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Prediction of post-harvest soil test value after rice (*Oryza sativa L.*) crop in *Vertisol* of Chhattisgarh plain climatic zone

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Abstract
The investigation was undertaken during *Kharif* season 2019 and 2020 at Research Farm, Indira Gandhi Krishi Vishwavidhyalaya, Raipur (Chhattisgarh) to study the relationship between actual and predicted post-harvest soil test value and generate post-harvest soil test value prediction equation after rice. Multiple regression analysis was performed by taking into account the post-harvest soil test values after rice as a dependent variable, and initial soil test levels, applied fertilizer doses and grain yields of rice as independent variables and predict the post-harvest soil test values for succeeding crops. The equations developed showed high predictability values for $KMnO_4$-N, Olsen's P and NH_4^+- acetate extractable K, respectively (98%, 99%, and 82%, respectively for rice). Significantly high R^2 values were recorded. This shows that such regression equations can be used for precisely predicting the availability of N, P, and K after rice for fertilizer recommendations based on targeted yield for succeeding crops. The prediction equations were then used to determine the predicted post-harvest soil test values of N, P and K for rice during 2020-21. The predicted values were then compared with the actual values observed for N, P and K and it was observed that considerably large R^2 values were obtained (0.94, 0.86 and 0.85 for rice) for N, P and K, respectively. The generated model for prediction was then calibrated by determining the root mean square error (RMSE) and relative error percentage (RE). RMSE values for N, P and K followed the order: K>N>P, while the RE values followed the order: P>N>K for rice RE values less than 10% are considered that prediction is excellent.

Keywords: STCR, INM, rice, post-harvest soil test value

Introduction

Soil testing between seasons becomes challenging in terms of time, money, and labour when intense cropping is used. At this point, Ramamoorthy and associates in 1971 [1] estimated post-harvest soil fertility, based on initial soil test values, fertilizer doses, and crop yield or uptake gains practical significance for formulating fertilizer recommendations for the entire cropping sequence. The estimated post-harvest soil test values serve as the initial soil test values for the succeeding crop in the sequence and can be used for computing the fertilizer dosages for any desired yield target of the succeeding crop.

Information on initial soil nutrients level is essential for estimation of fertilizer doses to achieve a definite yield goal. Hence, soil samples are to be taken before cropping and time constraint pose a problem of delayed crop sowing. Hence it is practical idea that nutrients level after cropping can be predicted using the relationship among the crop yield, initial nutrients status and fertilizer applied. The predicted values can be utilized for recommending the fertilizer doses for succeeding crops thus eliminating the need for soil tests after each crop.

For effective nutrient supply during crop growth, regular monitoring of soil test levels is needed. Hence a well-developed service infrastructure with excellent quality control laboratory is essential (Dobermann, *et al.*, 2003) [2] but this facility is not well established at Government as well as farmer's level to test the soil nutrients of each farm timely. So it has become necessary to predict the soil test values after the harvest of a crop or cropping system.

Keeping the aforementioned information in mind, the current experiment was conducted in *Vertisol* to explain the significant relation between soil test results and crop responses to fertilizer as well as to generate prediction equation for post-harvest soil test values *viz*., N, P, and K after rice for fertilizer recommendations based on targeted yield for succeeding crops.

Material and Methods

Field experiment was carried out as per suggested by Ramamoorthy *et al.* (1967) [3], the respective field was divided into three fertility strips (L_0, L_1 and L_2), onto which three levels of N, P_2O_5 and K_2O (0-0-0, 100-60-40, 200-120-80 kg ha^{-1} were applied, respectively, for the creation of fertility gradient, and fodder maize was grown as an exhaust crop during *Kharif* season 2019. After the harvest of fodder maize, the fertility strips were divided into three blocks, each with 7 treatments and 1 control, constituting 21 treatment combinations and 3 controls in each fertility strip. The design used was re-enforced resolvable block design. The treatment combinations consisted each of 4 levels of N (0, 50, 100, 150 kg ha^{-1}), P_2O_5 (0, 30, 60, 90 kg ha^{-1}) and K_2O (0, 30, 60, 90 kg ha^{-1}) for rice respectively with three levels of FYM (0, 5, 10 t ha^{-1}) superimposed across all the strips. Rice (Rajeshwari) were taken as test crops. The pre-sowing and post-harvest soil samples were collected from each fertility strip after rice and analyzed for alkaline KMnO4-N (Subbiah and Asija, 1956) [4], Olsen-P (Olsen *et al.*, 1954) [5] and NH4OAc-K (Hanway and Heidel, 1952) [6].

At harvesting of rice plant samples (grain and straw) were collected, processed and analyzed for N, P and K contents (Jackson) [5] and total NPK uptake was computed. Grain and straw yields of rice crops were recorded plot-wise and converted to hectares (q/ha). The representative samples of rice taken from each plot were also taken for dry matter yield and nutrient content analysis.

Prediction of post-harvest soil test values

Multiple regression equations obtained for post-harvest soil test values of N, P and K nutrients in the soil were predicted by the respective grain yields, initial soil test values and fertilization doses obtained in different plots, as shown below.

$$PHSTV=\alpha+\beta 1\ GY+\beta 2 ISTV+\beta 3 FN$$

Where α is intercept; β1, β2 and β3 are regression coefficients; ISTV is initial soil test value; PHSTV is post-harvest soil test value; FN is fertilizer nitrogen; GY is seed yield.

Similarly, we can calibrate the prediction equation for the estimation of post-harvest soil test values of nitrogen, phosphorus and potassium after rice.

Calibration of predicted post-harvest soil test values

It is necessary to calibrate and confirm the prediction of the generated model (for prediction of post-harvest soil test values) as the higher coefficient of determination (R^2) indicates insufficient accuracy for forecasting value precision. Therefore, following methods were used for the calibration and confirmation of the model generated for the precision of prediction.

Root mean square error (RMSE)

$$RMSE=\sqrt{\frac{\sum_{i=1}^{n}(A_i-P_i)^2}{n}}$$

Where,` A_i and P_i represent the actual and predicted post-harvest soil test values of nutrients at the I^{th} data point, and n represents the number of data points.

RMSE is an indicator of the closeness of the actual and predicted values with each other. Better predictability of the model is indicated by lower RMSE values.

Relative error (%)

$$RE=\sqrt{\frac{\sum_{i=1}^{n}((A_i-P_i)/A_i)^2}{n}}\times 100$$

Relative difference between the actual and predicted values is expressed as relative error (RE) in percentage. When RE is less than 10%, the predictions are considered excellent, between 10 and 20% they are considered good, between 20 and 30% they are considered fair, and when greater than 30% they are considered as poor (Jamieson *et al.*, 1991, Zhu *et al.* 2006) [7, 8].

Results and Discussion

The prediction equation for a post-harvest soil test value can be used to make a fertilizer recommendation for succeeding crops. This is very useful because the soil of farmer's fields under intensive cultivation cannot be tested for each crop or year for practical reasons. The interaction of post-harvest soil test values with the initial soil test values, fertilizer applied doses and grain yield from the treated plots for rice crops are presented in Table 1. The developed equations were showed high predictability values 98%, 99% and 82% for $KMnO_4$-N, Olsen's P and NH_4^+- acetate extractable K, respectively under IPNS after harvest of rice crop with large R^2 values while, when uptake by rice was considered the values were 98, 99 and 81 per cent for nitrogen, phosphorus and potassium, respectively. This suggests that such regression equations can be used with confidence for the prediction of available N, P and K after rice for correct level of targeted yield-based fertilizer recommendation for succeeding crops. Similar results were also found by Mahajan *et al.* (2019) [9], Suresh and Santhi (2019) [10], Singh *et al.*, (2020) [11] and Mondal *et al.* (2020) [12] for the three major nutrients.

The prediction equations were then used to determine the predicted post-harvest soil test values of N, P and K for rice during 2020-21. The predicted values were then compared with the actual values observed for N, P and K. The generated model for prediction was then calibrated by determining the root mean square error (RMSE) and relative error percentage (RE) (Table 2). RMSE values for N, P and K followed the order: K>N>P, while the RE values followed the order: P>N>K for rice. RE values less than 10% are considered that prediction is excellent. Our study indicated that the predictions were excellent for N, P and K. Selvam *et al.*, 2021 [13] have also reported on prediction of post-harvest soil test values and have calibrated the model with the help of RMSE and RE after barnyard millet. Mahajan *et al.*, 2019 [9] have also derived prediction equations for rice, wheat and rice-wheat cropping system and calibrated the model by determining the RMSE and RE values. The predicted and actual post-harvest soil test values for N, P and K were correlated for rice system and it was observed that the R (coefficient of correlation) values were 0.94, 0.86 and 0.85 for N, P and K, respectively (Table 3). Selvam *et al.*, 2021 [13] also reported higher correlation between the actual and predicted post-harvest soil test values of N, P and K after barnyard millet. Therefore, considering all the values of correlation coefficient and the calibrated values obtained in our study, it can be speculated that there was a close correlation between the actual and predicted post-harvest soil test values and the predicted values can be used with confidence to recommend fertilizers for the succeeding crop after rice. The relationship between the actual and predicted soil test values for N, P and K are given in Figure 1 (a, b and c) & 4.16.

Table 1: Multiple regression prediction equations for post-harvest soil test values of available N, P and K for Rice in two experimental years (2019-20)

S. No.	Post-harvest prediction equation	R^2
Based on yield		
1	PHSTVN = 5.947+0.171*GY+0.926*ISTVN+0.049*FN	0.98
2	PHSTVP = -1.389+0.112*GY+0.702*ISTVP+ 0.054*FP	0.99
3	PHSTVK= 92.997+0.615*GY+0.744*ISTVK+0.038*FK	0.82
Based on uptake		
1	PHSTVN = 8.052+0.064*TNU+0.924*ISTVN+0.071*FN	0.98
2	PHSTVP = -1.198+0.357*TPU+0.670*ISTVP+ 0.059*FP	0.99
3	PHSTVK = 106.41+0.289*TKU+0.724*ISTVK+0.073*FK	0.81

Where, PHSTVN = Post-harvest soil test value for nitrogen; PHSTVP = Post-harvest soil test value for Phosphorus; PHSTVK = Post-harvest soil test value for Potassium; GY = Grain yield; ISTVN = Initial soil test value of Nitrogen; ISTVP = Initial soil test value of Phosphorus; ISTVK = Initial soil test value of Potassium; GY = Grain yield; FN = Fertilizer Nitrogen; FP = Fertilizer phosphorus; FK = Fertilizer Potassium. TNU= Total nitrogen uptake; TPU= Total phosphorus uptake; TKU= Total potassium uptake

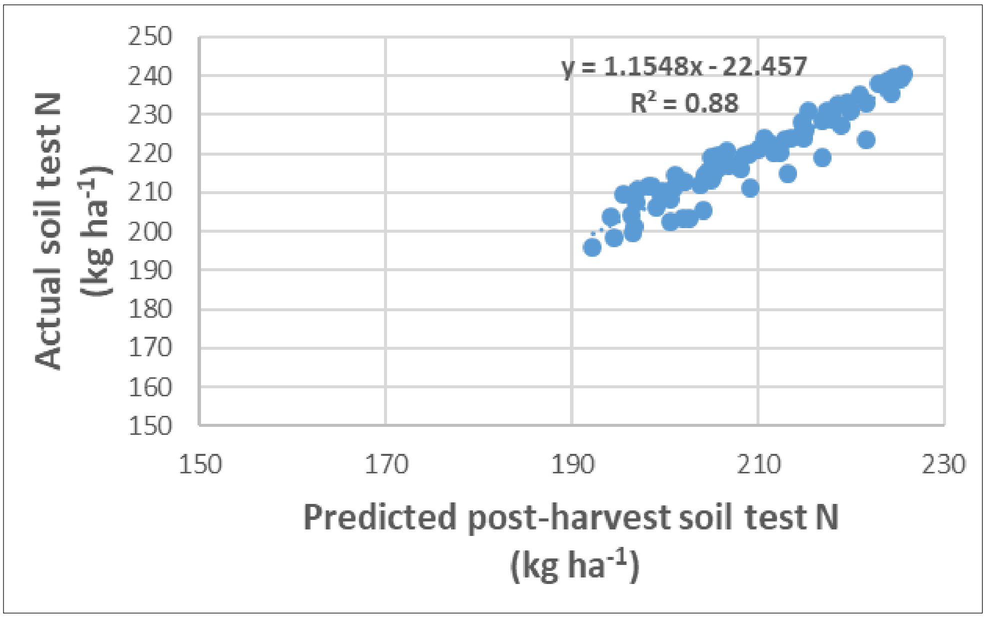
Table 2: Regression model for predicted and actual and their calibrated values

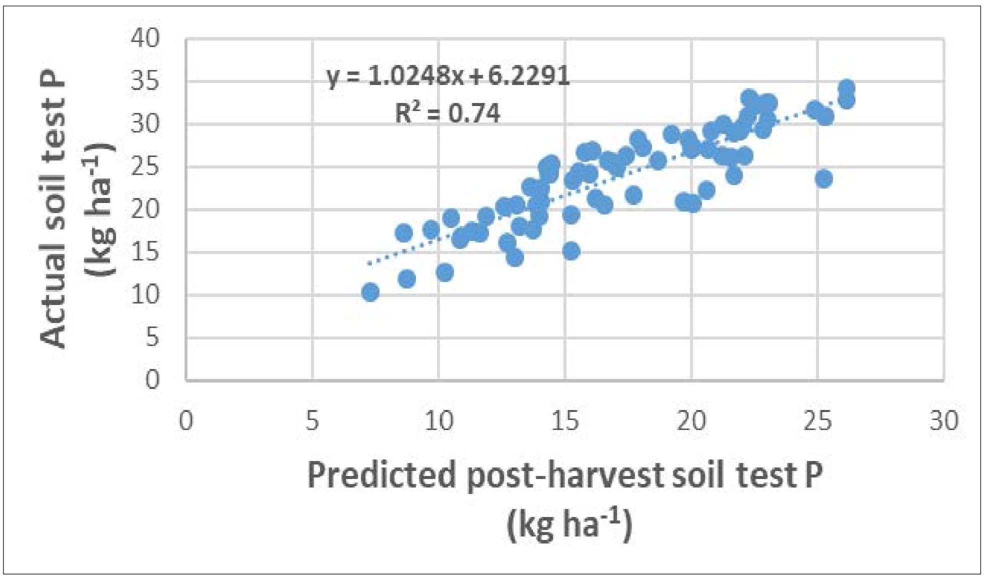
S. No.	Regression model	R2	RMSE (kg)	RE (%)
1	Y = 1.1548x-22.457	0.88	10.59	0.56
2	Y = 1.0248x+6.2291	0.74	7.24	3.52
3	Y = 1.0469x-20.096	0.72	14.37	0.34

Table 3: Estimates of correlation (r) between actual and predicted soil test values for rice

STV	Predicted values		
Actual values	N	P	K
N	0.94	-	-
P	-	0.86	-
K	-	-	0.85

Where, STV= Soil test values of NPK in kg/ha.





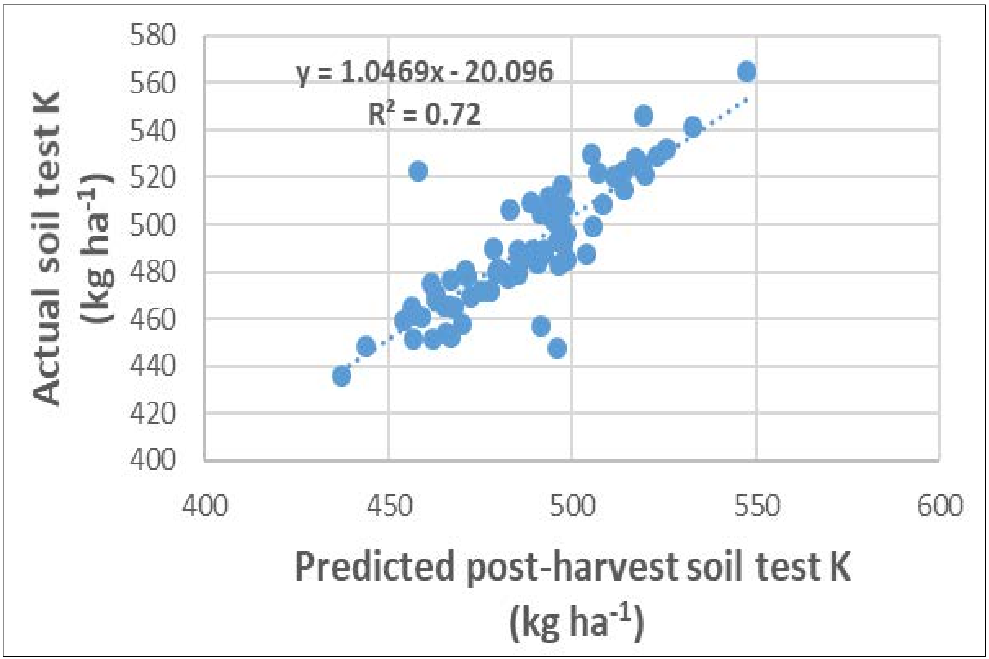


Fig 1: Relationship between the actual and predicted post-harvest soil test value of (a) N, (b) P and (c) K for rice crop

Conclusion

On the basis of the findings discussed above, it can be said that post-harvest soil test values were estimated using equations that were established to anticipate the availability of nitrogen, phosphorus, and potassium. These equations clearly show the possibility for their application in useful fertilizer recommendations for subsequent crops. Consequently, soil testing costs after each harvest are reduced.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Ramamoorthy B, M Velayutham. Soil Test-Crop Response Correlation Work in India. World Soil Resources, Report No. 41:96-102. FAO, Rome; c1971.
2. Dobermann A, Witt C, Abdulrachman S, Gines HS, Nagarajan R, Son TT, *et al.* Soil fertility and indigenous nutrient supply in irrigated rice domains of Asia. Agronomy J. 2003;95:913-923.
3. Ramamoorty B, Narasimhan RL, Dinesh R. Fertilizer application for specific yield targets of Sonera-64 (Wheat). Indian Farming. 1967;17:43-45.
4. Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. Curr. Sci. 1956;25:259-260.
5. Olsen SR, Cole CV, Watanabe FS, Dean A. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular. 1954;939:1-19.
6. Hanway JJ, H Heidel. Soil analysis methods as used in Iowa State College Soil Testing Laboratory. Iowa State College of Agriculture Bulletin. 1952;57:1-31.
7. Jamieson PD, JR Porter, DR Wilson. A test of the computer simulation model ARC-Wheat1 on wheat crops grown in New Zealand. Field Crops Research. 1991;27(4):337-50.
8. Zhu Y, Y Li, W Feng, Y Tian, X Yao, W Cao. Monitoring leaf nitrogen in wheat using canopy reflectance spectra. Canadian Journal of Plant Science. 2006;86(4):1037-46.
9. Mahajan GR, Pandey RN, Datta SC, Sahoo RN, Dinesh Kumar, Murgaonkar D, *et al.* Predicting post-harvest soil test values in hybrid rice (*Oryza sativa* L.) – wheat (*Triticum aesitvum* L.) cropping sequence using a multivariate analysis technique. Communications in Soil Science and Plant Analysis. 2019;50(13):1624-1639.
10. Suresh R, Santhi R. Prediction of post-harvest soil test values and fertilizer calibrations for a maize-based cropping sequence under integrated plant nutrition system. Madras Agric. J. 2019;106(1-3):63-68
11. Singh YV, Jatav, Surendra Singh, Bharteey PK. Development of fertilizer prescription targeted yield equation for soya (*Anethum graveolens L.*) crop based on soil test values in an Inceptisol. Annals of Plant and Soil Research. 2020;22(3):249-253.
12. Mondal Sudeshna, Gorai Debjit, Saha Niharendu, Dasgupta Shubhadip, Bhattacharyya Kallol, Dey Pradip. Integrated fertilizer prescriptions through a targeted yield model and prediction of post-harvest soil test values for Kharif Rice (*Oryza sativa*). Journal of the Indian Society of Soil Science. 2020;68(3):330- 336.
13. Selvam R, Santhi R, Margatham S, Chandrasekhar CN, Ganapathi PS. Extrapolation of post-harvest soil test values in barnyard millet-based cropping sequence through multivariate analysis. Journal of Applied and Natural Science. 2021;13(4):1545-1551.