__Original Research Article__

Development of soil test based fertilizerprescription equation using integrated nutrient management approach for targeted yield of maize crop in a *Vertisol* of Chhattisgarh plain, India

ABSTRACT

Field experiments were conducted at the research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* 2021, and *kharif* 2022. To study the fertilizer requirement and. Yield performance a regression model was performed to evaluate the variation between yield and fertilizer and found that fertilizer N contribute 87% and 88%(R^2 value 0.87,0.88). When applied through NPK variation found about 91 % and 90% (R^2 value 0.91, 0.90), for recommendation of fertilizer prescription a ready reckoner was prepared based on these equations for a range of soil test values and for yield targets of 50,60 and 70 q ha^{-1} for maize, it was found that for a soil test value of 200 kg ha^{-1} of $KMnO_4$ -N the fertilizer N doses required 91 kg ha^{-1}, 133 kg ha^{-1} and 175 kg ha^{-1}. For a soil test value of 12 kg ha^{-1} of Olsen-P, the dose of fertilizer P_2O_5 required for the yield target was 33 kg ha^{-1},48 kg ha^{-1} , 63 kg ha^{-1} respectively. Similarly for a soil test value of 250 kg ha^{-1} of NH_4OAc-K the fertilizer K doses required 54 kg ha^{-1}, 72 kg ha^{-1}, 91 kg ha^{-1}.

Key word- Nutrient requirement, targeted yield. Fertilizer prescription equation

INTRODUCTION

Maize is a crop that can grow in a variety of agro-climatic conditions and is farmed all year round in India. Because it has the highest genetic yield potential among cereals, maize is known as the "Queen of Cereals". As the third most significant cereal crop in India after rice and wheat, maize accounts for roughly 10% of all food grain production. India's maize acreage has grown to 9.86 million hectares during 2020–21, producing 31.51 million tonnes at a productivity of 3195 kg $ha^{–1}$.

In recent years, nitrogen has become most in demanded fertilizer in India, with phosphorus coming in second. Due to this, the NPK utilisation ratio in 2019–20 was severely out of balance, coming in at 7:2.7:1, as opposed to the ideal ratio of 4:2:1. Due to the uneven nutrient utilisation, the existing situation of nutrient utilization efficiency is rather poor for N (30-50%), P (15- 20%), S (8-12%), Zn (2-5%), Fe (1-2%), and Cu (1-2%). There is a significant lag between crop removal and fertilizer application due to the unbalanced nutrient levels. Therefore, balanced NPK fertilization has garnered a lot of interest in India. To ensure balanced fertilizer application, soil testing is crucial. It also enables farmers to utilize fertilizers in accordance with the requirements of their crops. fertilizer application based on targeted yield.

Chart 1 :Treatment Details

Treatment No	Block A N:P: K	Treatment No	Block B N:P: K	Treatment No	Block C N:P: K
T1	180:60:60	T9	120:60:30	T17	180:90:60
T2	120:90:60	T10	120:0:60	T18	0:0:0
T3	180:30:30	T11	180:60:30	T19	180:90:90
T4	60:60:60	T12	120:60:90	T20	180:90:30
T5	120:60:60	T13	120:30:30	T21	180:60:90
T6	120:30:60	T14	60:30:30	T22	120:90:90
T7	120:60:0	T15	0:0:0	T23	60:30:60
T8	0:0:0	T16	60:60:30	T24	0:60:60

Nutrient Requirement (NR

$$\text{a) Kg N required per quintal grain production} = \frac{\text{Uptake of N (kg/ha.)from grain+straw}}{\text{Green cob yield (q/ha.)}}$$

$$\text{b) Kg P required per quintal grain production} = \frac{\text{Uptake of P2O5 (kg/ha.)from grain+straw}}{\text{Green cob yield (q/ha.)}}$$

$$\text{c) Kg N required per quintal grain production} = \frac{\text{Uptake of K2O (kg/ha.)from grain+straw}}{\text{Green cob yield (q/ha.)}}$$

Percent contribution of nutrients from soil to the total nutrientuptake (Cs).

$$\text{a) Contribution of N from soil (\%)} = \frac{\text{Uptake of N (kg/ha) from grain+straw from control plot}}{\text{Soil test value for available N (kg/ha) from control plot}} \times 100$$

$$\text{b) Contribution of P from soil (\%)} = \frac{\text{Uptake of P2O5 (kg/ha) from grain+straw from control plot}}{\text{Soil test value for available P2O5 (kg/ha) from control plot}} \times 100$$

$$\text{c) Contribution of K from soil (\%)} = \frac{\text{Uptake of K2O (kg/ha) from grain+straw from control plot}}{\text{Soil test value for available K2O (kg/ha) from control plot}} \times 100$$

Percent contribution of nutrients from fertilizers to the totalnutrient uptake (Cf).

$$\text{a) Contribution of N from fertilizer (\%)} = \frac{\left\{\text{Uptake of N in kg ha}^{-1}\text{ from grain + straw}\right\} - \left\{\text{Soil test value for available N in kg ha}^{-1} \times \text{Percent contribution of N from soil / 100}\right\}}{\text{Fertilizer N applied in kg ha}^{-1}} \times 100$$

$$\text{b) Contribution of } P_2O_5 \text{ from fertilizer (\%)} = \frac{\left\{\text{Uptake of } P_2O_5 \text{ in kg ha}^{-1}\text{ from grain + straw}\right\} - \left\{\text{Soil test value for available } P_2O_5 \text{ in kg ha}^{-1} \times \text{Percent contribution of } P_2O_5 \text{ from soil /100}\right\}}{\text{Fertilizer } P_2O_5 \text{ applied in kg ha}^{-1}} \times 100$$

$$\text{c) Contribution of } K_2O \text{ from fertilizer (\%)} = \frac{\left\{\text{Uptake of } K_2O \text{ in kg ha}^{-1}\text{ from grain + straw}\right\} - \left\{\text{Soil test value for available } K_2O \text{ in kg ha}^{-1} \times \text{Percent contribution of } K_2O \text{ from soil /100}\right\}}{\text{Fertilizer } K_2O \text{ applied in kg ha}^{-1}} \times 100$$

Yield targeting equations.

From the above parameters, the yield targeting equations were calculated, which are as follows:

$$FN = \left[\frac{NR}{Cf} \times Y \right] - \left[\frac{Cs}{Cf} \times SN \right] - \left[\frac{CFYM}{Cf} \times FYM\ (t\ ha^{-1}) \right]$$

$$FP_2O_5 = \left[\frac{NR}{Cf} \times Y \right] - \left[\frac{Cs}{Cf} \times 2.29 \times SP \right] - \left[\frac{CFYM}{Cf} \times FYM\ (t\ ha^{-1}) \right]$$

$$FK_2O = \left[\frac{NR}{Cf} \times Y \right] - \left[\frac{Cs}{Cf} \times 1.21 \times SK \right] - \left[\frac{CFYM}{Cf} \times FYM\ (t\ ha^{-1}) \right]$$

Where,

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

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

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

NR = Nutrient requirement of N or P2O5 or K2O kg q^{-1}

Cs = Per cent contribution from soil

Cf = Per cent contribution from fertilizer

CFYM = Per cent contribution from FYM

SN = Soil test value for available N (kg ha^{-1})

SP = Soil test value for available P (kg ha^{-1})

SK = Soil test value for available K (kg ha^{-1})

Y = Yield target (q ha-1)

FYM = Farmyard manure (t ha^{-1})

Truog (1960) described the 'prescription method' for using fertilizers to obtain higher yields of maize crop with the help of empirical values of nutrient availability from fertilizer and soil. Ramamoorthy *et al.* (1967) validated the theoretical basis and experimental proof for Liebig's 'Law of Minimum' to equally operate well for N, P and K for the high yielding varieties of rice, wheat and pearl millet. The significance of P and K for determination of the response of crops to N and the essentiality of balanced nutrition in obtaining ~~the~~ efficiency in fertilizer use has been demonstrated (Ramamoorthy *et al.*, 1967; Ramamoorthy and Pathak, 1969). This paved way for the concept of 'targeted yield' for fertilizer recommendations. For obtaining a given yield, a certain amount of nutrients should be consumed by the plant (both from the fertilizers and soil) is illustrated from the linear relationship obtained between the level of yield and N,P and K uptake. The amount of fertilizer needed can thus be estimated, once this requirement is determined for given yield, taking into consideration the amounts contributed from available nutrients in soil and those contributed from fertilizers andorganic manures in addition.

statistical Analysis.

After considering the basic parameters, fertilizer adjustment equations were derived with the help of STCR software, which is made available from the All India Coordinated Research Project on Soil Test- Crop Response Correlation, Indian Institute of Soil Science, Bhopal. Multiple regression analysis was performed to test the relationship between the actual post-harvest soil test values, and the initial soil test values, fertilizers applied and crop yield response.

Result and Discussion

Status of available NPK in soil during kharif 2021 and *kharif* 2021.

Soil samples were collected from each plot and analysed for N, P, K before sowing of maize as a main crop. The minimum value, maximum and mean values of available N, P,K during *kharif* 2021 and *kharif* 2022 are given in (Table 1). The result observed that there was not significant variations in soil available nitrogen across the strip, while the mean values of initial soil test value was increasing Strip L0 to L2. The mean value of available nitrogen varies from 213.55 kg ha^{-1}, 214.81 kg ha^{-1}, 220.53 kg ha^{-1} during kharif 2021 and the mean values of available nitrogen was varies from 214.59 kg ha^{-1}, 216.18 kg ha^{-1}, 223.20 kg ha^{-1} during kharif 2022, respectively. The soil available phosphorus and potassium also showed increasing trend within each strip. The mean values of available phosphorus varies from 13.07 kg ha^{-1}, kg ha^{-1},19.46 kg ha^{-1}, 26.49 kg ha^{-1} during *kharif* 2021 and from 14.81 kg ha^{-1}, 21.23 kg ha^{-1}, 28.11 kg ha^{-1}during kharif 2022. Similarly for available potassium mean values varies from 428.72 kg ha^{-1}, 445.17 kg ha^{-1}, 456.25 kg ha^{-1} during *kharif* 2021 and from 432.15 kg ha^{-1}, 448.88 kg ha^{-1}, 460.061 kg ha^{-1} during *kharif* 2022 respectively. The fertility variation within the strip may also be due to application of FYM across the strip. The result indicated that the coefficient of variance high in case of phosphorus (31.68, 32.61%) within the strip due to phosphorus immobility and fixation in soil.

Table-1.Range and mean values of soil available N, P, K (kg ha^{-1}) before sowing of maize during kharif 2021 and kharif 2022.

	Kharif 2021					Kharif 2022				
Parameters kg ha^{-1}	**Strip I (L0)**	**Strip II (L1)**	**Strip III (L2)**	**SD**	**CV (%)**	**Strip I (L0)**	**Strip II (L1)**	**Strip III (L2)**	**SD**	**CV(%)**
Alkaline $KMnO_4^-$ N	190.70-238.3 (213.55)	192.70-243.3 (214.81)	198.30-244.6 (220.53)	**12.15**	**5.62**	195.70-236.24 (214.59)	195.70-245.34 (216.18)	200.24-240.61 (223.20)	**11.93**	**5.51**
Olsen's P	10.60-17.4 (13.07)	13.50-25.4 0(19.46)	19.50-33.9 0(26.49)	**6.23**	**31.68**	9.32-17.38 (14.81)	13.11-25.45 (21.23)	19.03-35.85 (28.11)	**6.32**	**32.61**

Neutral normal Amm. acetate extractable K	390.99-462.80 (428.72)	401.10-517.53 (445.17)	406.72-527.42 (456.25)	**33.40**	**7.53**	394.25-466.25 (432.15)	404.44-521.84 (448.88)	410.11-531.81 (460.06)	**33.66**	**7.83**

Evaluation of response of maize to added nutrient.

The result of grain yield of maize presented in (Table 2).it indicate that grain yield increase within the strip from L0 to L2 due to fertility gradient and different dose of fertilizer application. The highest yield was observed 77.56 q ha^{-1} , lowest yield was obtained 21.13 q ha^{-1} with a mean value (54.45 q ha^{-1}) in all strip during both cropping seasons respectively. The finding demonstrates that the maximum yield of kharif 2021 was 78.86 q ha^{-1} in strip L2 and lowest yield was obtained 18.92 in strip L0 with mean values (51.29 to 58.55 q ha^{-1}) respectively. Similar result also observed in *kharif* 2022 ,lowest yield was 20.80 q ha^{-1} with a mean value (49.60-56.96 q ha^{-1}) and maximum yield was recorded 77.06 q ha^{-1} respectively.

Table-2 . Yield response of maize to added nutrients.

Yield of Maize q ha^{-1} during kharif 2021					
STRIP	**Min**	**Max**	**Mean**	**S.D.**	**C.V. (%)**
L0	18.92	65.85	51.29	14.68	28.62
L1	26.45	72.20	55.52	13.82	24.90
L2	29.47	78.86	58.55	14.78	25.25

Yield q ha^{-1} (Whole Experiment 2021					
	Min	**Max**	**Mean**	**S.D.**	**C.V. (%)**
All Strips	18.92	78.86	55.11819	14.54096	26.38142
Yield q ha^{-1} (Strip Wise)					
STRIP	**Min**	**Max**	**Mean**	**S.D.**	**C.V. (%)**
L0	20.80	67.86	49.60	14.33	28.89
L1	24.07	71.2	53.94542	13.81869	25.61606
L2	28.33	77.06	56.96	14.78	25.95
Yield of Maize q ha^{-1} during kharif 2021					
	Min	**Max**	**Mean**	**S.D.**	**C.V. (%)**
All Strips	20.80	77.06	53.50	14.43	26.98

		Pooled Yield of Maize q ha^{-1}			
	Min	**Max**	**Mean**	**S.D.**	**C.V. (%)**
All Strips	20.13	77.96	54.45	14.45	26.61

Regression Model For Maize

Regression analysis was performed for both the cropping years (2021 and 2022) to determine the relation of grain yield of maize (as a dependent variable) with the applied N, P, K, FYM, and initial soil test values of N, P, K as independent variables (Table 3). Results found that fertilizer N contribute 87% and 88% (R^2 value 0.87,0.88). When it applied through NPK it contributed 91 % and 90% (R^2 value 0.91, 0.90), application of NPK with FYM it contributed 93% and 92% (0.93, 0.92) in both cropping season of maize respectively. Application of fertilizer N and P explained the 92% and 90% yield variation, whereas application of N and K shows 90 % and 89% as reflected in yield variation. It indicated that N levels accounted for a greater proportion of variation in the grain yield of maize. Its quadratic term gave better into the data which is conspicuous from the R^2 (coefficient of determination) value of 0.89 and with curvilinear equation (Eq. no.16 and 35) for both the cropping years. This shows that the response of maize yield was highly attributed to the higher requirement of N and since N is mobile in nature in the soils, it gets easily available to the crops in the root system sorption zone (Ramamoorthy *et al.*, 1967). The rest of the variations were explained by fertilizer P_2O_5 and K_2O. As soon as P is applied to the soil it gets fixed in the soil after its reaction with the soil constituents and forms inorganic compounds and thus, gets inaccessible to the plant roots. It has been recorded in various studies that even a small change in the rate of fertilizer NPK cause significant variation in growth and yield parameters of maize (Gong *et al.* 2011; Mahama *et al.* 2016).

Table-3 Regression model for yield variation of maize during kharif 2021 and kharif 2022.

S.NO	**REGRESSION MODEL FOR MAIZE 2021**	**R^2**
1.	Y= 31.82 +0.21FN	0.87
2.	Y= 37.89+0.34FP	0.49
3.	Y= 42.90+0.26FK	0.27
4.	Y= 5280+0.46FYM	0.017

5.	Y=	29.50+0.21FN+0.46FYM	0.89
6.	Y=	35.58+0.34FP+0.46FYM	0.51
7.	Y=	40.59+0.26FK+0.46FYM	0.29
8.	Y=	29.42+0.18FN+0.11FK	0.90
9.	Y=	30.23+0.20FN+0.06FP	0.92
10.	Y=	35.91+0.29FP+0.10FK	0.52
11.	Y=	29.00+0.18FN+0.10FP+0.02FK	0.91
12.	Y=	26.68+0.18FN+0.10FP+0.02FK+0.46FYM	0.93
13.	Y=	-4.77+0.18SN+0.18FN	0.88
14.	Y=	29.72+0.53SP+0.29FP	0.54
15.	Y=	40.77+0.0032SK+0.25FK	0.52
16.	Y=	$29.49 + 0.31FN - 0.00051FN^2$	0.89
17.	Y=	$35.25 + 0.52FP - 0020FP^2$	0.51
18.	Y=	$39.20 + 0.54FK - 0.00003FK^2$	0.31
19.	Y=	$52.81 + 0.44FYM + 0.0017FYM^2$	0.011
	REGRESSION MODEL FOR MAIZE 2022		
20.	**Y=**	30.28+0.21FN	0.88
21.	**Y=**	37.33+0.32FP	0.44
22.	**Y=**	41.59+0.25FK	0.26
23.	**Y=**	51.27+0.44FYM	0.016
24.	**Y=**	28.04+0.21FN+0.44FYM	0.90
25.	**Y=**	35.10+0.32FP+0.44FYM	0.46

26.	**Y=**	39.35+0.25FK+0.44FYM	0.28
27.	**Y=**	28.50+0.19FN+0.08FP	0.90
28.	**Y=**	28.87+0.20FN+0.05FK	0.89
29.	**Y=**	35.19FP+0.10FK	0.47
30.	**Y=**	28.012+0.18FN+0.07FP+0.03FK	0.90
31.	**Y=**	25.77+0.18FN+0.07FP+0.03FK+0.44FYM	0.92
32.	**Y=**	-7.20+0.187SN+0.186FN	0.89
33.	**Y=**	29.30+0.53SP+0.27FP	0.49
34.	**Y=**	35.38+0.015SK+0.24FK	0.26
35.	**Y=**	$28.21+0.30FN-0.00045FN^2$	0.89
36.	**Y=**	$30.06+0.50FP-0.002FP^2$	0.46
37.	**Y=**	$37.70+0.55FK-0.003FK^2$	0.30
38.	**Y=**	$51.38+0.31FYM+0.03FYM^2$	0.016

Established a relation between maize grain yield and uptake.

A close association was observed between the yield of maize and total N, P, K uptake during both ~~the~~ crop seasons (2021 and 2022). This relation was used to estimate the nutrient requirement for maize. The nutrient requirement (NR) is defined as the amount of nutrient required to produce unit amount of yield. The nutrient requirement can be given by the regression coefficient (b1) of yield (Y) and total nutrient uptake (U).

$$\mathbf{Y = b1\ U \text{ or } U = 1/b1 * Y}$$

Where 1/b1 gives the NR (Nutrient Requirement)

Table 4. Relation of Maize yield (Y) with total nutrient uptake (U)

Nutrient	2021		2022	
	Y=b1 U	R^2	Y=b1 U	R^2

N	1.62	0.95	1.62	0.94
P	3.17	0.90	3.04	0.89
K	0.49	0.93	0.51	0.92

Nutrient requirement of N, P and K for Maize.

The result shown in (Table 5) showed that to produce one quintal of maize required 1.62 kg of N, 0.33 kg of P_2O_5, and 2.09 kg of K_2O were required. Among the three nutrients, the requirement of K_2O was the highest followed by N and P_2O_5. The requirement of K_2O was 30 times higher than N and 409 times higher than P_2O_5. Singh et al. (2015) have reported that 19.4 kg of N, 5.70 kg of P_2O_5, and 18.4 kg of K_2O required for producing 1t of maize grain. Xalxo et al. (2018) have recorded 1.59 kg N, 0.32 kg P, 1.84 kg K requirement for 1 q maize grain production. Sivaranjani et al. (2018) have reported 1.76 Kg of N, 0.58 Kg of P_2O_5, 1.62 Kg of K_2O required to produce 1 quintal of hybrid maize.

Table 5. Nutrient requirements, for Maize.

Nutrient	Nutrient requirement for one quantal grain yield of Maize (kg/q)		
	2021	2022	Mean
N	1.63	1.62	1.62
P	0.32	0.33	0.33
K	2.11	2.08	2.09

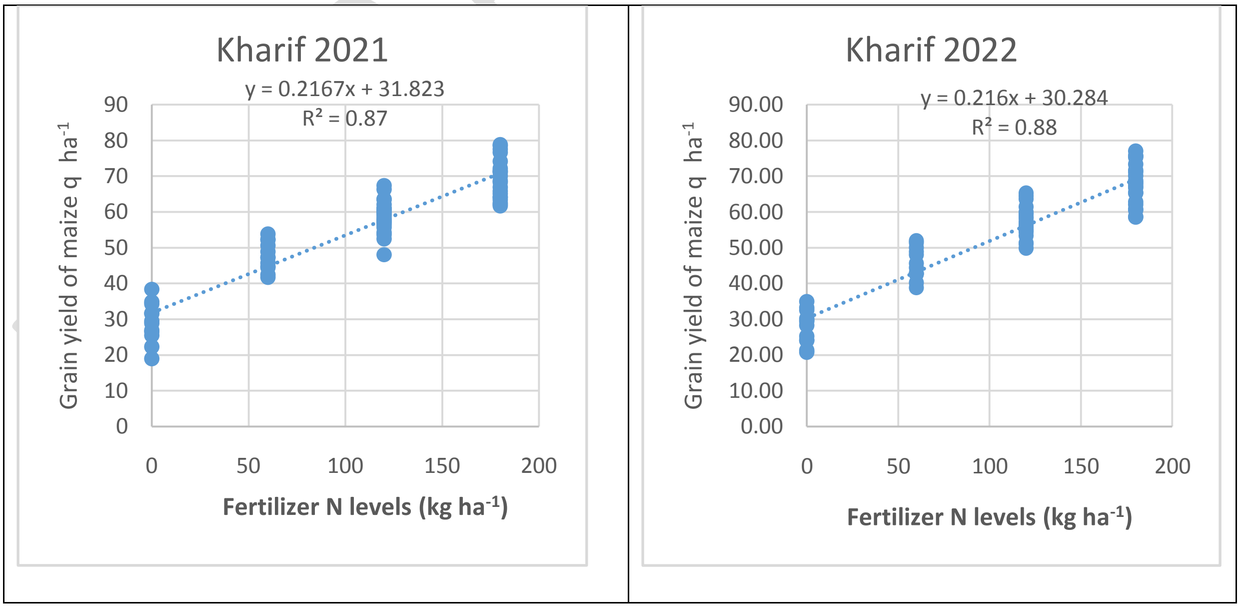

Fig.1. Response of maize to fertilizer N application at all levels of fertilizer P, K, FYM.

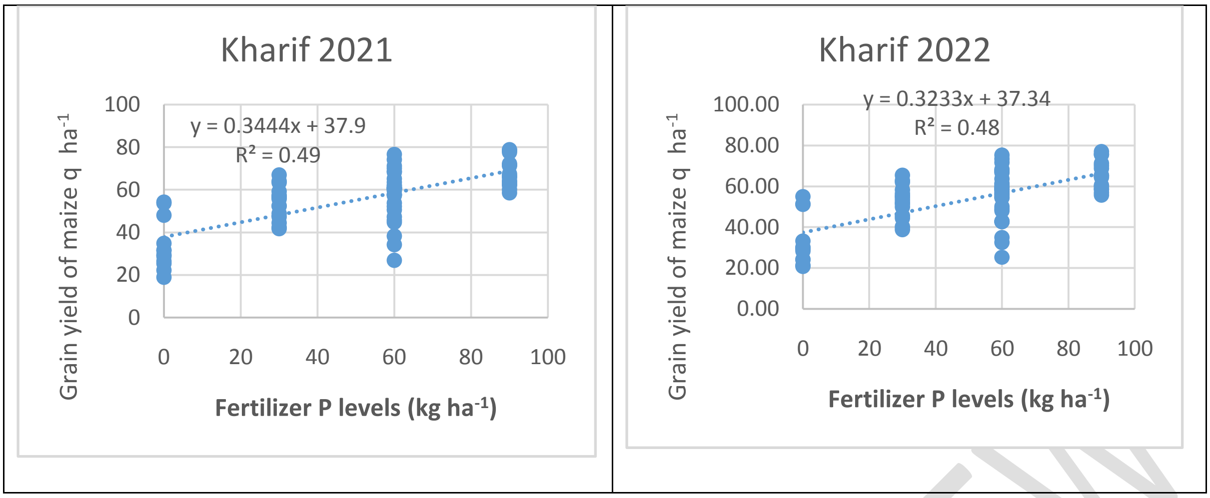

Fig. 2. Response of maize to fertilizer P application at all levels of fertilizer N, K, FYM.

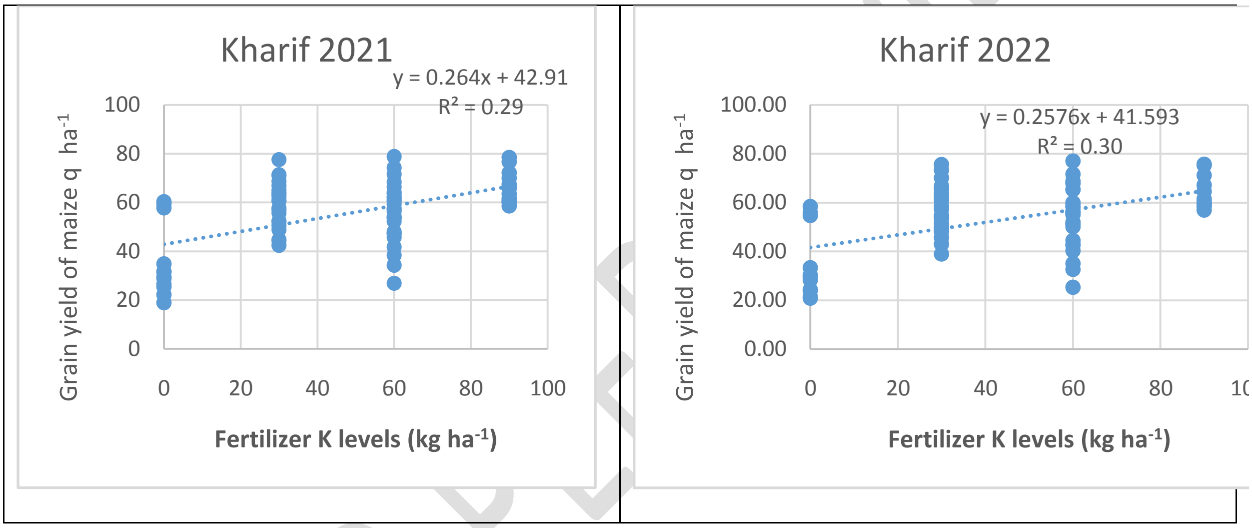

Fig.3. Response of maize to fertilizer K application at all levels of fertilizer N, P, FYM.

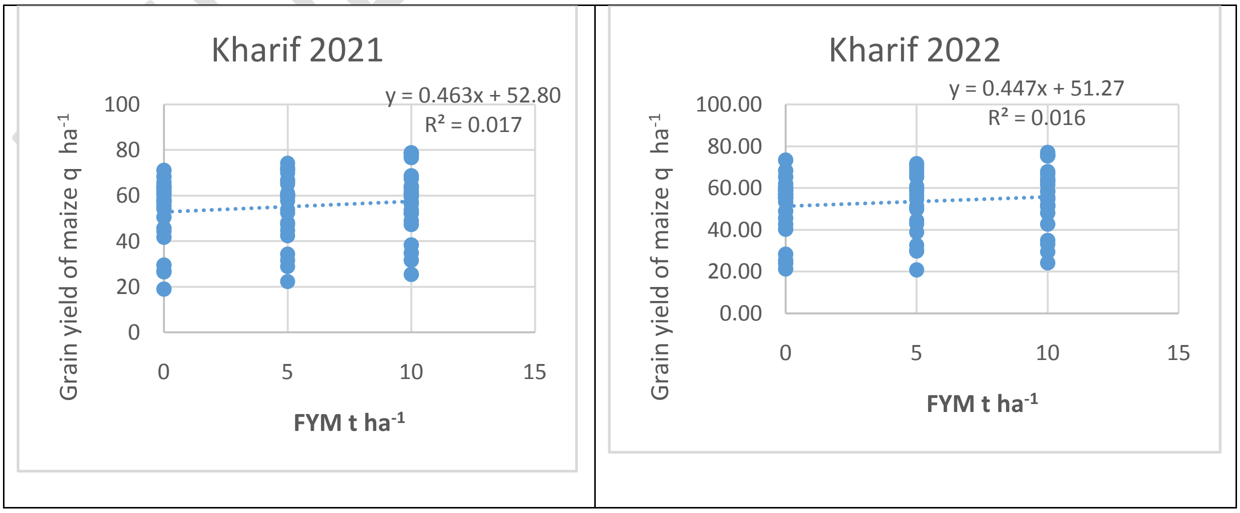

Fig-4. Response of maize to FYM application at all levels of fertilizer N, P, and K.

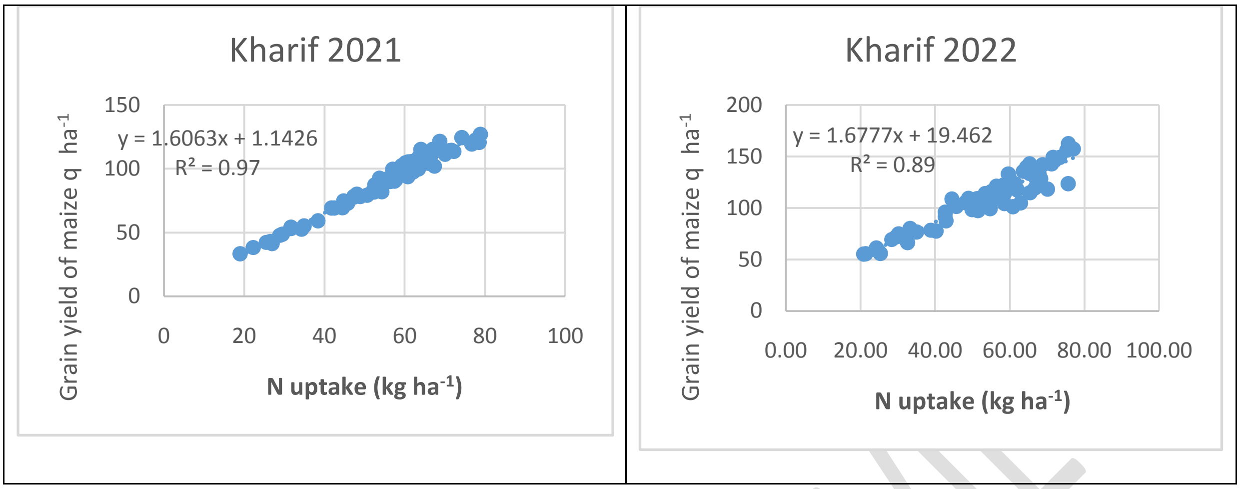

Fig. 5. Relationship between grain yield of maize and total N uptake of maize.

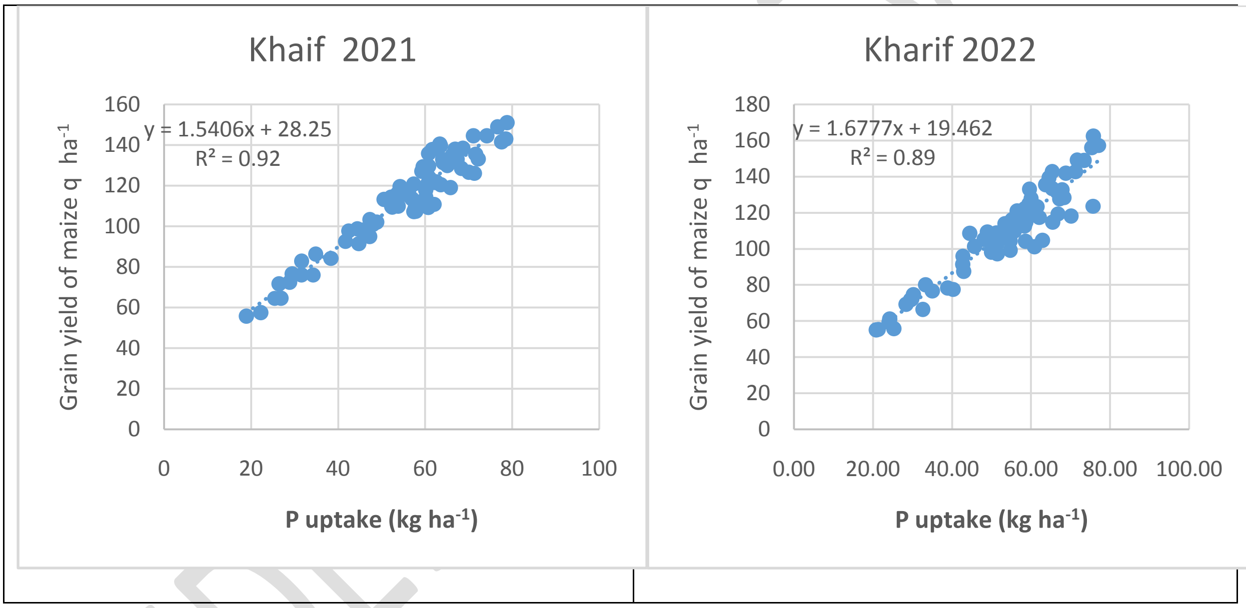

Fig. 6. Relationship between grain yield of maize and total P uptake of maize.

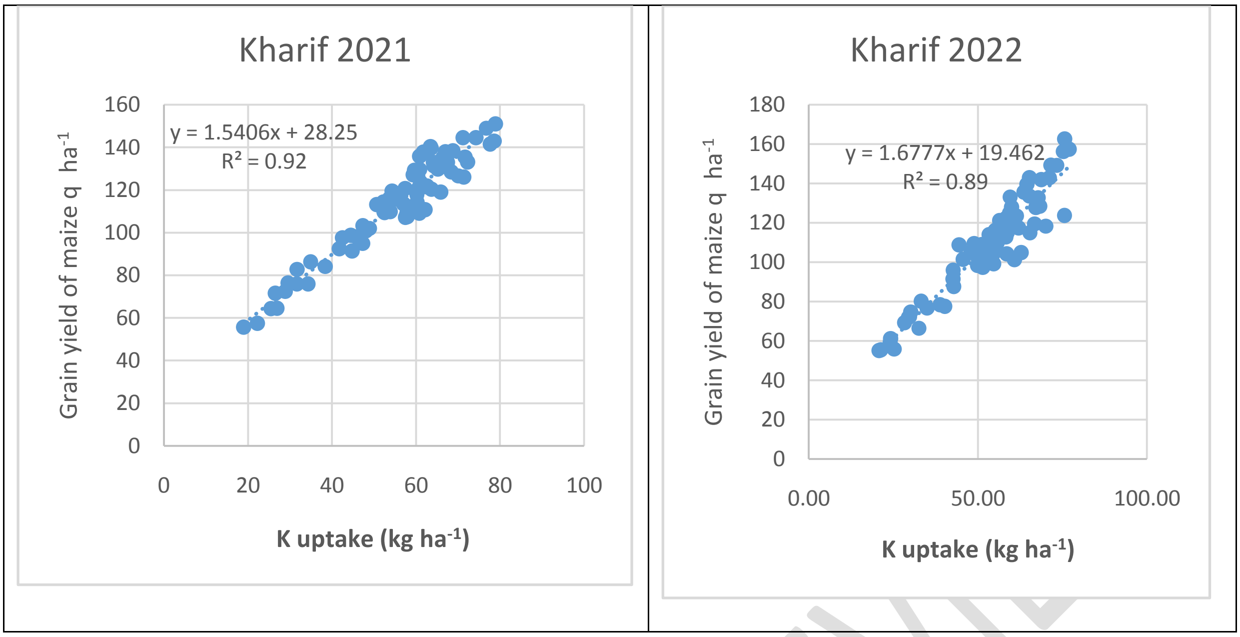

Fig. 7. Relationship between grain yield of maize and total K uptake of maize.

Fertilizer prescription equations based on soil test to achieve the desired yield of Maize.

Fertilizer adjustment equations were evolved for maize crop to achieve a definite yield target based on the basic parameters viz. nutrient requirement, efficiencies of fertilizer, soil test, and organic source (FYM). The following equations given in (Table 6).

Table 6. Soil test-based fertilizer prescription equations for desired yield target for Maize.

S. No.	Fertilizer adjustment equations for maize
1	**FN= 4.21 Y – 0.58 SN - 0.21 ON**
2	**FP = 1.50 Y – 3.28 SP - 0.91 OP**
3	**FK = 1.87 Y – 0.15 SK - 0.05 OK**

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

Ready reckoners chart for fertilizer recommendation for desired yield target of Maize.

A ready reckoner table was prepared based on these equations for a range of soil test values and for yield targets of 50,60 and 70 q ha^{-1} for maize (Table 7.) the data revealed that the fertilizer N, P_2O_5, and K_2O requirements decreased with increase in soil test values and for same soil test value fertilizer requirement increase with increase yield of crop. For achieving a yield target of 50 q ha^{-1}, 60 q ha^{-1}, and 70 q ha^{-1} of maize, for a soil test value of 200 kg ha^{-1} of $KMnO_4$-N the fertiliser N dose recorded 91 kg ha^{-1}, 133 kg ha^{-1}, and 175 kg ha^{-1} respectively. For a soil test value of 12 kg ha^{-1} of Olsen-P, the dose of fertilizer P_2O_5 recorded for the yield target of 50 q ha^{-1},60 q ha^{-1}, and 70 q ha^{-1} was 33 kg ha^{-1},48 kg ha^{-1} and 63 kg ha^{-1} respectively. Similarly for achieving a yield target of 50 q ha^{-1}, 60 q ha^{-1}, and 70 q ha^{-1} of maize, for a soil test value of 250 kg ha^{-1} of NH_4OAc-K the fertiliser K dose required 54 91 kg ha^{-1},72 91 kg ha^{-1} and 91 kg ha^{-1} respectively.

Table 7. Ready Reckoners for soil test-based fertilizer N, P_2O_5 and K_2O with 5 tons of FYM recommendation for Maize.

Soil Test values (kg/ha)			Yield Target of Maize (q/ha)								
			50 (q/ha)			60 (q/ha)			70 (q/ha)		
N	**P**	**FK**	**FN**	**FP**	**FK**	**FN**	**FP**	**FK**	**FN**	**FP**	**FK**
150	4	200	120	59	61	162	74	80	204	89	99
175	6	225	105	53	58	147	68	76	189	83	95
200	8	250	91	46	54	133	61	72	175	76	91
225	10	275	77	39	50	119	54	69	161	69	87
250	12	300	62	33	46	104	48	65	146	63	84
275	14	325	48	26	42	90	41	61	132	56	80
300	16	350	33	20	39	75	35	57	117	50	76
325	18	375	19	13	35	61	28	54	103	43	72
350	20	400	5	7	31	47	22	50	89	37	69
375	22	425	0	0	27	32	15	46	74	30	65

400	24	450	0	0	24	18	8	42	60	23	61

Conclusion

From the above finding, it can be concluded that integrated nutrient application through organic manure and inorganic fertilizer superior over the sole application of inorganic fertilizer alone in recording both higher yield and nutrient uptake by maize. The IPNS improves ~~the~~ soil fertility which helps to achieve sustained yield in maize with less environmen pollution. Moreover, STCR based fertilizer recommendation gives idea about yield target can be achieved with good agronomic practices and also STCR based fertilizer recommendation increases the profit by achieving higher yield and reduce the cost of cultivation by fertilizers savings.

Reference:-

Gong, Y., Guo., Z., He, L. and Li, J. 2011. Identification of maize genotypes with high tolerance or sensitivity to phosphorus deficiency. J Plant Nutr., 34(9): 1290–1302. doi:10.1080/01904167.2011.580816.

Mahama, G.Y., Vara Prasad, P.V., Roozeboom, K.L., Nippert, J.B. and Rice, C.W. 2016. Response of maize to cover crops, fertilizer nitrogen rates, and economic return. Agron J., 108(1):17–31. doi:10.2134/agronj15.0136.

Ramamoorthy, B. and Pathak, V.N. 1969. Soil Fertility Evaluation - Key to Targeted Yields. Indian Fmg. 18(3):29-33.

Ramamoorthy, B. and Velayutham, M. 1971. Soil Test-Crop Response Correlation Work in India. World Soil Resources Report No. 41:96-102. FAO, Rome.

Ramamoorthy, B., Narasimham, R.L. and Dinesh, R.S. 1967. Fertilizer Application for Specific Yield Targets of Sonora 64 (wheat). Indian Fmg, (5). 17:43-45.

Ramamoorthy, B., Velayuthan, M. and Mahajan. V.K. 1974. Recent trends in making fertilizer recommendation based on soil test under fertilizer resource constraints in India. In: Proc. FAI/FAO Natl. Seminar, New Delhi. pp. 335- 346.

Sivaranjani, C., Sellamuthu, K.M. and Santhi, R. 2018. Refinement of Fertilizer Prescription Equations for Hybrid Maize under Integrated Plant Nutrient System on an Inceptisol. Int. J. Curr. Microbiol., App. Sci. 7(2): 3670-3679.

Truog, E. 1960. Transaction, Seventh International Congress Soil Sci., 4 (7): 46-52.

Xalxo, A., Srivastava, L.K., Singh, M., Mishra, M. and Patel, P. 2018. Soil Test - Crop Response Correlation with Maize under IPNS System in Inceptisols of Surguja Hills Zone of Chhattisgarh, India. Int. J. Curr. Microbiol. App. Sci., 7(1): 408-411.