

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.807.246>

Fertilizer Calibrations for Hybrid Brinjal based Cropping Sequence using Post-Harvest Soil Test Values Prediction Equations under Soil Test Crop Response Based Integrated Plant Nutrition System

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ABSTRACT

Field experiments were conducted with hybrid brinjal under IPNS during 2017-18 adopting Inductive cum Targeted yield model (Ramamoorthy *et al*, 1967) to develop post-harvest soil test values (PHSTVs) prediction equations on Visakhapatnam soil series (TypicHaplustept) which is rednon-calcareous. The experiment was laid out in a fractional factorial design comprising twenty four treatments and the test crop experiment with hybrid brinjal was conducted with four levels of each of N (0, 80, 160 and 240 kg ha⁻¹), P₂O₅ (0, 40, 80 and 120 kg ha⁻¹) and (0, 60, 120 and 180 K₂O kg ha⁻¹) and three levels of FYM (0, 12.5 and 25 t ha⁻¹). The IPNS treatments were superimposed across the strips. There were 21 fertiliser treatments along with three controls which were randomized in each strip in such a way that all the treatments occurred in both directions. Using the plot wise initial test values, fertiliser doses and fruit yield and /or uptake of N, P & K by brinjal and post-harvest soil test values, PHSTVs prediction equations were developed. Both the predicted and observed soil test values revealed that the soil fertility was found to decline markedly under unfertilized (control) and increased based on fertiliser doses imposed and soil fertility gradient. Significant R² values 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. Using the predicted PHSTVs of hybrid brinjal soil test based fertiliser prescriptions for desired yield targets of any succeeding crop could be prescribed.

Keywords

STCR-IPNS, Inceptisol, PHSTVs prediction equations, Hybrid brinjal

Article Info

Accepted:

15 June 2019

Available Online:

10 July 2019

Introduction

Soil test crop response correlation studies help in making fertiliser prescription for desired yield of crops and such studies are crop, soil and climate specific. The soil test calibration and fertiliser prescription must be based on yield which should provide

significant correlation between soil test and crop response to fertiliser. Soil testing has to be rechristened as soil quality assessment and it has to assume a holistic role not limited to guide fertiliser prescription for a crop based on soil test but also for a sustainable crop production. Nutrient availability in soil after the harvest of a crop is much influenced by

initial soil nutrient status, the amount of fertiliser nutrients added and nature of crop raised. To apply soil test based fertiliser prescriptions for a cropping sequence, 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 first crop in a sequence which can be done by developing prediction equations. This provides the way for computing the fertiliser prescriptions for a whole cropping sequence based on initial soil test values. This is very useful because the soil of farmer's field under intensive cultivation cannot be tested for each crop for practical reasons. With this background, in the present study, an attempt has been made to predict the post-harvest soil test values for hybrid brinjal so as to prescribe soil test based fertiliser prescriptions for desired yield targets of any succeeding crop after the harvest of hybrid brinjal on Inceptisol of Andhra Pradesh.

Materials and Methods

Field experiments were conducted on a Visakhapatnam soil series (Typic Haplustept) of North Coastal zone of Andhra Pradesh at the Farm of College of Horticulture, Parvathipuram, Dr.YSR Horticultural University. The soil of the experimental field is well drained and sandy loam in texture. The initial soil pH, electrical conductivity, organic carbon, available nitrogen ($\text{KMnO}_4\text{-N}$), available phosphorus (Olsen-P), available potassium ($\text{NH}_4\text{OAc-K}$) were 7.38, 0.35 dSm^{-1} , 5.8 g kg^{-1} , 212 kg ha^{-1} , 26.0 kg ha^{-1} and 240 kg ha^{-1} , respectively. Field experiments were carried out in two phases *viz.*, fertility gradient and test crop experiment as per technical programme of STCR in fractional factorial design comprising twenty four treatments and test crop experiment with hybrid brinjal was conducted with four levels of N (0, 80, 160 and 240 kg ha^{-1}), P_2O_5 (0, 40, 80 and 120 kg ha^{-1}) and K_2O (0, 60, 120

and 180 kg ha^{-1}) and three levels of farm yard manure (FYM - 0, 12.5 and 25 t ha^{-1}). The initial and post-harvest soil samples were collected from each fertility strip after hybrid brinjal and analysed for alkaline $\text{KMnO}_4\text{-N}$ (Subbaiah and Asija, 1956), Olsen -P (Olsen *et al.*, 1954) and $\text{NH}_4\text{OAc-K}$ (Hanway and Heidal, 1952).

Fruit and stalk samples were collected, processed and analysed for N, P and K contents (Piper, 1966) and NPK uptake was computed. Crop was grown to maturity and plot wise fruit yield was recorded periodically and stalk weight was recorded at the end of growing period.

Development of prediction equations for post-harvest soil test values

The post-harvest soil test values were predicted by multiple regression equations, which were obtained by statistical evaluation by function of initial soil test values, applied fertiliser nutrient and fruit yield and/or the uptake of NPK by the crop were used as dependent variable and the post-harvest soil test values (independent variable) were used (Ramamoorthy, 1971).

The functional relationship is as follows:

$$\text{PHS} = f(\text{F, ISTV, yield /nutrient uptake})$$

Where, PHS= Post -harvest soil test value; F= Applied fertiliser nutrient; ISTV= Initial soil test value of available N, P and K.

Mathematical form of equation is, $\text{YPHS} = a + b_1\text{F} + b_2\text{ISTV} + b_3 \text{yield/uptake}$

Where, a= absolute constant and b_1 and b_2 and b_3 = Respective regression coefficients.

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

Results and Discussion

Under intensive cropping, soil testing between two seasons becomes difficult in terms of time, money and labour. At this juncture, the prediction of post-harvest soil fertility (Ramamoorthy *et al.*, 1971) developed using the initial soil test values, fertiliser doses and yield or uptake by the crop gains practical significance for making fertiliser prescriptions for the whole cropping sequence. The predicted 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 fertiliser doses for any desired yield targets of the succeeding crop.

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 harvest of hybrid brinjal and are furnished in Table 1 along with the concerned R^2 values. The results indicated that in case of prediction of $KMnO_4-N$, when hybrid brinjal yield was considered 96.64, 98.41 and 97.46 per cent of variations were accounted; while predictability values were 97.00, 98.56 and 97.00 per cent when nitrogen uptake is considered in NPK alone, NPK+FYM@12.5 t ha⁻¹ and NPK+FYM@ 25 t ha⁻¹ treatments respectively. For the purpose of comparison, the observed and predicted data based on yield and uptake for a set of selected treatments is furnished in Table 2. The observed mean $KMnO_4-N$ was 226.2 kg ha⁻¹ while mean predicted value using fruit yield and uptake were 231.4 and 232.1 kg ha⁻¹ respectively. The mean variation between observed and predicted value were 5.2 and 5.9 kg ha⁻¹ while fruit yield and uptake respectively used.

With respect to the prediction of Olsen-P, when yield was used, the extent of predictability was 94.24, 97.53 and 93.79 per

cent and 94.09, 97.47 and 93.85 per cent while uptake of phosphorus was used in the case of NPK alone, NPK+FYM@ 12.5 t ha⁻¹ and NPK+FYM @ 25 t ha⁻¹ treatments respectively (Table 2). The observed mean Olsen -P value was 32.4 kg ha⁻¹, while mean predicted value using fruit yield and uptake were 34.2 and 34.3 kg ha⁻¹ respectively. The mean variation between observed and predicted value were 1.8 and 1.9 kg ha⁻¹ while fruit yield and uptake were respectively used.

Similarly in the case of $NH_4OAc - K$, the predictability were 94.93, 97.69 and 98.47 per cent while yield was used and 94.91, 97.69 and 98.54 per cent when potassium uptake was used for the prediction of post-harvest soil nutrient status while considering NPK alone, NPK+FYM @ 12.5 t ha⁻¹ and NPK+FYM @ 25 t ha⁻¹ treatments respectively (Table 2). The observed mean $NH_4OAc -K$ value was 248.7 kg ha⁻¹ while the mean predicted value using fruit yield of hybrid brinjal is 251.7 and uptake was 251.9 kg ha⁻¹ respectively. The mean variation between observed and predicted value was 3.0 and 3.2 kg ha⁻¹ while fruit yield and uptake were respectively used.

The results clearly indicated that both 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 ($r=0.97^{**}$), ($r=0.95^{**}$) and ($r=0.97^{**}$) respectively for yield as well as uptake.

The difference between predicted and observed soil test values for the treated plots (five plots in each strip) were found to be very negligible and agree very closely. Analysis for available N, P and K also indicated highly significant relationship with high R^2 value and fall in category of good fit in present study taking a value of R^2 above 0.65 as

criterion for good fit and value of R^2 between 0.45 and 0.65 as moderate fit (Anon, 1973). The R^2 values suggested that the prediction equations could be used with confidence for the prediction of available N, P and K after the harvest of hybrid brinjal to make the soil test based fertiliser recommendations for any succeeding crop.

The prediction equations developed after hybrid brinjal can be used for prescribing fertiliser doses for any succeeding crop after hybrid brinjal. The predicted post-harvest soil test values of brinjal 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 giving fertiliser recommendations for the cropping sequence as a whole from initial soil test values. Such type of prediction equations were reported by Chandrasekhar Rao and Singh (1992) for maize-wheat and maize-wheat-moong sequence, Andi (1998) for sunflower-bhendi sequence in Inceptisol, Coumaravel *et al.*, (2013) for maize-tomato sequence, Praveena *et al.*, (2013) for cotton based sequence, Dey and Das (2014) for rice-wheat, rice-maize and rice-rice sequences, Sarvesh Kumar *et al.*, (2018) in turmeric in Mollisol and AlkaArya *et al.*, 2019 for cauliflower in Mollisol.

Accordingly in the present investigation, the soil test values for $KMnO_4$ -N, Olsen-P and NH_4OAc -K were compared with observed values (actually tested).

Figure 1 and 2 showed that the comparison between observed and predicted soil test values of available N, P and K after brinjal using regression line wherein all points stayed close to the regression line and values were in good agreement with each other as evidenced by highly significant correlation ($r = 0.97^{**}$, 0.97^{**} and 0.99^{**} respectively with both yield and uptake). Similar method of

comparison between the observed and predicted data was also reported by Timsina *et al.*, 1998; Sarvesh Kumar *et al.*, (2018), Praveena Katharine *et al.*, (2013).

From the results obtained for brinjal, 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 'r' values.

Fertiliser recommendations for desired yield targets for hybrid brinjal based on initial soil test values

Using the fertiliser prescription equations (FPEs) for hybrid brinjal and initial soil test values of available N, P and K (212:26:240 kg ha^{-1}), fertiliser recommendations were computed for a range of yield target under NPK alone and IPNS (NPK+FYM @ 12.5 and 25 t ha^{-1}). The post-harvest soil test values were predicted using the PHSTVs prediction equations for hybrid brinjal.

A perusal of the data in Table 3, showed that the quantity of fertilisers required to produce 50, 55 and 60 t ha^{-1} of fruit yield was 170, 208 and 245 kg Nha^{-1} ; 93, 110 and 127 kg $P_2O_5 ha^{-1}$ and 112, 139 and 167 kg $K_2O ha^{-1}$, respectively under NPK alone. When FYM @ 12.5 t ha^{-1} along with fertilisers, the fertiliser requirements were 134, 172 and 209 kg N ha^{-1} ; 73, 90 and 107 kg $P_2O_5 ha^{-1}$ and 83, 110 and 138 kg $K_2O ha^{-1}$. When FYM @ 25 t ha^{-1} along with fertilisers 98, 136 and 173 kg N ha^{-1} ; 53, 65 and 87 kg $P_2O_5 ha^{-1}$ and 54, 81 and 109 kg $K_2O ha^{-1}$.

The predicted post-harvest soil test values were 227, 231 and 234 kg ha^{-1} of $KMnO_4$ -N; 32.1, 33.6 and 35.0 kg ha^{-1} Olsen-P and 247, 252 and 255 kg ha^{-1} NH_4OAc -K respectively, under NPK alone for 50, 55 and 60 t ha^{-1} of yield targets of hybrid brinjal.

Table.1 Prediction equations for post-harvest soil test values (PHSTVs) of available N, P and K for hybrid brinjal

PHSTVs Prediction Equations	R ²
NPK alone	
YPHN = 19.19 + 0.86739** SN + 0.07638** FN + 0.00021** fruit yield	0.9664**
YPHN = 28.67 + 0.79726** SN + 0.06024** FN + 0.10926** uptake	0.9700**
YPHP = -0.88 + 0.915536** SP + 0.07157** FP + 0.00005** fruit yield	0.9424**
YPHP = 0.28 + 0.90378 **SP+0.07608** FP + 0.04618** uptake	0.9409**
YPHK = 4.52 + 0.93725** SK + 0.12496** FK + 0.00007** fruit yield	0.9493**
YPHK = 4.10+ 0.93544** SK + 0.12735** FK + 0.03022** uptake	0.9491**
NPK+ FYM @ 12.5 t ha⁻¹	
YPHN = 13.77 + 0.89581 ** SN + 0.081324** FN + 0.000203** fruit yield	0.9841**
YPHN = 14.20 + 0.902261 **SN + 0.089505**FN + 0.038516** uptake	0.9856**
YPHP = -6.66 + 1.02000 ** SP + 0.08814** FP + 0.00009**fruit yield	0.9753**
YPHP = -5.28 + 0.92186 ** SP + 0.08370** FP + 0.21472 ** uptake	0.9747**
YPHK = 2.13+0.93797 ** SK + 0.11859** FK + 0.00020 **fruit yield	0.9769**
YPHK = -2.30 + 0.94231 ** SK + 0.12196** FK + 0.08977 ** uptake	0.9758**
NPK+ FYM @ 25 t ha⁻¹	
YPHN = 13.26 + 0.85876 ** SN + 0.07309 **FN + 0.00043** fruit yield	0.9746**
YPHN = 14.56 + 0.911314 **SN + 0.10580 ** FN + 0.02143** uptake	0.9700**
YPHP = 1.22 + 0.964313**SP + 0.132731**FP - 0.000018** fruit yield	0.9379**
YPHP = 0.08+ 0.89643 ** SP + 0.1218** FP + 0.096338** uptake	0.9385**
YPHK = 14.97 + 0.94761 ** SK + 0.11056** FK + 0.00004 **fruit yield	0.9847**
YPHK = 16.01 + 0.95903 ** SK + 0.11338** FK - 0.04328** uptake	0.9854**
*Significant at P = 0.05; **Significant at P = 0.01; PH = Post Harvest; FN, FP and FK = Fertiliser doses of N, P ₂ O ₅ and K ₂ O in kg ha ⁻¹ .	

Table.2 Observed and predicted post-harvest soil KMnO₄-N, Olsen-P and NH₄OAc-K for hybrid brinjal

Strip	Treatments	KMnO ₄ -N (kg ha ⁻¹)			Olsen -P (kg ha ⁻¹)			NH ₄ OAc-K (kg ha ⁻¹)		
		Observed	Predicted based on		Observed	Predicted based on		observed	Predicted based on	
			Yield	Uptake		Yield	Uptake		Yield	Uptake
NPK alone										
I	N0P0K0	193	196	197	16.6	18.3	18.8	215	216	216
III	N0P2K2	246	247	248	40.1	37.9	38.0	274	267	264
III	N1P1K1	263	256	256	39.6	40.4	40.5	272	262	263
II	N2P2K2	232	237	235	36.8	36.2	36.0	250	255	255
II	N3P3K3	241	247	247	31.2	39.2	39.2	268	264	264
NPK+FYM @ 12.5 t ha⁻¹										
I	N0P0K0	196	202	204	17.4	17.4	18.1	219	218	219
II	N0P2K2	218	226	225	36.4	30.9	32.0	263	259	260
II	N1P1K1	232	235	235	33.2	34.7	35.2	258	257	257
I	N2P2K2	210	218	217	26.2	27.6	27.2	234	241	242
I	N3P3K3	221	228	229	29.8	31.6	31.6	238	247	247
NPK+FYM @ 25 t ha⁻¹										
I	N0P0K0	190	201	206	17.0	25.2	24.6	218	230	230
I	N0P2K2	196	208	209	30.2	26.6	26.9	241	245	246
I	N1P1K1	218	219	220	26.4	30.7	30.2	230	240	241
III	N2P2K2	260	268	268	51.8	55.0	54.5	273	286	286
III	N3P3K3	277	283	285	52.8	61.8	61.5	277	289	288
	Mean	226.2	231.4	232.1	32.4	34.2	34.3	248.7	251.7	251.9
	'r' value		0.97**	0.97**		0.97**	0.97**		0.99**	0.99**

Table.3 Fertiliser prescription and predicted post-harvest soil test values for hybrid brinjal based on initial soil test values

Yield target (t ha ⁻¹)	Fertiliser Doses (kg ha ⁻¹)			PHSTV (kg ha ⁻¹)		
	N	P ₂ O ₅	K ₂ O	N	P	K
Under NPK alone						
50	170	93	112	227	32.1	247
55	208	110	139	231	33.6	251
60	245	127	167	234	35.0	255
NPK+FYM @ 12.5 t ha⁻¹						
50	134	73	83	228	32.7	250
55	172	90	110	232	34.7	254
60	209	107	138	236	36.7	258
NPK+FYM @ 25 t ha⁻¹						
50	98	53	54	229	37.7	257
55	136	65	81	234	39.9	261
60	173	87	109	239	42.1	264

ISTV: KMnO₄-N = 212 kg ha⁻¹, Olsen-P= 26 kg ha⁻¹, NH₄OAc =240 kg ha⁻¹

Fertiliser Prescription Equations

STCR-NPK alone		STCR-IPNS (NPK+FYM)	
FN	= 0.75T - 0.93 SN	FN	= 0.75 T- 0.93 SN -0.53 ON
FP₂O₅	= 0.34 T - 2.97 SP	F P₂O₅	= 0.34 T- 2.97 SP - 0.83 OP
FK₂O	= 0.55 T - 0.68 SK	F K₂O	= 0.55 T - 0.68 SK - 0.51 OK

FN, FP₂O₅ and FK₂O –fertiliser N, P₂O₅ and K₂O (kg ha⁻¹); T- yield target (q ha⁻¹); SN, SP and SK- Alkaline KMnO₄-N, Olsen-P and NH₄OAc-K (kg ha⁻¹); ON, OP and OK –N, P and K through FYM (kg ha⁻¹)

Fig.1 Comparison between observed and predicted post-harvest $\text{KMnO}_4\text{-N}$, Olsen-P and $\text{NH}_4\text{OAc-K}$ for hybrid brinjal (using yield data)

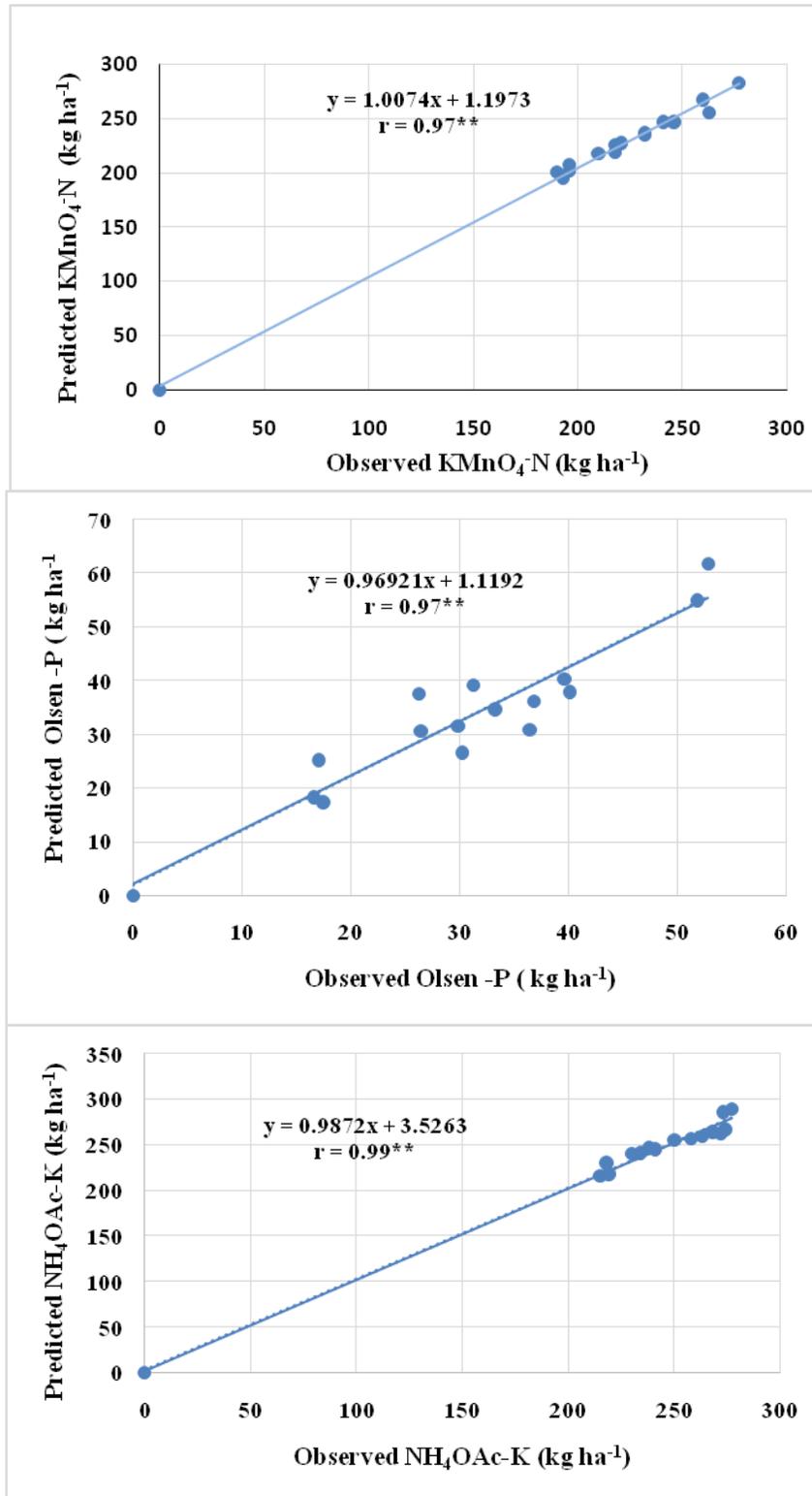
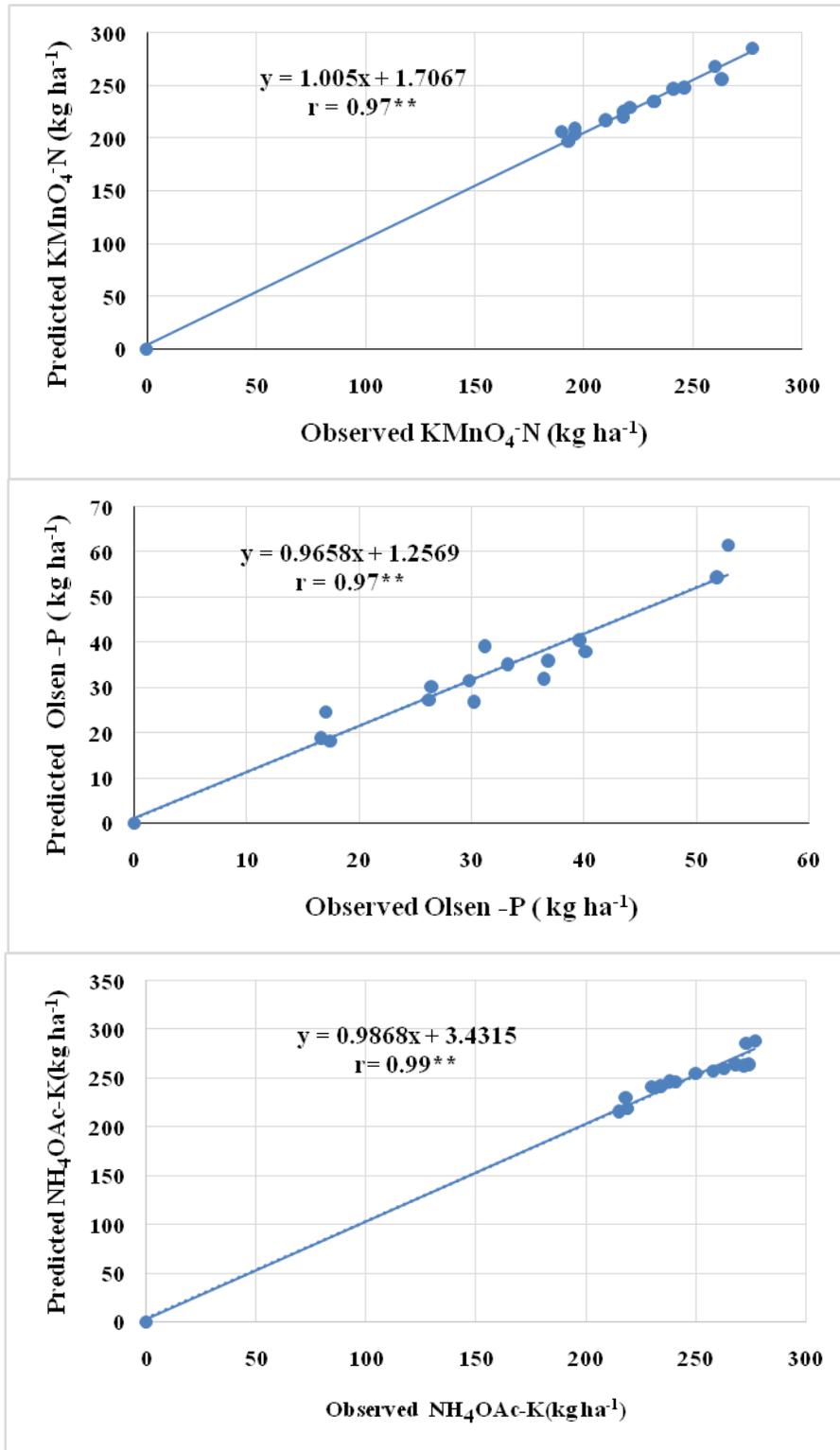


Fig.2 Comparison between observed and predicted post-harvest $\text{KMnO}_4\text{-N}$, Olsen-P and $\text{NH}_4\text{OAc-K}$ for hybrid brinjal (using uptake data)



Similarly the post-harvest soil test values were calculated under NPK+FYM @ 12.5 t ha⁻¹ (IPNS) and values were 228,232 and 236kg ha⁻¹ of KMnO₄-N; 32.7,34.7 and 36.7 kg ha⁻¹ Olsen-P and 250,254 and 258 kg ha⁻¹ NH₄OAc-K, respectively and also in NPK+FYM @ 25 t ha⁻¹ (IPNS) values were 229,234 and 239 kg ha⁻¹ of KMnO₄-N; 37.7,39.9 and 42.1kg ha⁻¹ Olsen-P and 257,261 and 264kg ha⁻¹NH₄OAc-K.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.

The results indicated that irrespective of yield targets, there was built-up of soil available N,P and K and the magnitude was higher with increasing yield targets. Among the three nutrient management practices, the magnitude of built-up was relatively higher with NPK+FYM @25 t ha⁻¹ followed by NPK + FYM @12.5t ha⁻¹ and NPK alone. This high lightened the significance of IPNS in cropping sequence. Similar type of computing fertiliser recommendations were developed by Santhi and Selvakumari (1998) for rice-rice-blackgram, Srivastava *et al.*, (1999) for pigeon pea- wheat and Praveena Katharine *et al.*,(2013) on Inceptisol and Coumaravel *et al.*, (2013) for maize-tomato sequence on Alfisol.

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How to cite this article:

Kirankumar, Ch., R. Santhi, D. Srihari and Maragatham, S. 2019. Fertilizer Calibrations for Hybrid Brinjal based Cropping Sequence using Post-Harvest Soil Test Values Prediction Equations under Soil Test Crop Response Based Integrated Plant Nutrition System. *Int.J.Curr.Microbiol.App.Sci.* 8(07): 2051-2061. doi: <https://doi.org/10.20546/ijcmas.2019.807.246>