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Available Status of Soil as Influenced by Validation of Fertilizer Prescription Equations of Kharif Grain Maize on Different Soil Orders

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A B S T R A C T

The experiment was conducted on Inceptisol (Pather series, *Vertic Haplustepts*) during the year 2009-10 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". 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 *Kharif* 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) inrespect to soil pH and organic corbon content was higher in Vertisols (8.22 and 1.04 %) and Inceptisols order (8.29 and 1.05 %). Electrical conductivity of Vertisols and Entisols was higher (0.138 and 0.135 dSm^{-1}). Residual calcium carbonate content in Inceptisols and Vertisols was more (7.27 and 6.41 %). Addition of fertilizer application as per 60, 80 and 10 q ha^{-1} yield target + 10 t ha^{-1} FYM decreased the calcium carbonate content in all the soil series of Entisols, Inceptisols and Vertisols. 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.

Introduction

The present production of fertilizer nutrients of the country is not enough to meet the total plant nutrient requirement for the expected food grain production. In recent years the imbalanced and inadequate fertilizer use coupled with low use efficiency of other inputs, has declined the response efficiency of fertilizer nutrients under intensive agriculture system. The sustainable agriculture system will be the management of soil organic matter, nutrients and the rational use of organic inputs such as animal manures, crop residues, green manures, sewage, sludge and food industry waste. However, since organic manures cannot meet the total plant nutrient need of intensive agriculture. Hence, the integrated use of nutrient through inorganic fertilizers, organic manures and biofertilizers sources are need of the time. The need of Integrated Nutrient Management did not associate with the negative nutrient balance and the only chemical fertilizer alone nor can the organic sources exclusively achieve the production sustainability of soils. The Integrated Nutrient Management helps to restore and sustain soil fertility and crop productivity. It may help to check the emerging deficiencies of nutrients. Further, it brings economy and efficiency in fertilizer use, improvement in physical, chemical and biological environment of soils.

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 is varying in their physical 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 Haplustert*. 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 were analysed for physicochemical 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*.

Physico-chemical properties

Entisols

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 series includes soils of well drained and moderately permeable occurring on very gently slope of undulating topography. The soils have been interpreted as shallow and suitable for arable crops with proper management. The characteristics of soil series of Entisol soil order are as below (Table 1).

The texture of soil series of Karwali was clayey with low in available nitrogen (150 Kg ha^{-1}), low in available phosphorus (9.42 Kg ha^{-1}) and moderately high in potassium (224 Kg ha^{-1}). The soil was alkaline in reaction (pH 8.41).

The texture of soil series of Rahuri was clayey with low in available nitrogen (150 Kg ha^{-1}), low in available phosphorus (9.80 Kg ha^{-1}) and moderately high in potassium (246 Kg ha^{-1}). The soil was moderately alkaline in reaction (pH 8.20).

The texture of soil series of Akole was clayey with low in available nitrogen (125 Kg ha^{-1}), low in available phosphorus (9.70 Kg ha^{-1}) and high in potassium (269 Kg ha^{-1}). The soil was moderately alkaline in reaction (pH 8.50).

Inceptisols

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 characteristics soil series of Inceptisol soil order are as below (Table 1). The texture of soil series of Pather was clayey with low in available nitrogen (150 Kg ha^{-1}), low in available phosphorus (8.04 Kg ha^{-1}) and Very high in potassium (314 Kg ha^{-1}). The soil was alkaline in reaction (pH 8.48).

The texture of soil series of Beed was clayey with low in available nitrogen (163 Kg ha^{-1}), low in available phosphorus (11.09 Kg ha^{-1}) and Very high in potassium (347 Kg ha^{-1}). The soil was alkaline in reaction (pH 8.45).

The texture of soil series of Kolyachiwadi was clayey with low in available nitrogen (175 Kg ha^{-1}), low in available phosphorus (8.87 kg ha^{-1}) and very high in potassium (370 kg ha^{-1}). The soil was alkaline in reaction (pH 8.65).

Vertisols

A layer of 25 cm or more thick with an upper boundry within 100 cm of the mineral soil surface, that has either slickensides or wedge-shaped peds that have their long axes tilled 10 to 60 degrees from the horizontal and a weighted average of 30 per cent or more clay in the fine earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 per cent or more clay in the fine earth fraction of all horizons between a depth of 18 cm and cracks that open and close periodically. The soil series of experimental plot were grouped under the order Vertisol and classified taxonomically *as Typic Haplusterts*. The soils were deep black comprising members of clayey, montmorillonitic, isohyperthermic family of *Typic Haplusterts.*

The series includes soils of well drained and slow permeability occurring on very gently slope (1-3 %). The soils are developed on weathering of basalt, having very dark grayish brown clay, with medium, weak angular blocky structure. The characteristics soil series of Vertisol soil order are as below (Table 1).

The texture of soil series of Targaon was clayey with low in available nitrogen (213 Kg ha^{-1}), low in available phosphorus (11.92 Kg ha^{-1}) and Very high in potassium (358 Kg ha^{-1}). The soil was alkaline in reaction (pH 8.51).

The texture of soil series of Ambulga was clayey with low in available nitrogen (163 Kg ha^{-1}), low in available phosphorus (12.47 Kg ha^{-1}) and Very high in potassium (370 Kg ha^{-1}). The soil was alkaline in reaction (pH 8.48).

The texture of soil series of Babulgaon was clayey with low in available nitrogen (163 $Kgha^{-1}$), low in available phosphorus (9.70 Kg ha^{-1}) and Moderate in potassium (179 Kg ha^{-1}). The soil was alkaline in reaction (pH 8.40).

Results and Discussion

The pH and electrical conductivity in respect to soil order, soil series, fertilizer application and their interactions were assessed after harvest of grain maize crop.

Soil pH

Soil pH at harvest of grain maize crop was significantly influenced by the soil order, series, fertilizer application and their interactions (Table 2).

Soil order

Soil pH of the Inceptisols soil order was slightly higher (8.29) than the Vertisols (8.22) and Entisols (8.08). The soil series of Entisols order showed the Variation in soil pH whereas, the soil series of Inceptisols and Vertisols were not varied significantly for the pH of soil at harvest of grain maize. This might be associated with the salt accumulation by the clay content in both the soil orders are might be similar. The Entisols soil order is shallow in depth having good drainability than Vertisols and Incetisols hence less pH values.

Fertilizer treatment

The treatment of fertilizer application to grain maize significantly influenced the soil pH at harvest of grain maize. It was numerical less in fertilizer application as per yield target 60, 80 and 100 q ha^{-1} with 10 t ha^{-1} FYM in all the soil series of Entisols, Inceptisols and Vertisols soil orders.

Application of organics resulted in decline of soil pH from the original value of 8.41, 8.20 and 8.50 to 8.14, 7.80 and 8.30 in *Karwali*, *Rahuri* and *Akole* series of Entisols, decline of soil pH from the original value was observed from 8.48, 8.45 and 8.65 to 8.19, 8.24 and 8.44 in *Pather*, *Beed* and *Kolyachiwadi* series of Inceptisols and decline of soil pH from the original value of 8.51, 8.48 and 8.40 to 8.20, 8.27 and 8.20 in *Targaon*, *Ambulga* and *Babulgaon* series of Vertisols. The considerable decline in soil pH was observed in fertilizer application in presence of Farm yard manure. This was probably due to the addition of organic fertilizers produced organic acids on their decomposition in soil which may temporarily reduce the soil pH values (Jayaprakash *et al.*, 2004).

The noticeable decrease in pH may also be ascribed to increased retention of exchangeable bases and enhanced buffering capacity of the soil arising out of the farm yard manure addition. These results are in conformity with results of Acharya *et al.*, (1988).

The decrease in soil pH at harvest grain maize by the fertilizer application as per 60, 80 and 100 q ha^{-1} yield target with 10 t ha^{-1} FYM might be associated with formation of acids on decomposition of FYM in soil (Laxminarayana and Patiram, 2005).

Soil series x Fertilizer treatment

Interaction effects of soil series and fertilizer application treatments were non significant for soil pH and significant in soil series of Inceptisols soil order.

The interactions of soil series with fertilizer application treatment as per target 60, 80 and 100 q ha^{-1} with 10 t ha^{-1} FYM recorded less values of soil pH than the fertilizer application without FYM application. The FYM has an ability to enhance the Cation exchange capacity. Solubilization of insoluble salts to solubilized form, production of organic acids to certain extents. These changes may reduced the soil pH(Mann *et al.*,2006).

Interactions within soil order

The t-test values for interaction among the soil orders were negatively significant in Entisols vs Inceptisols, Entisols vs. Vertisols and positively significant Inceptisols vs. Vertisols. The t-test values indicated that the change in soil pH at harvest of grain maize might be because of variation in inherent soil characteristics of soil series and additive effect of chemical fertilizer and organic manures like FYM.

Electrical conductivity

The electrical conductivity of soil as influenced by soil order, series, fertilizer application and their interactions are reported in (Table 3). The change in electrical conductivity of soil showed the revere trend to that of observed in soil pH by the treatments of fertilizer application and similar trend by the soil series and interaction effects between soil series and fertilizer application.

Soil series

Application of organics resulted decrease in Electrical conductivity from the original value of 0.170, 0.155 and 0.156 dSm^{-1} to 0.147, 0.127 and 0.131 dSm^{-1} in *Karwali*, *Rahuri* and *Akole* series of Entisols,0.164, 0.147 and 0.143 to 0.141, 0.122 and 0.121 dSm^{-1} in *Pather*, *Beed* and *Kolyachiwadi* series of Inceptisols. and 0.160, 0.168 and 0.167 to 0.131, 0.142 and 0.143 dSm^{-1} in Targaon, Ambulga and Babulgaon series of Vertisols.

Fertilizer treatment

The fertilizer treatment to grain maize grown on soil series of Entisols, Inceptisols and Vertisols were found to significant for electrical conductivity at harvest. It was increased in the treatment fertilizer application as per 60, 80 and 100 q ha^{-1} yield target with 10 t ha^{-1} FYM. This was only because of addition of FYM solubilize the salts in soils and naturally enhanced the electrical conductivity of soil. This decrease in EC of post-harvest soil samples might be due to leaching of salts due to rains and utilization of nutrients by the crop. The results are in accordance with the findings of Verma *et al.*, (2010).

Table.1 Physico-chemical properties of soil series of Entisol, Inceptisol, Vertisol

Sr. No.	Particulars	Entisol			Inceptisols			Vertisols		
		Karwali	**Rahuri**	**Akole**	**Pather**	**Beed**	**Kolyachiwadi**	**Targaon**	**Ambulga**	Babulgaon
1.	Sand	27.1	23.9	28.5	20.2	22.3	37.2	5.7	3.7	**15.9**
2.	Silt	32.8	34.4	31.1	30.4	25.9	20.5	32.1	31.4	**26.5**
3.	Clay	40.1	41.7	40.4	49.4	51.8	42.3	62.2	64.9	**57.6**
4.	Textural Class	Clayey	Clayey	Clayey	Clayey	Clayey	Clayey	Clayey	Clayey	**Clayey**
5.	Bulk density (gcc^{-1})	1.33	1.32	1.32	1.32	1.33	1.33	1.34	1.33	**1.34**
6.	Moisture storage capacity (mm)	59.85	73.92	53.20	194.83	191.52	127.68	309.54	307.23	**377.44**
7.	pH (1:2.5)	8.41	8.20	8.50	8.48	8.45	8.65	8.51	8.48	**8.40**
8.	EC (dSm^{-1})	0.170	0.155	0.156	0.164	0.147	0.143	0.160	0.168	**0.167**
9.	Organic Carbon (%)	0.67	0.57	0.54	0.63	0.66	0.52	0.51	0.60	**0.64**
10.	$CaCO_3$ (%)	6.00	5.00	7.25	8.75	5.75	10.25	10.00	6.00	**6.50**
11.	Available N ($Kgha^{-1}$)	150	150	125	150	163	175	213	163	**163**
12.	Available P ($Kgha^{-1}$)	9.42	9.80	9.70	8.04	11.09	8.87	11.92	12.47	**9.70**
13.	Available K ($Kgha^{-1}$)	224	246	269	314	347	370	358	370	**179**
14.	Available S (µg g^{-1})	8.66	5.96	6.93	4.42	5.39	3.85	4.62	3.85	**5.19**
15.	Exchangeable Ca (cmol (p+) kg^{-1})	26.94	23.36	25.0	32.50	31.47	25.25	34.0	35.50	**35.67**
16.	Exchangeable Mg (cmol(p+) kg^{-1})	13.50	12.67	13.34	15.64	14.44	15.88	20.50	21.12	**19.0**
17.	DTPA Micronutrients (µg g^{-1})									
I.	Fe	4.71	4.52	4.64	4.32	5.69	3.28	3.96	5.58	**5.02**
II.	Mn	5.45	2.52	3.33	5.87	3.68	2.57	3.11	2.98	**2.75**
III.	Cu	4.82	2.22	2.39	4.78	2.67	2.45	2.89	2.24	**2.54**
IV.	Zn	0.44	0.48	0.24	0.39	0.46	0.31	0.39	0.34	**0.28**
18.	Available B (µg g^{-1})	0.39	0.41	0.40	0.41	0.40	0.39	0.38	0.43	**0.40**
19.	**Available Mo (µg g^{-1})**	**0.090**	**0.086**	**0.089**	**0.115**	**0.119**	**0.110**	**0.120**	**0.118**	**0.126**

Table.2 pH of soil as influenced by soil orders, series and treatments at harvest

Order/ Series		Soil pH (1:2.5)						
		T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	Mean
Ent.	S1	8.23	8.17	8.19	8.13	8.09	8.00	**8.14**
	S2	7.85	7.81	7.83	7.76	7.72	7.80	**7.80**
	S3	8.36	8.31	8.33	8.26	8.30	8.22	**8.30**
	Mean	**8.15**	**8.10**	**8.12**	**8.05**	**8.04**	**8.01**	8.08
Inc.	S1	8.29	8.2	8.26	8.17	8.13	8.09	**8.19**
	S2	8.30	8.26	8.28	8.21	8.17	8.25	**8.24**
	S3	8.50	8.46	8.48	8.41	8.37	8.45	**8.44**
	Mean	**8.36**	**8.31**	**8.34**	**8.26**	**8.22**	**8.26**	8.29
Vert.	S1	8.26	8.22	8.24	8.19	8.17	8.12	**8.20**
	S2	8.33	8.29	8.31	8.24	8.20	8.26	**8.27**
	S3	8.25	8.21	8.23	8.19	8.13	8.17	**8.20**
	Mean	**8.28**	**8.24**	**8.26**	**8.21**	**8.17**	**8.18**	8.22
Grand mean		**8.26**	**8.21**	**8.23**	**8.17**	**8.14**	**8.15**	8.19

	Entisols			**Inceptisols**			Vertisols		
	Series	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	Series x Treat.
S.E.±	**0.008**	**0.045**	**0.028**	**0.016**	**0.034**	**0.020**	**0.008**	**0.030**	0.018
C.D.@ 5 %	**0.029**	**0.172**	**NS**	**0.057**	**0.128**	**0.058**	**0.026**	**0.114**	NS

Interaction	**E Vs I**	**E Vs V**	I Vs V
t-test	**-3.612****	**-2.715***	2.171*
Initial pH (1 : 2.5)	**Entisols**	**Inceptisols**	Vertisols
S_1	**8.41**	**8.48**	8.51
S_2	**8.20**	**8.45**	8.48
S_3	8.50	8.65	8.40

Table.3 Electrical Conductivity of soil as influenced by soil orders, series and treatments at harvest

Order/ Series	Electrical Conductivity (dS m^{-1})						
	T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	Mean
Ent. S1	0.137	0.148	0.142	0.145	0.152	0.156	**0.147**
S2	0.119	0.121	0.123	0.126	0.133	0.138	**0.127**
S3	0.122	0.129	0.125	0.133	0.137	0.141	**0.131**
Mean	**0.126**	**0.133**	**0.130**	**0.135**	**0.141**	**0.145**	0.135
Inc. S1	0.134	0.142	0.136	0.139	0.145	0.149	**0.141**
S2	0.113	0.119	0.116	0.122	0.127	0.132	**0.122**
S3	0.113	0.120	0.117	0.122	0.125	0.128	**0.121**
Mean	**0.120**	**0.127**	**0.123**	**0.128**	**0.132**	**0.136**	0.128
Vert. S1	0.123	0.132	0.127	0.129	0.136	0.138	**0.131**
S2	0.133	0.135	0.137	0.143	0.148	0.153	**0.142**
S3	0.134	0.141	0.137	0.145	0.148	0.150	**0.143**
Mean	**0.130**	**0.136**	**0.134**	**0.139**	**0.144**	**0.147**	0.138
Grand mean	**0.125**	**0.132**	**0.129**	**0.134**	**0.139**	**0.143**	0.134

	Entisols			**Inceptisols**			Vertisols		
	Series	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	Series x Treat.
S.E.±	**0.001**	**0.004**	**0.002**	**0.001**	**0.004**	**0.002**	**0.001**	**0.005**	0.003
C.D.@ 5 %	**0.003**	**0.014**	**NS**	**0.002**	**0.014**	**NS**	**0.003**	**0.017**	NS

Interaction	**E Vs I**	**E Vs V**	I Vs V
t-test	**1.921NS**	**-1.055NS**	-3.227**
Initial EC (dS m^{-1})	**Entisols**	**Inceptisols**	Vertisols
S_1	**0.170**	**0.164**	0.160
S_2	**0.155**	**0.147**	0.168
S_3	0.156	0.143	0.167

Table.4 Organic carbon of soil as influenced by soil orders, series and treatments at harvest

Order/ Series		Organic carbon (%)						
		T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	Mean
Ent.	S1	0.84	1.21	0.93	1.18	1.27	1.24	**1.11**
	S2	0.67	0.83	0.70	0.90	1.05	1.17	**0.89**
	S3	0.65	0.84	0.71	0.90	1.10	1.15	**0.89**
	Mean	**0.72**	**0.96**	**0.78**	**0.99**	**1.14**	**1.19**	0.96
Inc.	S1	0.78	1.08	0.93	0.99	1.22	1.35	**1.06**
	S2	0.75	0.93	0.82	1.11	1.18	1.27	**1.01**
	S3	0.73	1.06	0.86	1.27	1.29	1.35	**1.09**
	Mean	**0.75**	**1.02**	**0.87**	**1.12**	**1.23**	**1.32**	1.05
Vert.	S1	0.63	0.96	0.72	0.81	1.08	1.20	**0.90**
	S2	0.78	0.99	0.86	1.17	1.26	1.38	**1.07**
	S3	0.78	1.15	0.91	1.29	1.31	1.41	**1.14**
	Mean	**0.73**	**1.03**	**0.83**	**1.09**	**1.22**	**1.33**	1.04
Grand mean		**0.73**	**1.01**	**0.83**	**1.07**	**1.20**	**1.28**	1.02

	Entisols			**Inceptisols**			Vertisols		
	Series	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	Series x Treat.
S.E.±	**0.008**	**0.043**	**0.026**	**0.009**	**0.041**	**0.025**	**0.013**	**0.061**	0.037
C.D.@ 5 %	**0.029**	**0.163**	**0.074**	**0.031**	**0.158**	**0.072**	**0.044**	**0.230**	0.105

Interaction	**E Vs I**	**E Vs V**	I Vs V
t-test	**1.921NS**	**-1.055NS**	-3.227**
Initial OC(%)	**Entisols**	**Inceptisols**	Vertisols
S_1	**0.67**	**0.63**	0.51
S_2	**0.57**	**0.66**	0.60
S_3	0.54	0.52	0.64

Table.5 Calcium carbonate of soil as influenced by soil orders, series and treatments at harvest

Order/ Series	Calcium carbonate (%)						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Ent. S1	5.38	4.44	4.88	4.38	4.13	3.94	**4.52**
S2	4.88	4.63	4.81	4.50	4.19	4.31	**4.55**
S3	6.19	5.63	5.88	5.38	4.50	4.69	**5.38**
Mean	**5.48**	**4.90**	**5.19**	**4.75**	**4.27**	**4.31**	4.82
Inc. S1	8.06	6.88	7.88	7.19	6.63	6.38	**7.17**
S2	5.63	5.38	5.44	5.31	5.00	4.94	**5.28**
S3	9.63	9.44	9.50	9.38	9.06	9.25	**9.38**
Mean	**7.77**	**7.23**	**7.60**	**7.29**	**6.90**	**6.85**	7.27
Vert. S1	9.13	8.13	9.13	8.38	7.75	7.25	**8.29**
S2	5.81	5.69	5.75	5.44	5.13	5.38	**5.53**
S3	6.19	5.56	5.63	5.31	4.94	4.75	**5.40**
Mean	**7.04**	**6.46**	**6.83**	**6.38**	**5.94**	**5.79**	6.41
Grand mean	**6.77**	**6.20**	**6.54**	**6.14**	**5.70**	**5.65**	6.17

	Entisols			**Inceptisols**			Vertisols		
	Series	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	Series x Treat.
S.E.±	**0.11**	**0.34**	**0.21**	**0.08**	**0.29**	**0.18**	**0.11**	**0.33**	0.20
C.D.@ 5 %	**0.37**	**1.31**	**NS**	**0.29**	**1.11**	**0.51**	**0.39**	**1.27**	0.58

Interaction	**E Vs I**	**E Vs V**	I Vs V
t-test	**1.921NS**	**-1.055NS**	-3.227**
Initial $CaCO_3$ (%)	**Entisols**	**Inceptisols**	Vertisols
S_1	**6.0**	**8.75**	10
S_2	**5.0**	**5.75**	6.0
S_3	7.25	10.25	6.50

Table.6 Fertilizer application to follow up trials of grain maize grown on soil series of Entisols for validation

Sr. 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.7 Fertilizer application to follow up trials of grain maize grown on soil series of Inceptisols for validation

Sr. 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.8 Fertilizer application to follow up trials of grain maize grown on soil series of Vertisols for validation

Sr. 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**

Soil series x Fertilizer treatment

The interaction effects of soil series with fertilizer applications was found non significant for electrical conductivity of soil at harvest of maize crop. The non significant results indicated that the characteristics of soils of individual soil series *viz.*, clay content, CEC, organic carbon, drainability, nutrient fixation, adsorption, desorption phenomenon plays dominant role in salt accumulation and release. Therefore, the interaction effects were non significant for electrical conductivity of soil (Mann *et al.* 2006).

Interactions among soil order

The t-test values for interaction effects within soil order were non significant in Entisols vs Inceptisols and Entisols vs Vertisols. It was negatively significant for Inceptisol vs Vertisols. The salt accumulation and salt solubilization mostly depend on physical, chemical and biological properties of individual soil order. Hence non significant results was observed for electrical conductivity, Tandon (1974).

Organic carbon

Soil order, soil series, fertilizer application and their interactions were significantly influenced the soil organic carbon at harvest of grain maize (Table 4).

Soil order

The average organic carbon content was numerically higher in Vertisols (1.04 %) followed by Inceptisols (1.05 %) and Entisols (0.96%). The higher content of organic carbon in Inceptisols and Vertisols soil order might be associated with the higher clay content and organic matter content, Bharambe and Tomar (2004). Similarly in both the soil order there was increased biomass production of grain maize and might be also increased root biomass in soil. These root biomass was mixed in soil after harvest of grain maize which ultimately increased the organic carbon in soil. Similar results were also reported by Tolanur and Badanur (2003).

Soil series

The soil series of Vertisols and Inceptisols soil orders were recorded higher values of organic carbon than Entisols soil series irrespective of fertilizer application. This might be associated with increased root biomass of grain maize and higher clay content of the soil series.

Fertilizer treatment

The treatments of fertilizer application were found to record the higher amount of organic carbon in 60, 80 and 100 q ha^{-1} yield target + 10 t ha^{-1} FYM in all the soil order irrespective soil series. However, it was more in Vertisols and Inceptisols soil orders.

Application of farm yard manure resulted to increase in soil organic carbon from the original value of 0.67, 0.57 and 0.54 to 1.11, 0.89 and 0.89 % in *Karwali*, *Rahuri* and *Akole* series of Entisols, 0.63, 0.66 and 0.52 to 1.06, 1.01 and 1.09 % in *Pather*, *Beed* and *Kolyachiwadi* series of Inceptisols and from 0.51, 0.60 and 0.64 to 0.90, 1.07 and 1.14% in *Targaon*, *Ambulga* and *Babulgaon* series of Vertisols respectively.

The beneficial increase in the organic carbon content of the soil was attributed to the addition of higher level of fertilizer and mineralization of the nutrients. The addition of FYM enhanced the microbial population and profused root growth increased the organic carbon content of soil. The results corroborate the findings of Jayaprakash *et al.*, (2004).

The increase in organic carbon content may be attributed to addition of organic materials and better root growth. The subsequent decomposition of these roots might have resulted in increased organic carbon content of soil. These observations are in agreement with the findings of Tolanur and Badanur (2003).

Soil series x Fertilizer treatment

The interaction effects of soil series and fertilizer application were significant for residual soil organic carbon. The increased soil organic carbon content by interaction effects was might be because of addition of organic manures to maize grain, higher clay content of soil series, organic matter content and addition of root biomass after harvest of maize grain.

Interactions among the soil order

The interaction effects between Entisols x Inceptisols and Entisols x Vertisols were negatively non significant. This was mainly because of less clay content and organic matter contents of Entisols. However, interactions between Inceptisols x Vertisols were positively significant for organic carbon content of soils. This was mainly atributed to clay content and organic matter of soils of both the soil order.

Calcium carbonate

Calcium carbonate content of soil at harvest of grain maize was significantly influenced by the soil order, soil series, fertilizer application and their interactions (Table 5).

Soil order

The residual $CaCO_3$ content of Inceptisols soil order was higher (7.27 %) followed by Vertisols (6.41 %) and Entisols (4.82 %).

Soil series

The calcium carbonate content of soil series of Inceptisols was found to record the higher values than rest of soil series. This might be because of soils of these soil series are formed from parent material and clay minerals *viz.*, calcite, dolomite (Acharya *et al*.1988).

Fertilizer treatment

The fertilizer application reduced the calcium carbonates in all the soil orders irrespective of soil series. It was more pronounced in fertilizer application as per 60, 80 and 100 q ha^{-1} yield target + 10 t ha^{-1} FYM.

Application of organics resulted decrease in calcium carbonate content from the original value of 6.0, 5.0 and 7.25 to 4.52, 4.55 and 5.38 in Karwali, Rahuri and Akole series of Entisols, 8.75, 5.75 and 10.25 to 7.17, 5.28 and 9.38 in Pather, Beed and Kolyachiwadi series of Inceptisols and 10, 6.0 and 6.50 to 8.29, 5.53 and 5.40 in Targaon, Ambulga and Babulgaon series of Vertisols.

The decreased in calcium carbonate content in the soil might be because of addition of sufficient organic matter in soil decomposes the calcium carbonate. Similar results were also reported by Goswami and Sahrawat (1982).

Soil series x Fertilizer treatment

The interaction effects of soil series and fertilizer applications were significant for calcium carbonate content of soils. Calcium carbonate content of all the soil series of Vertisols, Inceptisols and Entisols were significantly lower in interactions between soil series and 60, 80 and 100 q ha^{-1} yield target with 10 t FYM at harvest of maize. This might be associated with the addition of FYM.

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_2O_5 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 6, 7 and 8.

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