK with FYM as compared to NPK alone. This might be attributed to the prevention of losses of nutrients under NPK with FYM, even after meeting the crop needs. The findings of Pachauri and Vinay Singh (2001) and Santhi *et al.,* (2002) also supported the results recorded in the present study.

Apparent N balances was positive (7.22%) in all soil fertility levels or strips and fertilizer treatments, but a negative P (-6.92) and K (-8.25%) balance was noticed in turmeric in soil test crop response. Further, these results cautioned to develop fertilizer recommendations based on crop demand for a specified yield targeted and indigenous soil nutrient supplying capacity.

Thus, it can be concluded that the post-harvest soil test values prediction equations were developed for available N, P and K and post-harvest soil test values were calculated from these equations and it clearly indicate a possibility for these equations would be very meaningful for fertilizer recommendation for next crop. Nutrients balances at the end of the experiment showed different results depending on the nutrient. The magnitude of negative balance of P and K was greater among the three strips. But Nitrogen shows positively balance. So, the rates of application of these two nutrients should be increased.

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