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Effect of validation of fertilizer prescription equations of kharif grain maize on grain and stover yield

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Abstract
Main experiment was conducted on experimental farm of the Soil Test Crop Response Correlation Project, M.P.K.V Rahuri for evaluation of a scientific basis for calculating the "Nutrient requirement of maize by conjoint use of FYM and chemical fertilizers based on targeted yield approach on Inceptisol". The experiment was conducted on Inceptisol (Pather series, *Vertic Haplustepts*) during the year 2009-10, based on the fertility gradient approach The validity of these equations were tested by conducting nine follow up trials of maize grain on three soil series of Entisol (*Viz.* Karwali, Rahuri and Akole),three soil series of Inceptisol (*Viz.* Pather,Beed and Kolyachiwadi) and three soil series of Vertisol (*Viz.* Targaon, Ambulga and Babulgaon) during *Khari* of 2010-11 Post Graduate Farm, Dairy farm and D block, M.P.K.V. Rahuri. The results revealed that the fertilizer application as per yield target 60, 80 and 100 q ha-1 + 10 t ha-1 FYM to maize crop for validation on different soil series of Entisol (viz., Karwali, Rahuri and Akole), Inceptisol (viz., Pather, Beed and Kolyachiwadi) and Vertisol (viz.,Targaon, Ambulga and Babulgaon) were achieved the targeted yield with (+ 10%). Thus, fertilizer prescription equation for grain maize developed on Inceptisol can be suitable for Entisol and Vertisol soil order. However, it was more resembling with Vertisol than Entisol.

Keywords: Effect of validation, fertilizer prescription, kharif grain, stover yield

Introduction
Maize (*Zea mays L.*) is important cereal crop of the world serving as food for man and forage for cattle. It is called as "Queen of Cereals" and "King of Fodder" due to its great importance in human and animal diet. Besides as a food grain crop, maize plays a vital commercial role in Indian economy. It is used as raw material for manufacture of syrup, alcohol, starch, glucose, paper, adhesives, synthetic rubber, resins, acetic acids, lactic acids etc., the demand for which is increasing day by day. The green plant also serves as palatable fodder for cattle. Besides this, the maize produce in our country is being also utilized by poultry industries. A judicious use of fertilizers is essential since the cost of fertilizers has gone up very high in recent years. The targeting of crop yields is of importance so as to obtain varying production levels and to monitor the stress on soil fertility, since exhaustion of the nutrients from the soil are directly proportional to the yield level obtained. This also ensures judicious use of fertilizers and allows to alter the profit per unit investment of fertilizers. Targeted yield approach was first developed by Troug (1960) and Ramamoorthy (1967) [2]. established theoretical basis and experimental technique to suit Indian conditions. Soil test based fertilizer recommendations result in efficient fertilizer use and maintenance of soil fertility. Soil test and crop response (STCR) approach is based on soil contribution and yield level is used for recommending fertilizer dose. The targeted yield concept which is being widely followed since 1967 in All India Co-ordinated Research Project on STCR, which employs multiple regression equation to study the nutrient interactions. STCR approach appears to be a viable technology to sustain higher crop productivity and assure better soil quality under intensive agriculture system. The IPNS based STCR equations are useful for deciding the appropriate dose of chemical fertilizers in conjunction with the organic manures.

Materials and Methods
The field experiment with Maize crop was conducted during 2010-2011 on soil series of Entisol (viz- Karwali Rahuri, Akole), Inceptisol (viz- Pathar, Beed, Kolyachiwadi) and Vertisol (viz-Targaon, Ambulga, babulgaon) at cental campus, Mahatma Phule Krishi

Vidyapeeth, Rahuri (M.S.). The experimental farm is located under semi-arid tropics with an annual rainfall varying from 307 to 619 mm. The average annual precipitation during experiment period was 520 mm. The soil of these sites are varying in their physicsl and chemical properties. The Entisols are recently formed shallow soils, no subsurface diagnostic horizon. The soil series of experimental plot were grouped under the order Entisol comprising members of loamy, isohyperthermic and taxonomically classified as *Typic Ustorthents*. The Inceptisol soil order has a cambic horizon with its upper boundry within 100 cm of the mineral soil surface and its lower boundry at a depth of 25 cm or more below the mineral soil surface. The soils of experimental plot were grouped under the order Inceptisol and taxonomically classified as *Vertic Haplustepts*. The soils were medium deep black. The Vertisol is classified taxonomically *as Typic Haplusterts*. The soils were deep black comprising members of clayey, montmorillonitic, isohyperthermic family of *Typic Haplusterts.*

The maize grain (cv- Rajashree) was sown by dibbling in experimental plot having four replications and six treatments. The experiment was laid out in split plot design with six treatments as T_1 = Control (No fertilizer), T_2 = GRDF (120:60:40 N:P_2O_5:K_2O Kg ha^{-1}+10 t FYMha^{-1}), T_3 = As per soil test, T_4 = 60 q ha^{-1} yield target + 10 t ha^{-1} FYM, T_5 = 80 q ha^{-1} yield target + 10 t ha^{-1} FYM and T_6 = 100 q ha^{-1} yield target + 10 t ha^{-1} FYM. The Farm Yard Manure is analysed for its nutrient contents. Maize grain was harvested and the soil samples are analysed for chemical properties and available macro and micro nutrients. The fertilizer prescription equations with and without FYM were developed for maize grain by using basic data NR, CS, CF and CFYM.

Fertilizer prescription equations

i) Without FYM

FN = 4.51 X T – 0.65 X SN

F P_2O_5 = 1.93 X T - 1.05 X SP

F K_2O = 2.57 X T – O.16 X SK

ii) With FYM

FN = 3.88 X T – 0.56 X SN – 3.19 X FYM(t ha^{-1})

FP_2O_5 =1.91 X T – 0.99 X SP – 1.46 X FYM(t ha^{-1})

FK_2O =2.09 X T – 0.13 X SK – 1.08 X FYM (t ha^{-1})

Where, FN,FP_2O_5 and K_2O is fertilizer N,P_2O_5 and K_2O in kg ha^{-1}, T is yield target (q ha^{-1})and SN,SP and SK are soil available N,P and K in kg ha^{-1} and FYM is farm yard manure in t ha^{-1}. The present investigation showsrepresents the grain yield, stover yield and fertilizer application to soil series of *Entisol. Inceptisol* and *Vertisol*.

Results and Discussions

Grain yield

Soil order, series, fertilizer treatments and their interactions were significantly influenced the maize grain yield (Table 1). Vertisols and Inceptisols soil orders recorded the numerically similar grain yield of maize (70.24 and 70.05 q ha^{-1}). Whereas, Entisols soil order recorded less grain yield of maize (63.91 q ha^{-1}). The difference in maize grain yield between the soil orders might be associated with the inherent soil fertility, textural constituents, soil depth and moisture holding capacity, Lal and Mathur (1989) [5].

Table 1: Grain yield of maize crop as influenced by soil orders, series and treatments at harvest

Order/ Series	Grain yield (q ha^{-1})						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Ent. S1	17.73	69.27	59.28	54.17	73.08	91.91	59.24
S2	15.56	72.47	70.98	62.36	79.16	84.24	64.96
S3	13.15	77.69	46.42	66.38	82.70	90.92	64.54
Mean	15.48	73.14	58.89	60.97	79.98	90.69	63.91
Inc. S1	19.08	74.47	56.34	60.71	79.47	97.11	64.53
S2	15.83	82.48	72.33	64.51	91.38	106.66	72.20
S3	14.13	88.49	75.79	71.90	88.04	102.23	73.43
Mean	16.35	81.81	68.15	65.70	86.29	102.00	70.05
Vert. S1	14.04	76.21	64.01	67.96	83.34	104.52	68.35
S2	11.49	79.49	70.62	66.89	94.84	104.65	71.33
S3	13.92	78.32	72.51	71.34	89.41	100.82	71.05
Mean	13.15	78.01	69.04	68.73	89.20	103.33	70.24
Grand mean	14.99	74.32	65.36	61.80	81.82	98.66	65.40

	Entisols			Inceptisols			Vertisols		
	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.
S.E.±	0.70	5.44	3.31	0.93	5.19	3.15	1.53	5.28	3.21
C.D.@ 5 %	2.42	20.70	9.43	3.22	19.73	8.98	N.S.	20.08	N.S.
Interaction	E Vs I			E Vs V			I Vs V		
t-test	-0.225NS			-0.241NS			-0.02NS		

The fertilizer prescription equation developed on Inceptisols soil order can be suitably used on Vertisol soil order. Whereas, fertilizer application as per fertilizer prescription equation on Inceptisol to grain maize on Entisols did not found suitable for harvest of targeted yield. Hence, fertilizer prescription equation of grain maize developed on Inceptisols was not suitable on Entisol soil order for fertilizer application to harvest the targeted yield of grain maize. The soil series of Vertisols (Targaon, Ambulga *and* Babulgaon) and Inceptisol (Pather, Beed and Kolyachiwadi) were found to vary in their maize grain yield. The maize grain yield of Taragon, Ambulga and Babulgaon were found non-significant.

The soil series of Inceptisols were statistically on par with each other for their grain yield of maize (64.53,72.20 and 73.43 q ha^{-1} respectively). It also indicated that fertilizer application as per fertilizer prescription equations are equally suitable for all the soil series of Vertisols and Inceptisols soil order. Similar results were also reported by Suri and Verma (1999) [7] and Bangar (2001). The higher productivity levels of soil series of Vertisols and Inceptisols under integrated nutrient management could be due to fact that organic source might have enhanced the efficient utilization of native as well

as added fertilizer nutrients with the receipt of *Kharif* rains which maintained the balance between growth, yield attributes and yield. Similar results were reporded by Banerjee *et al.*, (2006) [1, 3]. The fertilizer applications to grain maize as per fertilizer prescription equations were supplemented with 10 t ha^{-1} FYM.

The positive response to higher level of nitrogen on grain yield to be ascribed to overall improvement in crop growth enabled the plant to absorb more nutrients and moisture which empowered the plant to synthesize more quantity of photosynthate and accumulating in sink which are converted in to economic yield of grain maize. The results are concordance with the findings of Suryavanshi *et al.*, (2008) [8]. The differences between the yield targets and mean actual yields obtained in each case (60, 80 and 100 q ha^{-1}, respectively) were nonsignificant indicating that the yields targeted could be achieved through fertilizer application based on yield target concept. These results corroborate the findings of Prasad and Prasad (1996), Tamboli *et al.* (1996) [9] and Tamboli and Sonar (1998) [10]. The targeted yield approach was superior to general recommended dose and soil test based fertilizer treatments. These results corroborate the findings of Tamboli *et al.* (1996) [9].

The interaction effects between soil series and fertilizer application treatments were found significant for harvest of maize grain yield in Entisols and Inceptisols soil orders. Whereas interaction between soil series and fertilizer application treatment to harvest the maize grain yield on Vertisols soil order were non significant The t-test values of interaction effects among the soil orders as Entisols vs Inceptisols, Entisols vs Vertisols and Inceptisols vs Vertisols were found non-significant.

Stover Yield

The stover yield of maize grain was numerically higher in Entisols soil order (32.13 q ha^{-1}) followed by Inceptisols and Vertisols (30.68 q ha^{-1}). This might be because of the Inceptisols and Vertisols soil orders was produced higher grain yield of maize, there might be translocation of all the photosynthates and other constituents were translocated to grain as result the Inceptisols and Vertisols soil orders recorded lower values of stover yield of maize. The soil series *Karawali* of Entisols produced the higher stover yield (36.85 q ha^{-1}). It was significantly higher than Akole series (25.78 q ha^{-1}) and at par with Rahuri (33.76 q ha^{-1}). Similarly, Pather soil series of Inceptisols and Babulgaon soil series of Vertisols was found superior for higher stover yield of maize (40.49 and 32.19 q ha^{-1}).

Table 2: Stover yield of maize as influenced by soil orders, series and treatments at harvest

Order/Series	Stover yield (q ha^{-1})						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Ent. S1	11.31	36.45	40.92	42.41	43.89	46.13	36.85
S2	7.29	26.78	38.31	37.94	43.15	49.10	33.76
S3	6.84	24.08	25.66	29.27	33.11	35.73	25.78
Mean	8.48	29.11	34.96	36.54	40.05	43.65	32.13
Inc. S1	12.79	33.89	43.15	47.61	52.08	53.44	40.49
S2	8.64	26.04	28.27	28.28	31.25	32.11	25.76
S3	8.33	28.03	25.27	29.02	32.73	31.24	25.77
Mean	9.92	29.32	32.23	34.97	38.69	38.93	30.68
Vert. S1	9.52	31.73	28.27	32.73	34.22	34.96	28.57
S2	7.88	29.02	21.00	27.53	33.48	36.45	25.89
S3	7.14	35.71	42.41	35.71	37.94	34.22	32.19
Mean	8.18	32.15	30.56	31.99	35.21	35.21	28.88
Grand mean	8.86	30.19	32.58	34.50	37.98	39.26	30.56

	Entisols			Inceptisols			Vertisols		
	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.
S.E.±	1.44	4.58	2.79	1.01	3.37	2.05	1.72	4.30	2.62
C.D.@ 5 %	4.99	17.43	NS	3.50	12.83	5.84	NS	16.37	7.46
Interaction	E Vs I			E Vs V			I Vs V		
t-test	0.338NS			0.822NS			0.456NS		

However, the stover yield of maize in soil series of Vertisols were found statistically non-significant. The stover yield of grain maize was statistically at par with each other in fertilizer application as per soil test and fertilizer application as per yield targets 60, 80 and 100 q ha^{-1} along with 10 t ha^{-1} FYM (34.96, 36.54, 40.45 and 43.65 q ha^{-1} respectively).Similar trend was observed in Inceptisols (32.23, 34.97, 38.69 and 38.93 q ha^{-1} respectively) and Vertisols except fertilizer application as general recommended dose of fertilizers(32.15, 30.56, 31.99, 35.21 and 35.21 q ha^{-1} respectively).

Increase in stover yield with balanced nutrition through partially organic treatments could partly be attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth. Similar results were obtained by Kler and Walia (2005). The beneficial effects of farm yard manure in increasing the stover yield might be due to its contribution in supplying additional plant nutrients, improvement of soil physical conditions and biological process in soil Dahiya *et al.*, (1987) [4]. The non-significant results showed that the all the soil series equally responded to produce the stover yield of The interaction effects between soil series and fertilizer application in Entisols soil order was non-significant grain maize. Whereas, it was significant in Inceptisols and Vertisols order. The interaction effects among the soil series as Entisols vs Inceptisols, Entisols vs Vertisols and Inceptisols vs Vertisols were found non-significant for stover yield of grain maize. These results indicated that application of fertilizer to grain maize according to Control, GRDF, AST, as per yield target 60, 80 and 100 q ha^{-1} along with 10 t ha^{-1} FYM were recorded the similar response for production of stover yield of grain maize.

Fertilizer application to Validation trials of maize grain on different soil orders

For obtaining yield targets of 60, 80 and 100 q ha^{-1} the

fertilizer is calculated by using fertilizer prescription equation and the required amount of N, P_2O5 and K_2O is applied through the chemical fertilizers. The amount of fertilizers (Urea, SSP and MOP etc.) applied is varied with the yield targets and treatments. The fertilizer application to *Kharif* grain maize crop applied were calculated as per treatments on nutrient basis as kg ha^{-1} quantity of fertilizers of respective nutrients per plot are presented in following tables 3, 4 and 5.

Table 3: Fertilizer application to follow up trials of grain maize grown on soil series of Entisols for validation

S. No	Nutrient/Treatment	FYM (tha^{-1})	FYM (kg $plot^{-1}$)	Nutrients (kgha^{-1})			Fertilizers (kg $plot^{-1}$)		
				N	P_2O_5	K_2O	Urea	SSP	MOP
	Karawali								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	40	0.95	1.37	0.20
4	60 q ha^{-1}+10t ha^{-1} FYM	10	29.25	117	90	85	0.74	1.65	0.42
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	195	128	127	1.23	2.34	0.62
6	100 q ha^{-1} +10t ha^{-1} FYM	10	29.25	272	166	169	1.72	3.03	0.82
	Rahuri								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	40	0.95	1.37	0.20
4	60 q ha^{-1}+10t ha^{-1}FYM	10	29.25	117	90	83	0.74	1.64	0.40
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	195	128	124	1.23	2.34	0.60
6	100 q ha^{-1}+10t ha^{-1} FYM	10	29.25	272	166	166	1.72	3.03	0.81
	Akole								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	20	0.95	1.37	0.10
4	60 q ha^{-1}+10t ha^{-1}FYM	10	29.25	131	90	80	0.74	1.64	0.40
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	209	128	121	1.23	2.34	0.60
6	100 q ha^{-1}+10t ha^{-1} FYM	10	29.25	286	167	185	1.72	3.03	0.81

Table 4: Fertilizer application to follow up trials of grain maize grown on soil series of Inceptisols for validation

S. No	Nutrient/Treatment	FYM (tha^{-1})	FYM (kg $plot^{-1}$)	Nutrients (kgha^{-1})			Fertilizers (kg $plot^{-1}$)		
				N	P_2O_5	K_2O	Urea	SSP	MOP
	Pather								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	20	0.95	1.37	0.10
4	60 q ha^{-1}+10t ha^{-1} FYM	10	29.25	117	92	95	0.74	1.67	0.46
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	195	130	116	1.23	2.37	0.56
6	100 q ha^{-1} +10t ha^{-1} FYM	10	29.25	272	168	157	1.72	3.07	0.76
	Beed								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	20	0.95	1.37	0.10
4	60 q ha^{-1}+10t ha^{-1}FYM	10	29.25	110	89	69	0.70	1.62	0.34
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	188	127	111	1.19	2.32	0.54
6	100 q ha^{-1}+10t ha^{-1} FYM	10	29.25	265	165	153	1.68	3.01	0.74
	Kolyachiwadi								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	40	0.95	1.37	0.20
4	60 q ha^{-1}+10t ha^{-1}FYM	10	29.25	103	91	88	0.65	1.66	0.43
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	181	129	108	1.14	2.36	0.53
6	100 q ha^{-1}+10t ha^{-1} FYM	10	29.25	258	167	150	1.63	3.05	0.73

Table 5: Fertilizer application to follow up trials of grain maize grown on soil series of Vertisols for validation.

S. No	Nutrient/Treatment	FYM (tha^{-1})	FYM (kg $plot^{-1}$)	Nutrients (kgha^{-1})			Fertilizers (kg $plot^{-1}$)		
				N	P_2O_5	K_2O	Urea	SSP	MOP
	Targaon								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	30	0.95	1.37	0.15
4	60 q ha^{-1}+10t ha^{-1} FYM	10	29.25	131	90	80	0.52	1.60	0.33
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	209	128	121	1.01	2.30	0.53
6	100 q ha^{-1} +10t ha^{-1} FYM	10	29.25	286	167	185	1.50	3.00	0.74
	Ambulga								
1	Control	0	0	0	0	0	0.00	0.00	0.00

2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	20	0.95	1.37	0.10
4	60 q ha^{-1}+10t ha^{-1}FYM	10	29.25	110	87	67	0.70	1.59	0.32
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	188	128	133	1.19	0.14	0.65
6	100 q ha^{-1}+10t ha^{-1} FYM	10	29.25	265	167	175	1.68	3.04	0.85
	Babulgaon								
1	Control	0	0	0	0	0	0.00	0.00	0.00
2	GRDF	10	29.25	120	60	40	0.76	1.09	0.20
3	As per soil test	0	0	150	75	40	0.95	1.37	0.20
4	60 q ha^{-1}+10t ha^{-1}FYM	10	29.25	110	90	91	0.70	1.64	0.44
5	80 q ha^{-1}+10t ha^{1} FYM	10	29.25	188	128	133	1.19	2.34	0.65
6	100 q ha^{-1}+10t ha^{-1} FYM	10	29.25	265	167	175	1.68	3.04	0.85

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