The Bioscan 14(3): 211-218, 2019
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

POST-HARVEST SOIL TEST VALUES (PHSTVS) PREDICTION EQUATION FOR A PEARL MILLET BASED CROPPING SEQUENCE ON AN INCEPTISOL

UDAYAKUMAR SEKARAN[1], R. SANTHI[1], P. DEY[2], S. MEENA[1] AND S. MARAGATHAM[3]
[1]Department of Soils Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore - 641003, Tami Nadu, INDIA.
[2]AICRP-STCR, ICAR - Indian Institute of Soil Science, Bhopal, Madhya Pradesh, INDIA.
[3]Agricultural College and Research Institute, Tamil Nadu Agricultural University, Pudukottai, Tamil Nadu, INDIA.
e-mail: dhayagri307@gmail.com

KEYWORDS
Inceptisol
pearl millet
prediction equation
STCR-IPNS

Received on :
13.03.2019

Accepted on :
29.07.2019

***Corresponding author**

ABSTRACT

Analyzing soil samples for prescribing soil test based fertilizer doses after each crop in a sequence is time, labour and energy consuming and involves additional cost. With a view to develop post-harvest soil-test values (PHSTVs) prediction equations with multiple linear regression, field experiments were conducted during 2015-16 by adopting Inductive cum Targeted yield model, on an Inceptisol (Vertic Ustropept) with pearl millet under integrated plant nutrition system (IPNS). The experiment was laid out in a fractional factorial design comprising twenty-four treatments. When grain yield was considered, the predictability values of KMnO4-N, Olsen-P, and NH4OAc-K under NPK plus FYM @ 12.5 t ha-1 treatment were 98.4, 97.5, and 98.1%, respectively. When uptake was considered, the predictability values of KMnO4-N, Olsen-P, and NH4OAc-K under NPK plus FYM @ 12.5 t ha-1 treatment were 98.4, 97.6, and 98.1%, respectively. Significant R2-values (>0.65) were recorded for these regression equations which could be used with confidence for the prediction of post-harvest KMnO4-N, Olsen-P and NH4OAc-K. The data on observed and predicted soil test values of available N, P and K were in good agreement with each other, proving the validity of the post-harvest soil test values prediction equations as evidenced by highly significant correlation.

INTRODUCTION

Nutrient application in agricultural systems is expected to increase in the coming years to produce more food, feed, and fiber from the diminishing arable lands. Efficient application of nutrients is key to sustainability in agricultural systems (Jemila *et al*., 2017a, b; Sahu *et al*., 2017; Sekaran *et al*., 2019; Udayakumar and Santhi, 2017). Efficient fertilization means optimizing crop yields, while minimizing nutrient losses to the environment, which is important economically and environmentally (Jemila *et al*., 2017c; Singh *et al*., 2019). Efficient nutrient application necessitates balanced fertilizer use and sound management decisions and practices (Sharma, 2014; Sharma *et al*., 2013; Udayakumar and Jemila, 2016; Velayutham *et al*., 2016). So, judicious use of fertilizers can only be achieved with their proper prescriptions based on initial soil test values. Decisions on fertilizer use needs knowledge of the expected response of crop yield to nutrient application, which is function of crop nutrient need and supply of nutrients from indigenous source (Dobermann *et al*., 2003; Sharma *et al*., 2013; Singh *et al*., 2015a; Udayakumar *et al*., 2017; Yargholi and Azarneshan, 2014).

Soil testing is a scientific tool to evaluate soil fertility by predicting the probability of getting a profitable crop response to recommended fertilizer application under specific soil-crop condition (Dey, 2015; Usman and Kundiri, 2016). Though there are numerous soil testing laboratories in operation, in a vast country like India with millions of hectares of cultivated land, soil testing for each field season after season and prior to the cultivation of each crop seems to be practically impossible for the want of time, money, labour and energy consuming and highly expensive which is neither economical nor environmental friendly (Mishra *et al*., 2015). At the same time, practice of intensive cropping systems by farmers leads to a very short span of time between the crops to complete soil testing of nutrients. Analysis of soil for nutrients within such a short period of time for making fertilizer prescription to crops is not quite possible. Hence, the prediction of post-harvest soil test values (PHSTVs) using the pre-sowing soil test values, fertilizer doses and yield or uptake by the crop has much of practical significance (Sellamuthu *et al*., 2015).

Kumar (2016) developed PHSTVs prediction equations for turmeric (*Curcuma longa* L.) by using pre-sowing soil test values, fertilizer doses and rhizome yield and/or NPK (nitrogen, phosphorus, and potassium, respectively) uptake on Mollisol. Mahajan *et al*. (2019) developed PHSTVs prediction equations for hybrid rice (*Oryza sativa* L.) -wheat (*Triticum aesitvum* L.) cropping sequence using a multiple linear regression (MLR) found these equations were highly significant for predicting nutrient status. Srivastava *et al*. (1999) reported that PHSTVs prediction equations can be used to prescribe fertilizer doses for pigeon pea-wheat sequence on Typic Ustochrepts. Karamanos and Cannon (2002) have shown that it is even possible for 'virtual soil testing' through mechanistic model predicted soil test levels for western Canadian soil testing laboratories to offer supplemental information for those fields that are not soil tested on a yearly basis. Bera *et al*. (2006) developed prediction equations for PHSTVs for rice and found these equations were highly significant for the major nutrients *viz*. N, P and K. Sharma *et al*. (2019) predicted PHSTVs for N, P and K in maize, wheat and pearl millet for different cultivars and concluded that such approach is highly useful for making fertilizer prescription for whole cropping sequence as well.

So, exploring techniques for estimation of soil nutritional status other than soil testing is need of an hour. One of the viable alternative options to skip soil nutrient testing is prediction of left-over nutrient using mathematical models. Prediction of soil nutrients left over after a crop suggest new possibilities to make fertilizer prescription for individual crops as well as cropping sequence with knowledge of initial soil test values, target yield, amount of applied nutrients through fertilizer and farmyard manure (Ramamoorthy and Velayutham, 1971). We hypothesized that developing prediction equations using MLR can predict the PHSTVs with more than 0.65 R2 values. The objective of this present study was to develop and validate PHSTVs prediction equations for pearl millet-blackgram and pearl millet-bhendi cropping sequence on an Inceptisol.

MATERIALS AND METHODS

Experimental site

Field experiments were conducted during 2015-16 with pearl millet (TNAU Cumbu Hybrid CO 9) on an Inceptisol (Vertic Ustropept) at farmer's holding of Allapalayam village, Coimbatore district (Western zone of Tamil Nadu), India (11º14'51.6"N 77º09'48.0"E). The soil of the experimental field belongs to Periyanaickenpalayam soil series which is mixed black calcareous, moderately deep and well drained, sandy clay loam in texture with pH of 8.10 and electrical conductivity (EC) of 0.14 dS m^{-1}. The initial soil available $KMnO_4$-N, Olsen-P and NH_4OAc-K status was 185, 16.5 and 346 kg ha^{-1}, respectively. The P and K fixing capacities of the soil were 100 and 80 kg ha^{-1}, respectively. The DTPA extractable iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) were in sufficient range.

Experimental design and sampling

The approved treatment structure and layout design as followed in the All India Coordinated Research Project for Investigations on Soil Test Crop Response Correlation based on "Inductive cum Targeted yield model" (Ramamoorthy *et al*., 1967) was adopted in the present investigation. The field experiments with pearl millet were conducted in two phases.

Phase I of the experiment

In the first phase, by adopting "Inductive methodology'' (Ramamoorthy *et al*., 1967), three fertility gradients were created in the same experimental field during September to November 2015. For this purpose, the experimental field was divided into three equal strips with N0P0K0 (SI), N1P1K1 (SII) and N2P2K2 (SIII) levels and a gradient crop of fodder sorghum (var. CO 30) was grown, so that the fertilizers could undergo transformations in soil with plant and microbial agencies. An operational range of soil test values in respect of available N, P and K was created and the data on post-harvest soil available N, P and K, fodder yield and uptake of N, P and K confirmed the creation of soil fertility gradient among the three strips. More details are provided in our previous paper on artificial soil fertility gradient strategy (Udayakumar *et al*., 2017) at the same experimental site.

Phase II of the experiment

After the establishment of fertility gradients, in the second phase of the field experiment, each strip was divided into 24 plots so as to accommodate 24 treatments with four levels each of N (0, 50, 100 and 150 kg ha^{-1}), P_2O_5 (0, 25, 50 and 75 kg ha^{-1}) and K_2O (0, 25, 50 and 75 kg ha^{-1}) and the experiment was laid out in fractional factorial design. There were three levels of FYM (0, 6.25 and 12.5 t ha^{-1}) and the IPNS treatments *viz*., NPK + FYM @ 6.25 t ha^{-1} and NPK + FYM @ 12.5 t ha^{-1} and the NPK alone treatments were superimposed across the strips. The 21 fertilizer treatments and three controls were randomized in such a way that all the 24 treatments were present in all the three strips on both the directions (Fig. 1). The treatment structure is given in Table 1.

Soil and plant sampling and analysis

Pre-sowing soil samples were collected from each plot before the application of fertilizers and manure and analyzed for alkaline $KMnO_4$-N (Asija and Subbiah, 1956), Olsen-P (Olsen, 1954) and NH_4OAc-K status (Stanford *et al*., 1949). The test crop pearl millet (TNAU Cumbu hybrid CO 9) was raised during February 2016, grown to maturity and harvested during April 2016. The grain and straw yields were recorded and plot wise grain and straw samples from each plot were analyzed for total N (Humphries, 1956), P and K (Piper, 1966) contents and uptake of N, P and K by pearl millet were computed.

Fertilizer prescription equations (FPEs)

A brief overview of test crop experiment is given here; more details are provided in our previous paper on STCR-IPNS for pearl millet on Inceptisol (Udayakumar and Santhi, 2017) at the same experimental site. Making use of the data on the yield of pearl millet, total uptake of N, P and K, initial soil test values for available N, P and K and doses of fertilizer N, P2O5 and K2O applied, the basic parameters *viz*., nutrient requirement (NR), contribution of nutrients from soil (Cs), fertilizer

(Cf) and farmyard manure (Cfym) were calculated as outlined by Ramamoorthy *et al*. (1967). Making use of these parameters, the fertilizer prescription equations (FPEs) were developed for hybrid pearl millet under NPK alone and IPNS.

NPK alone			IPNS (NPK + FYM)		
FN	=	6.04 T - 0.49 SN	FN	=	6.04 T - 0.49 SN - 0.80 ON
FP2O5	=	2.78 T - 1.65 SP	FP2O5	=	2.78 T - 1.65 SP - 0.97 OP
FK2O	=	3.29 T - 0.17 SK	FK2O	=	3.29 T - 0.17 SK - 0.58 OK

where, FN, FP2O5 and FK2O are fertilizer N, P2O5 and K2O in kg ha^{-1}, respectively; T is the yield target in q ha^{-1}; SN, SP and SK respectively are alkaline KMnO4-N, Olsen-P and NH4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K in kg ha^{-1} supplied through FYM.

FPEs for blackgram and bhendi

FPEs for Blackgram

FN	=	10.4 T - 0.39 SN
FP2O5	=	7.23 T - 1.00 SP
FK2O	=	5.20 T - 0.04 SK

NPK alone			IPNS (NPK+FYM)		
FN	=	1.15 T - 0.46 SN	FN	=	1.15 T - 0.46 SN - 0.81 ON
FP2O5	=	0.52 T - 1.31 SP	FP2O5	=	0.52 T - 1.31 SP - 0.87 OP
FK2O	=	1.77 T –0.64 SK	FK2O	=	1.77 T –0.64 SK - 0.91 OK

where, FN, FP_2O5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in q ha^{-1}; SN, SP and SK respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K in kg ha^{-1} supplied through FYM.

Post-harvest soil test values prediction equation

An attempt was made in the present study to predict the PHSTVs by multiple regression model developed by Ramamoorthy *et al*. (1971), which were obtained by the statistical evaluation of the dependence of the post-harvest soil test values on initial soil test values and other associated parameters *viz*., yield / uptake and fertilizer doses. The functional relationship is as follows:

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

where, YPHS is the post-harvest soil test value; F is the applied fertilizer nutrient and ISTV is the initial soil test value of N/P/K. The equation will take the mathematical form,

YPHS = a + b1F + b2 IS + b3 yield / uptake

where, a is the absolute constant and b2 and b3 are the respective regression co-efficients. Using these regression equations, the post-harvest soil test values of N, P and K were predicted after pearl millet.

RESULTS AND DISCUSSION

PHSTVs prediction equations were developed for the prediction of post-harvest soil test values after pearl millet and are furnished in Table 2 along with the concerned r values. In the case of prediction of $KMnO_4$-N, when grain yield was considered, the predictability values under NPK alone, NPK plus FYM @ 6.25 t ha^{-1} and NPK plus FYM @ 12.5 t ha^{-1} treatments were 98.1, 98.0 and 98.4 per cent, respectively, while the predictability values were 98.1, 98.0 and 98.4 per cent respectively when nitrogen uptake was considered. For the purpose of comparison, the observed and predicted data based on yield and uptake for a set of selected treatments from each block (NPK alone, NPK + FYM @ 6.25 t ha^{-1} and NPK + FYM @ 12.5 t ha^{-1}) are furnished in Table 3. The observed mean $KMnO_4$-N values were 196.5 kg ha^{-1} while the mean predicted value using grain yield and uptake were 197.3 and 197.7 kg ha^{-1}, respectively. The mean variation between observed and predicted value was 0.8 and 1.2 kg ha^{-1} when yield and uptake were respectively used for prediction.

Figure 1: Layout of Test crop experiment with Pearl Millet

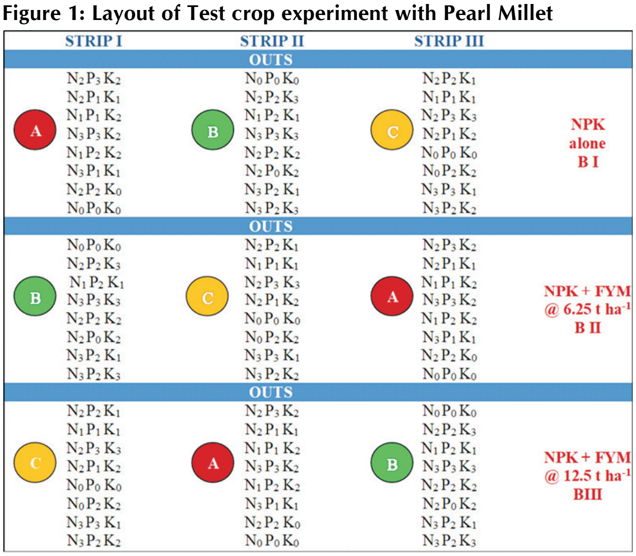


Table 1: Treatment structure for test crop experiment (Pearl millet)

Sl. No	Treatment combination: Nitrogen	Phosphorus	Potassium	Levels of nutrients (kg ha^{-1}): N	P_2O_5	K_2O
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	2	2	0	50	50
5	1	1	1	50	25	25
6	1	2	1	50	50	25
7	1	1	2	50	25	50
8	1	2	2	50	50	50
9	2	1	1	100	25	25
10	2	0	2	100	0	50
11	2	1	2	100	25	50
12	2	2	2	100	50	50
13	2	2	1	100	50	25
14	2	2	0	100	50	0
15	2	2	3	100	50	75
16	2	3	2	100	75	50
17	2	3	3	100	75	75
18	3	1	1	150	25	25
19	3	2	1	150	50	25
20	3	2	2	150	50	50
21	3	3	1	150	75	25
22	3	3	2	150	75	50
23	3	2	3	150	50	75
24	3	3	3	150	75	75

Table 2: Prediction equations for post-harvest soil test values of available N, P and K for pearl millet under NPK alone and IPNS

PHSTVs Prediction equations	R2
NPK alone	
YPHN = 1.71+0.995**SN+0.077* FN-0.00052 yield	0.9812**
YPHN = -0.72+1.01**SN+0.08** SK-0.037 uptake	0.9813**
YPHP = -0.091082+1.069** SP+0.071** FP-0.00043 yield	0.9814**
YPHP = -1.38+1.07** SN+0.07** FP-0.05 uptake	0.9813**
YPHK = 16.15+0.91** SK+0.212** FK+0.0037** yield	0.9852**
YPHK = 15.57+0.91** SK+0.22** FK+0.15** uptake	0.9846**
NPK+ FYM @ 6.5 t ha-1	
YPHN = 7.25+0.95** SN+0.05 FN+0.002* yield	0.9800**
YPHN = 8.60+0.95** SN+0.054 FN+0.048* uptake	0.9796**
YPHP = -3.48+1.07** SP+0.06** FP+0.00077 yield	0.9945**
YPHP = -2.59+1.06**SP+0.06** FP+0.089* uptake	0.9944**
YPHK = 3.96+0.98** SK+0.21** FK+0.00076 yield	0.9899**
YPHK = 3.40+0.98**SK+0.21** FK+0.018** uptake	0.9898**
NPK+ FYM @ 12.5 t ha-1	
YPHN = 0.015+1.01** SN+0.06** FN +0.0013* yield	0.9839**
YPHN = -3.58+1.06** SN+0.07 ** FN-0.015 uptake	0.9838**
YPHP = -0.41+1.09** SP+0.07** FP-0.000044 yield	0.9754**
YPHP = -0.35+1.1 ** SP +0.07 ** FP-0.029 uptake	0.9755**
YPHK = 23.4+0.93**SK+0.15** FK+0.002** yield	0.9809**
YPHK = 25.5+0.92**SK+0.15FK**+0.12** uptake	0.9811**

*Significant at P = 0.05; **Significant at P = 0.01; PH = Post-Harvest; FN, FP and FK = fertilizer N, P_2O_5 and K_2O respectively in kg ha-1; SN, SP and SK = Soil available N, P and K respectively in kg ha^{-1}.

Table 3: Observed and predicted post-harvest soil $KMnO_4$-N, Olsen-P and NH_4OAc-K for pearl millet

Treatments	$KMnO_4$-N (kg ha^{-1}) Observed	Predicted based on Yield	Uptake	Olsen-P (kg ha^{-1}) Observed	Predicted Yield	based on Uptake	NH_4OAc-K (kg ha^{-1}) Observed	Predicted Yield	based on Uptake
NPK alone									
N0P0K0	162	168	167	11	14	13	318	321	321
N0P2K2	216	216	217	40	41	40	387	388	387
N1P1K1	228	223	223	40	40	39	380	383	381
N2P2K2	206	205	205	32	32	31	379	379	377
N3P3K3	205	205	205	29	30	29	377	382	379
NPK + FYM @ 6.25 t ha^{-1}									
N0P0K0	168	173	173	11	12	12	328	331	330
N0P2K2	203	202	201	32	32	31	379	381	379
N1P1K1	208	207	207	29	29	29	374	374	372
N2P2K2	182	180	180	15	16	15	338	340	338
N3P3K3	187	188	188	15	16	16	344	346	345
NPK + FYM @ 12.5 t ha^{-1}									
N0P0K0	168	172	174	12	13	13	324	331	331
N0P2K2	173	181	182	17	17	13	346	342	330
N1P1K1	178	176	177	14	14	13	341	340	333
N2P2K2	231	229	231	43	42	38	401	399	387
N3P3K3	233	234	236	44	45	40	404	407	392
Mean	196.5	197.3	197.7	25.6	26.2	25	361.3	362.9	358.8
'r' value		0.99**	0.99**		0.99**	0.99**		0.99**	0.97**

Table 4: Fertilizer prescriptions for pearl millet-blackgram sequence based on initial soil test values under NPK alone and IPNS

i. NPK alone

Yield target (t ha^{-1})	First crop (Pearl millet) Fertilizer doses (kg ha^{-1}) N	P2O5	K2O	PHSTV (kg ha^{-1}) N	P	K	Yield target (q ha^{-1})	Second crop (Blackgram) Fertilizer doses* (kg ha^{-1}) N	P2O5	K2O
3.0	91	54	39	191	22	354	8.0	12.5**	36	27
3.5	121	68	56	193	22	359	8.5	12.5**	39	30
4.0	151	82	72	195	23	365	9.0	12.5**	42	32

ii. IPNS (NPK+FYM @ 12.5 t ha^{-1})

Yield target (t ha^{-1})	First crop (Pearl millet) Fertilizer doses (kg ha^{-1}) N	P2O5	K2O	PHSTV (kg ha^{-1}) N	P	K	Yield target (q ha^{-1})	Second crop (Blackgram) Fertilizer doses* (kg ha^{-1}) N	P2O5	K2O
3.0	50	30	20	194	21	358	8.0	12.5**	25**	12.5**
3.5	80	44	28	196	22	360	8.5	12.5**	25**	12.5**
4.0	111	58	45	199	23	365	9.0	12.5**	25**	12.5**

NB: PHSTV: Post-harvest soil test value; IPNS: Integrated Plant Nutrition System; Initial soil test value (ISTV): $KMnO_4$-N = 185 kg ha^{-1}; Olsen-P = 18 kg ha^{-1} and NH_4OAc-K = 350 kg ha-1. Blanket dose for blackgram (varieties): 25:50:25 kg N, P_2O_5 and K_2O kg ha^{-1}. *computed using the already existing fertilizer prescription equations for blackgram (varieties) on Periyanaickenpalayam soil series; ** maintenance dose (50 per cent of the blanket dose).

Table 5: Fertilizer prescriptions for pearl millet-bhendi sequence based on initial soil test values under NPK alone and IPNS

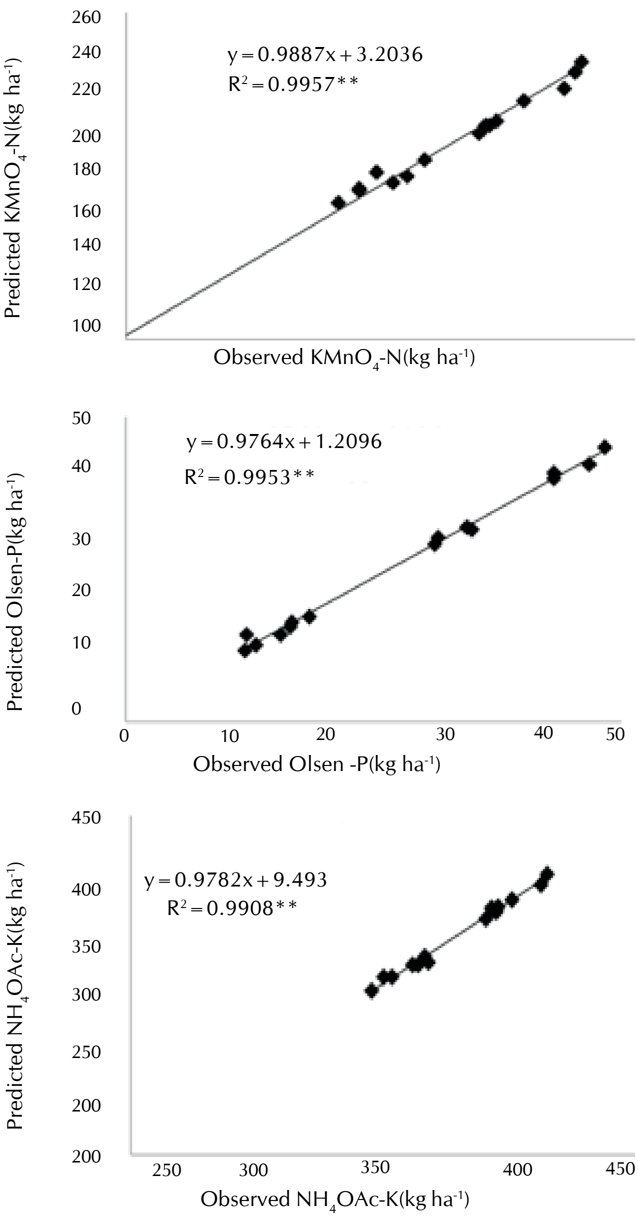
i. NPK alone

Yield target (t ha^{-1})	First crop (Pearl millet) Fertilizer doses (kg ha^{-1}) N	P2O5	K2O	PHSTV (kg ha^{-1}) N	P	K	Yield target (t ha^{-1})	Second crop (Bhendi) Fertilizer doses* (kg ha-1) N	P2O5	K2O
3.0	91	54	39	191	22	354	15	80***	50	39
3.5	121	68	56	193	22	359	16	80***	54	53
4.0	151	82	72	195	23	365	17	80***	59	60***

ii. IPNS (NPK+FYM @ 12.5 t ha-1)

Yield target (t ha^{-1})	First crop (Pearl millet) Fertilizer doses (kg ha^{-1}) N	P2O5	K2O	PHSTV (kg ha^{-1}) N	P	K	Yield target (t ha^{-1})	Second crop (Bhendi) Fertilizer doses* (kg ha^{-1}) N	P2O5	K2O
3	50	30	20	194	21	358	15	41	28	15**
3.5	80	44	28	196	22	360	16	51	32	15**
4	111	58	45	199	23	365	17	61	36	22

Figure 2 : Comparison between observed and predicted post-harvest $KMnO_4$-N, Olsen-P and NH_4OAc-K for pearl millet (using yield data)



The extent of predictability with respect to Olsen-P was 98.1, 99.5 and 97.5 per cent while yield was used for prediction and 98.1, 99.4 and 97.6 per cent while uptake of phosphorus was used in the case of NPK alone, NPK plus FYM @ 6.25 t ha[1] and NPK plus FYM @ 12.5 t ha-1 treatments respectively (Table 2). The observed mean Olsen-P value was 25.6 kg ha-1 while the predicted mean value using grain yield and uptake (Table 3) was 26.2 and 25.0 kg ha-1 respectively. The mean variation between observed and predicted values were 0.6 and 0.6 kg ha-1 for both yield and uptake were respectively used.

Likewise, in case of NH_4OAc-K, the predictability was 98.5, 99.0 and 98.1 per cent when yield was used and 98.5, 99.0 and 98.1 per cent when potassium uptake was used for the prediction of post-harvest soil K status under NPK alone, NPK plus FYM @ 6.25 t ha^{-1} and NPK plus FYM @ 12.5 t ha^{-1} treatments respectively (Table 2). The observed mean NH_4OAc-K value was 361.3 kg ha^{-1} while the mean predicted value using grain yield and uptake (Table 3) was 362.9 and 358.8 kg ha^{-1}, respectively. The mean variation between observed and predicted values was 1.6 and 2.5 kg ha^{-1} for both yield and uptake were respectively used.

The data on observed and predicted soil test values of available N, P and K were in good agreement with each other, proving the validity of the post-harvest soil test values prediction equations as evidenced by highly significant correlation (R2 = 0.99** and 0.99** respectively for N with yield as well as uptake). While it was R2 = 0.99** and 0.99** for P with regard to yield and uptake respectively and in the case of K, R2 = 0.99** and 0.97**, respectively for yield and uptake.

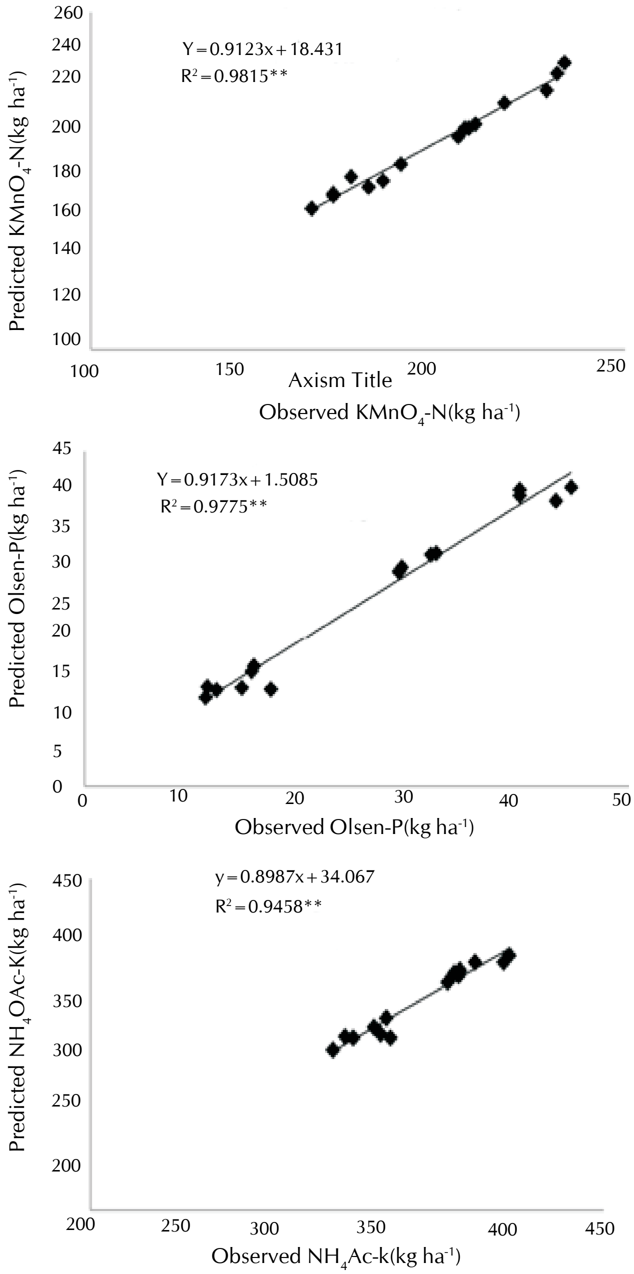
Fertilizer prescription for pearl millet cropping sequence

Using the FPEs for pearl millet and an average initial soil test value of available N, P and K (185:18:350 kg ha^{-1}), fertilizer prescriptions were computed for a range of desired yield target under NPK alone and IPNS (NPK + FYM @ 12.5 t ha^{-1}). The post-harvest soil test values were predicted using the PHSTVs prediction equations for pearl millet. A perusal of the data in Table 4 showed that the quantity of fertilizers required to produce 3.0, 3.5 and 4.0 t ha^{-1} of grain yield was 91, 121 and 151 kg N ha^{-1}; 54, 68 and 82 kg P_2O_5 ha^{-1} and 39, 56 and 72 kg K_2O ha^{-1}, respectively under NPK alone. When FYM was applied @ 12.5 t ha^{-1} along with fertilizers, the fertilizer requirements were 50, 80 and 111 kg N ha^{-1}; 30, 44 and 58 kg P_2O_5 ha^{-1} and 20, 28 and 45 kg K_2O ha^{-1} (Table 5).

The predicted PHSTVs were 191,193 and 195 kg ha-1 of $KMnO_4$-N; 22.0, 22.0 and 23.0 kg ha^{-1} Olsen-P and 354, 359 and 365 kg ha^{-1} NH_4OAc-K respectively under NPK alone for 3.0, 3.5 and 4.0 t ha^{-1} of yield targets of pearl millet. Similarly, the PHSTVs were calculated under IPNS and the values were 194, 196 and 199 kg ha^{-1} of $KMnO_4$-N, 21.0, 22.0 and 23.0 kg ha^{-1} of Olsen-P and 358, 360 and 365 kg ha^{-1} of NH_4OAc-K under NPK plus FYM 12.5 t ha^{-1}. The results indicated that irrespective of yield targets, there was either maintenance or built-up of post-harvest soil available N, P and K as compared to the initial status and the magnitude was higher with increasing yield targets. Between NPK alone and IPNS, the magnitude of built-up was relatively higher with IPNS.

In present investigation, the PHSTVs prediction equations developed found to have high predictability for $KMnO_4$-N, Olsen-P and NH_4OAc-K. Highly significant R2-values of 0.9812 with yield and 0.9813 with N uptake were recorded for $KMnO_4$-N under NPK alone for pearl millet. Similarly, under IPNS (NPK + FYM @12.5 t ha^{-1}), R2-values of 0.9839 and 0.9838 were recorded. The difference between the predicted and observed (experimental) soil test values for the treated plots (five plots in each block) was found to be negligible and found to agree very closely. Similarly, for Olsen-P and NH_4OAc-K the R2-values under NPK alone and NPK plus FYM @ 12.5 t ha^{-1} were 0.9814, 0.9852 and 0.9754, 0.9809, respectively with yield; in case of uptake it was 0.9813, 0.9846 and 0.9755, 0.9811, respectively. It indicated highly significant relationship with high R2-values and fall in the category of good fit in the present investigation, taking a value of r above 0.65 as the

Figure 3: Comparison between observed and predicted post-harvest KMnO4-N, Olsen-P and NH4OAc-K for pearl millet



criterion for good fit. The R2-values suggested that the prediction equations could be used with confidence for the prediction of available N, P and K after pearl millet for making the soil test and yield target-based fertilizer prescriptions for the succeeding crop.

The prediction equations developed after pearl millet can be used for prescribing fertilizer doses for any succeeding crop after pearl millet. The predicted post-harvest soil test values of pearl millet would become the initial soil test values for the succeeding crop. Thus, the prediction equations developed can be used to assess the post-harvest soil fertility at the end of the crop and would be useful in prescribing fertilizer doses for the cropping sequence as a whole from the initial soil test values. Such type of prediction equations were developed by Rao and Singh (1992) for Maize-Wheat and Maize-Wheat-Moong sequence and Andi (1998) for Sunflower-Bhendi sequence on Inceptisol, Bera *et al*. (2006) for rice-rice, Mishra *et al*. (2015) for chickpea on Inceptisol, and Poonam *et al*. (2017) for french bean maize sequence on Mollisol. These authors reported highly significant correlation between actual and predicted soil test values. Kumar (2016) predicted the PHSTVs for turmeric and analyzed nutrient balance for next crop. They concluded that developed PHSTVs equations clearly indicated a possibility for predicting and recommending meaningful fertilizer doses for next crop in the sequence. Using MLR model Suresh and Santhi (2019) also developed PHSTVs prediction equation for maize-cotton sequence on Typic Haplustert soils. The results showed that using PHSTVs equations developed from MLR model predicted the soil test values more accurately (R2 > 0.65).

Accordingly, in the present investigation, the soil test values for $KMnO_4$-N, Olsen-P and NH_4OAc-K were predicted and compared with the observed values (actually tested). Fig. 2 and 3 showed the comparison between observed and predicted soil test values of available N, P and K after pearl millet using 1:1 regression line wherein all the points stayed close to the regression line and the values were in good agreement with each other as evidenced by highly significant correlation (r = 0.99**, 0.99**and 0.99** respectively with yield; 0.98**, 0.97** and 0.94**, respectively with uptake). Similar method of comparison between the observed and predicted data was also reported by many scientists (Bera *et al*., 2006; Singh *et al*., 2015b).

From the results obtained for pearl millet, both observed and predicted soil test values were in good agreement proving the validity of the post-harvest soil test values prediction equations which was also exhibited in the 1:1 regression line with highly significant 'R2' values. Using the predicted PHSTVs and already existing fertilizer prescription equations (FPEs) for any succeeding crop (*viz*., for pearl millet - blackgram and pearl millet-bhendi sequence) on the same or allied soil series, fertilizer prescriptions can very well be computed under different nutrient management practices. Such a computed model is furnished in Table 4 and 5. Studies on this aspect were carried out by many workers for various cropping sequences and soil types which has been documented by Muralidharudu *et al*. (2007) and Dey and Das (2014).

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Indian Council of Agricultural Research, New Delhi and Indian Institute of Soil Science, Bhopal and Tamil Nadu Agricultural University, Coimbatore for funding and implementing the All India Coordinated Research Project for Investigations on Soil Test Crop Response Correlation (AICRP-STCR) at Tamil Nadu Agricultural University, Coimbatore.

REFERENCES

Andi, K. 1998. Soil Test Crop Response Studies Under Integrated

Plant Nutrition System For Bhendi-Sunflower Cropping Sequence On Inseptisol, Tamil Nadu Agricultural University; Coimbatore.

Asija, G. and Subbiah, B. 1956. A rapid procedure for the estimation of available nitrogen in soils. *J. of Current Sci.* **25:** 259-260.

Bera, R., Seal, A., Bhattacharyya, P., Das, T., Sarkar, D. and Kangjoo, K. 2006. Targeted yield concept and a framework of fertilizer recommendation in irrigated rice domains of subtropical *India. J. of Zhejiang University SCI.* B**(7):** 963-968.

Dey, P. 2015. Targeted yield approach of fertiliser recommendation for sustaining crop yield and maintaining soil health. *JNKVV Research J.* **49:** 338-346.

Dey, P. and Das, H. 2014. Progress report (2010-13) of the All India Coordinated Project for Investigations on Soil Test Crop Response. IISS, NabiBagh, Berasi road, Bhopal.

Dobermann, A., Witt, C., Abdulrachman, S., Gines, H., Nagarajan, R., Son, T., Tan, P., Wang, G., Chien, N. and Thoa, V. 2003. Soil fertility and indigenous nutrient supply in irrigated rice domains of Asia. *Agron. J.* **95:** 913-923.

Humphries, E. 1956. Mineral components and ash analysis. In "Moderne Methoden der Pflanzenanalyse/Modern Methods of Plant Analysis", pp. 468-502. Springer.

Jemila, C., Saliha, B. B. and Udayakumar, S. 2017a. Evaluating the effect of phosphatic fertilizers on soil and plant P availability and maximising rice crop yield. *Oryza*. **54:** 305-313.

Jemila, C., Saliha, B. B. and Udayakumar, S. 2017b. Evaluating the performance of phosphatic fertilizers on plant nutrients (N, P and K) concentration and uptake by the rice crop. *Research on Crops* 18.

Jemila, C., Saliha, B. B. and Udayakumar, S. 2017c. A Study on the Distribution of Inorganic P Fractions in Soils of Low and High Available Phosphorus through a Laboratory Incubation Experiment. *International J. of Current Microbiology and Applied Sci*. **6:** 929-937.

Karamanos, R. E. and Cannon, K. R. 2002. Virtual soil testing: Is it possible? Communications in soil Sci. and plant analysis. **33:** 2599-2616.

Kumar, S. 2016. Soil test crop response studies for balanced fertilization of turmeric (*Curcuma longa* L.) in a mollisol of Uttarakhand, GB Pant University of Agriculture and Technology, Pantnagar-263145 (Uttarakhand).

Mahajan, G., Pandey, R., Datta, S., Kumar, D., Sahoo, R., Patel, K., Murgaonkar, D. and Das, B. 2019. 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 Sci. and Plant Analysis. **50:** 1624-1639.

Mishra, S. A., Singh, Y. and Pradeep, D. 2015. Quantitative estimation of fertilizer requirement forchickpea in the alluvial soil of the indo-gangeticplains. *The Bioscan.* **10:** 435-438.

Muralidharudu, Y., Rathore, A. and Subba Rao, A. 2007. 18th Progress report of All India Co-ordinated project for Investigation on Soil Test Crop Response Correlation. *Indian Institute of Soil Science.* Bhopal.

Olsen, S. R. 1954. "Estimation of available phosphorus in soils by extraction with sodium bicarbonate," United States Department Of Agriculture; Washington.

Piper, C. S. 1966. "Soil and plant analysis," Hans Publishers; Bombay.

Poonam, G., Poonam, G. and Sobaran, S. 2017. Evaluation of soil test methods for available N, P and K for French bean and maize in a mollisol. *International J. of Basic and Applied Agricultural Research* .**15:** 23-27.

Ramamoorthy, B., Aggarwal, R. and Singh, K. 1971. Soil fertility management under multiple-cropping. Indian farming.

Ramamoorthy, B., Narasimham, R., and Dinesh, R. 1967. Fertilizer application for specific yield targets on Sonora 64 (wheat). *Indian Farming.* **17:** 43-45.

Ramamoorthy, B. and Velayutham, M. 1971. Soil test crop response correlation work in India. FAO, , Rome: World Soil Resources Report No. **41:** 96–100.

Rao, C. and Singh, K. 1992. Prediction of Post-Harvest Soil Test Values after Maize-Wheat and Maize-Wheat-Moong Sequences Based on Initial Soil Test Values. *J. of the Indian Society of Soil Sci.* **40:** 748-752.

Sahu, G., Chatterjee, N. and Ghosh, G. K. 2017. Integrated Nutrient Management In Lentil (Lens culinaris Medikus) In Red And Lateritic Soils Of West Bengal. Bulletin of Environment, P*harmacology and Life Sci.* **6:** 55-62.

Sekaran, U., McCoy, C., Kumar, S. and Subramanian, S. 2019. Soil microbial community structure and enzymatic activity responses to nitrogen management and landscape positions in switchgrass (*Panicum virgatum* L.). GCB Bioenergy. **11:** 836-851.

Sellamuthu, K., Santhi, R., Maragatham, S. and Dey, P. 2015. Validation of soil test and yield target based fertilizer prescription model for wheat on inceptisol. Research on Crops **16:**

Sharma, D. 2014. Quality evaluation and storage stability of jamun mango blended jam. *The Bioscan.* **9:** 953-957.

Sharma, G., Thakur, R., Raj, S., Kauraw, D. and Kulhare, P. 2013. Impact of integrated nutrient management on yield, nutrient uptake, protein content of wheat (Triticum astivam) and soil fertility in a typic haplustert. *The Bioscan.* **8:** 1159-1164.

Sharma, P., Yadav, R., Bundela, D., Kumar, A., Sanwal, S., Meena, R., Banyal, R., Singh, J., Kumar, R. and Fagodiya, R. 2019. Abstracts: Golden Jubilee International Salinity Conference (GJISC-2019). ISSSWQ and ICAR-CSSRI.

Singh, N., Dhaliwal, J. K., Sekaran, U. and Kumar, S. 2019. Soil hydrological properties as influenced by long term nitrogen application and landscape positions under switchgrass seeded to a marginal cropland. GCB Bioenergy 00. PP.1-15.

Singh, Y., Mishra, S. A. and Dey, P. 2015a. Soil test crop response based gradient experiment on rice (*Oryza sativa* L.) to NPK fertilizers in the alluvial soil of the Indo-Gangetic plains. *Crop Research.* **50:**

Singh, Y., Parihar, M., Singh, S., Sharma, P. and Dey, P. 2015b. Soil test based fertilizer prescriptions under integrated plant nutrient management system for maize in an Inceptisol of Varanasi. *J. of the Indian Society of Soil Sci*. **63:** 83-87.

Srivastava, S., Singh, K. and Rao, A. S. 1999. Fertiliser recommendations for pigeonpea-wheat cropping system based on initial soil test values. *International J.tropical agriculture.* **17:** 83-90.

Stanford, G., English, L., Comstock, R., Robinson, H. and Harvey, P. 1949. 2140261. Use of the flame photometer in rapid soil tests for K and Ca. *Agron. J.* **41:** 446-447.

Suresh, R. and Santhi, R. 2019. Prediction of Post-harvest Soil Test Values and Fertilizer Calibrations for a Maize Based Cropping Sequence under Integrated Plant Nutrition System. *Madras Agricultural J.* **106:**

Udayakumar, S., Basker, K., Bakiyathu Saliha, B. and Jemila, C. 2017. Impact of Integrated Nutrient Management on Soil Fertility and Nutrient Uptake of Ratoon Sugarcane. *Chemical Sciecne Review and Letters.* **6:** 567-573.

Udayakumar, S. and Jemila, C. 2016. Secondary and micronutrient uptake of ratoon sugarcane as influenced by integrated nutrient management strategy. *Himachal J. of Agricultural Research.* **42:** 137-142.

Udayakumar, S. and Santhi, R. 2017. Soil test based integrated plant nutrition system for pearl millet on an Inceptisol. *Research on Crops.* **18:**

Usman, S. and Kundiri, A. 2016. Role of soil science: an answer to sustainable crop production for economic development in sub-Saharan

Africa. *International J. of Soil Sci.* **11:** 61-70.

Velayutham, M., Santhi, R., Rao, A. S., Muralidharudu, Y. and Dey, P. 2016. The'Law of Optimum'and its application for realizing targeted yields in India-a mini-review. *Electronic International Fertilizer Correspondent*.PP. 12-20.

Yargholi, B. and Azarneshan, S. 2014. Long-term effects of pesticides and chemical fertilizers usage on some soil properties and accumulation of heavy metals in the soil (case study of Moghan plain's (Iran) irrigation and drainage network). *International J. of Agriculture Crop Sci.* **7:** 518.