Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 1062-1070
Received: 07-07-2018
Accepted: 09-08-2018

Ghodke Pallavi Dipak
Department Of Soil Science and Agril. Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri- 413 722, Dist. Ahmednagar, Maharashtra, India

Kadlag Ashok Dattatray
Department Of Soil Science and Agril. Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri- 413 722, Dist. Ahmednagar, Maharashtra, India

Correspondence
Ghodke Pallavi Dipak
Department Of Soil Science and Agril. Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri- 413 722, Dist. Ahmednagar, Maharashtra, India

Nutrient uptake and yield of *kharif* grain maize as influenced by validation of fertilizer prescription equations on Entisols, inceptisols and vertisols

Ghodke Pallavi Dipak and Kadlag Ashok Dattatray

Abstract
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 2010-11on Post Graduate Farm, Dairy farm and D block, M.P.K.V. Rahuri. The results revealed that the total nitrogen, phosphorus and potassim uptake by grain maize was higher in Vertisols and Inceptisols, for nitrogen (85.17 and 78.79 kg ha^{-1}), phosphorus (82.65 and 76.85 kg ha^{-1}) and potassium (11.24 and 108.05 kg ha^{-1}). Soil series of Vertisols and Inceptisols were equally suitable for nitrogen, phosphorus and potassium uptake by grain maize. 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: Nutrient uptake, yield of *kharif* grain maize, influenced, validation, fertilizer prescription

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. It is a predominant source of carbohydrates and forms of staple diet of large section of the world's population. 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. In India the area under maize was 8.19 million hectare with production and productivity of 12.61 million tonnes and 2355 kg ha^{-1}. In Maharashtra area under maize was 0.67 million hectare with production and productivity of 1.79 million tonnes and 2664 kg ha^{-1} (Anon., 2009) [1]. Maharashtra ranks fourth in terms of production of maize in the country.

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. Soil test correlation approach consists of selecting a group of soils ranging in fertility from high to low in respect of a particular nutrient and testing varying dose of that particular nutrient on a crop. Among the various approaches the targeted yield approach (Ramamoorthy *et al*., 1967) [14] has found popularity in India. This method not only estimates soil test based fertilizer dose but also the level of yields that the farmers can achieve with that particular dose.

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 analyzed 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 FK_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}.

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).

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

S. 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

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 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 Discussions

Nutrient uptake

The nutrient concentration of grain and stover *viz.* NPK and micronutrients Fe, Mn, Cu and Zn were determined at harvest. The total nutrient uptake was calculated by multiplying the nutrient concentration with dry matter yield of grain and stover. The effects of soil orders, soil series and fertilizer applications as per fertilizer prescription equations are discussed under individual nutrient uptake.

Nitrogen uptake

The total uptake of nitrogen by the grain maize was significantly influenced by soil order, series, fertilizer application and their interactions (Table 2).The total nitrogen uptake by grain maize was considerably higher in Vertisols soil order (85.17 kg ha^{-1}) followed by Inceptisols (78.79 kg ha^{-1}) and Entisols (71.67 kg ha^{-1}) irrespective of soil series and fertilizer application treatments. The numerical difference between soil orders for nitrogen uptake by grain maize might be due to variation in clay content, organic carbon and soil available nitrogen. The Vertisols are higher in Clay content followed by Inceptisols and Entisols. Soil series of Entisols, Inceptisols and Vertisols soil orders were significantly vary in the total uptake of nitrogen by grain maize soil series of Vertisols soil order viz., *Targaon, Ambulga* and *Babulgaon* were found to record the higher nitrogen uptake (101.73, 83.47 and 79.33 kg ha^{-1}, respectively) followed by soil series of Inceptisols (78.99, 80.60 and 76.79 kg ha^{-1}, respectively) and Entisols (72.00, 72.20 and 70.80 kg ha^{-1}, respectively). This might be due to variation in inherent soil fertility of all the soil series.

Table 2: Total nitrogen uptake of maize as influenced by soil orders, series and treatments at harvest.

Order/ Series	Total nitrogen uptake (Kg ha^{-1})						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Entisols S1	9.92	76.97	53.24	68.05	100.83	123.04	72.00
S2	7.53	69.46	54.71	67.06	113.21	121.21	72.20
S3	8.55	75.08	61.17	67.27	97.52	115.23	70.80
Mean	8.67	73.84	56.37	67.46	103.85	119.83	71.67
Inceptisols S1	14.67	79.11	58.51	72.22	112.16	137.24	78.99
S2	9.27	85.66	75.69	77.92	106.92	128.14	80.60
S3	7.50	89.32	52.99	81.44	102.76	126.72	76.79
Mean	10.48	84.70	62.39	77.20	107.28	130.70	78.79
Vertisols S1	16.88	101.95	78.22	93.48	133.37	186.45	101.73
S2	11.35	80.18	69.04	79.28	113.33	147.61	83.47
S3	9.21	69.32	41.61	76.62	99.07	126.17	79.33
Mean	12.48	83.81	62.96	83.12	115.26	153.41	85.17
Grand mean	10.54	80.78	60.58	75.93	108.80	134.65	78.55

	Entisols			Inceptisols			Vertisols		
	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.
S.E.±	0.04	0.18	0.11	0.05	0.28	0.17	0.07	0.27	0.16
C.D.@ 5 %	0.14	0.52	NS	NS	1.06	NS	0.26	1.03	NS
Interaction	E Vs I			E Vs V			I Vs V		
t-test	0.442NS			0.957NS			0.563NS		

The decreased nitrogen uptake by the grain maize in soil series of Entisols might be due to less organic matter content and soil available nitrogen than the soil series of Vertisols. The lower organic matter content in soil reduced the use efficiency of nitrogen added through chemical fertilizers. Similar results were reported by Jayprakash *et al.* (2005) [9].

However, nitrogen uptake by the grain maize in soil series of Inceptisols were non-significant. The non-significant results of nitrogen uptake by the grain maize indicated that the all the soil series of Inceptisols were having similar inherent soil fertility and supplying capacity of soil available nitrogen.

Fertilizer treatment, Soil series x Fertilizer treatment and Interactions within soil orders

The total nitrogen uptake of grain maize was significantly influenced by the nutrient application through chemical fertilizer as per fertilizer prescription equations irrespective of soil series of Entisols, Inceptisols and Vertisols soil orders. However, fertilizer application to grain maize as per yield target 80 and 100 q ha^{-1} was significantly higher in Vertisols, Inceptisols and Entisols irrespective of their soil series. Similar findings were also reported by Bangar (2001) [3].

The total nitrogen uptake by grain maize by the fertilizer application with 80 and 100 q ha^{-1} yield target with 10 t ha^{-1} FYM was higher in Vertisols (115.26 and 153.41 kg ha^{-1}) and Inceptisols (107.28 and 130.70 kg ha^{-1}) than the Entisols (103.85 and 119.83 kg ha^{-1}).This might be due to addition of nutrient as per fertilizer prescription equation with FYM enhanced the use efficiency nitrogen added through chemical fertilizers. This might be reflected in higher nitrogen uptake by grain maize. These results also indicated that the fertilizer application as per yield target equations to maize grain grown on Inceptisols and Vertsols are suitable to harvest the yield target. These results are in conformity with the results of Sriniwas *et al.*, (2001) [15].

The increase in uptake of nutrients can be attributed to the fact of additional nutrients added and beneficial effects of the humus contributed by organic manures. The humus might have improved the physical condition of the soil, making a favourable environment for increased uptake of nutrient elements by the plants. Similar findings were also reported by Helkian (1981) [8]. Total uptake of N, P and K were increased with progressive supply of NPK to the crops because of higher availability of these nutrients. Application of NPK at 100 per cent optimum level of NPK alone. Similar results were reported, by Bharambe and Tomar (2004) [4]. Application of FYM @ 10 t ha^{-1} increased uptake of N, P and K significantly over the control. It appears that availability of these nutrients increased in soil under organic manure application as reflected by higher yields that have resulted into more uptake of these nutrients. The increased rate of P application increased the uptake of macronutrients. The P at 60 kg P_2O_5 ha^{-1} significantly increased the uptake of N, P and K. This could be ascribed to their greater availability in root environment along with extraction and transportation towards plant system. Similar findings were reported by Rao and Shaktawat (2002) [13].

The interaction effects between soil series and fertilizer application treatments were found non-significant for total nitrogen uptake by the grain maize. These results revealed that all the soil series released the nitrogen in similar pattern from added fertilizers irrespective of soil orders. The interaction effects of soil orders between Entisols vs Inceptisols, Entisols vs Vertisols and Inceptisols vs Vertisols were non-significant for total nitrogen uptake by grain maize. The non-significant interaction effects indicated that the fertilizer applications as per fertilizer prescription equations are suitable to all the types soil under study for nitrogen uptake.

Phosphorus uptake

A close look to the data presented in Table 3 indicated that total uptake of phosphorus by grain maize influenced by soil order, soil series, fertilizer applications and their interactions were showed the similar trend to that of total nitrogen uptake. However, Vertisols soil order recorded the higher phosphorus uptake by grain maize (82.65 kg ha^{-1}). It was numerically closely followed by Inceptisols (76.85 kg ha^{-1}) and less in Entisols (71.42 kg ha^{-1}).The variation in phosphorus uptake by grain maize might be associated with calcium carbonate content, soil pH and inherent soil available phosphorus content of soils, El-Swaify *et al.* (1985) [6].

Table 3: Total phosphorus uptake of maize as influenced by soil orders, series and treatments at harvest.

Order/ Series	Total phosphorus uptake (Kg ha^{-1})								
	T_1	**T_2**		**T_3**	**T_4**	**T_5**		**T_6**	**Mean**
Entisols S1	8.99	71.24		57.13	67.73	97.75		111.73	69.09
S2	8.85	69.46		59.56	66.34	95.67		112.79	68.78
S3	8.26	75.26		65.56	74.05	115.48		119.65	76.38
Mean	8.70	71.99		60.75	69.37	102.97		114.72	71.42
Inceptisols S1	14.52	70.76		52.12	58.81	95.11		117.83	68.19
S2	13.45	95.07		67.75	73.72	110.24		116.87	79.52
S3	9.78	105.59		62.79	76.08	119.01		123.86	82.85
Mean	12.58	90.47		60.89	69.54	108.12		119.52	76.85
Vertisols S1	14.74	76.52		62.07	70.61	98.01		124.35	74.38
S2	11.52	72.63		60.55	76.61	111.23		144.03	79.43
S3	14.56	102.57		59.04	89.90	129.17		169.55	94.13
Mean	13.61	83.90		60.55	79.04	112.80		145.98	82.65
Grand mean	11.63	82.12		60.73	72.65	107.96		126.74	76.97
	Entisols			**Inceptisols**			**Vertisols**		
	Series	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	**Series x Treat.**	**Series**	**Treat.**	**Series x Treat.**
S.E.±	0.03	0.13	0.08	0.02	0.14	0.08	0.02	0.15	0.09
C.D.@ 5 %	NS	0.48	NS	0.07	0.52	NS	0.07	0.56	NS
Interaction	E Vs I			E Vs V			I Vs V		
t-test	0.427NS			0.846NS			0.45NS		

Soil series of Entisols, Inceptisols and Vertisols soil orders were significantly vary in the uptake of phosphorus by grain maize. Soil series of Vertisols viz., *Targaon, Ambulga* and *Babulgaon* were found to record the higher phosphorus uptake (74.38, 79.43 and 94.13 kg ha^{-1} respectively) followed by *Pather*, *Beed* and *Kolyachiwadi* of Inceptisols (68.19, 79.52 and 82.85 kg ha^{-1} respectively) and *Karwali*, *Rahuri* and *Akole* soil series of Entisols (69.09, 68.78 and 76.38 kg ha^{-1} respectively). This might be because of variation in inherent soil fertility, calcium carbonate content and organic matter content of all the soil series. Among the soil series *Babulgaon* soil series of Vertisols and *Kolyachiwadi* soil series of Inceptisols were found to record the higher phosphorus uptake (94.13 and 82.85 kg ha^{-1}). However, *Ambulga* and *Beed* soil series of Vertisols and Inceptisols were found similar for phosphorus uptake by grain maize (79.43 and 79.52 kg ha^{-1}). This results indicated that the nutrient application as per fertilizer prescription equations by the grain maize grown on soil series of Vertisols and Inceptisols are equally suitable. Whrease, it was not suitable for soil series of Entisols. The lower uptake of phosphorus by the grain maize grown on soil series of Entisols was might be associated with the shallow depth soil, less clay content and moisture holding capacity, higher calcium carbonate content with less amount of organic matter (Goswami and Sahrawat, 1982) [8].

Fertilizer treatment, **Soil series x Fertilizer treatment and Interactions within soil orders**

Total phosphorus uptake by the grain maize due to fertilizer application grown on different soil series of Entisols, Inceptisols and Vertisols were significantly influenced. Nutrient application as per fertilizer prescription equation for the target 80 and 100 q ha^{-1} with 10 t FYM was found to significantly superior for total phosphorus uptake on Entisols (102.97 and 114.72 kg ha^{-1}), Inceptisols (108.12 and 119.52 kg ha^{-1}) and Vertisols (112.80 and 145.98 kg ha^{-1}). Whereas, nutrient application as per 80 and 100 q ha^{-1} target along with 10 t ha^{-1} FYM to grain maize grown on Vertisols irrespective of soil series was higher and closely followed by Inceptisols. This indicated that phosphorus application as per fertilizer prescription equations with FYM are most suitable for both the soil series of Vertisols and Inceptisols even though the equations were developed on Inceptisols. This might be associated with exchangeable calcium and sesquioxide content in medium black soil had inverse relation with availability of phoshorus, which however could be increased through fertilizer application. Similar results were also reported by Moshi *et al.*, (1975) [12].

The higher phosphorus uptake by grain maize grown on Vertisols and Inceptisols might be associated with the higher soil depth, moisture holding capacity, nutrient retension capacity and orgnic matter content. Similraly, addition of FYM along with chemical fertilizer improves the use efficiency of added phosphorus. The decomposition of FYM after their addition in soil release organic acids in rhizosphere and increased the availability of native and added phosphorus to crop plants. Similarly, it also enhancing the population and activity of phosphorus solubilizing bacteria. As a result increased availability of phosphorus in soil and their uptake by grain maize. Similar findings were also reported by Rao and Shaktawat (2002) [13]. Higher uptake of phosphorus might be due to beneficial effect of higher level of phosphorus on growth and development by way of increased length and number of roots, thus leading to increased uptake of nutrients and moisture and improving the photosynthetic efficiency of plant. The present findings corroborate with the earlier findings of Suryavanshi *et al.,* (2008) [17].

The interaction effects between soil series and fertilizer application treatments were found non signification for total phosphorus uptake by the grain maize. The non-significant interaction effects of soil series and fertilizer application as per fertilizer prescription equations for total phosphorus uptake by grain maize indicated that the phosphorus uptake was governed by the inherent soil properties in respect to their physical, chemical and biological properties and phosphorus supplying capacity of chemical fertilizer after interaction with soil conditions (Venkateshwarlu, 1976) [20].

Potassium uptake

Data presented in Table 4 indicated that total uptake of potassium of grain maize was influenced by soil order, soil series and fertilizer applications. The total potassium uptake by grain maize was considerably higher in Vertisols soil order (111.24 kg ha^{-1}) followed by Inceptisols (106.38 kg ha^{-1}) and Entisols (96.47 kgha^{-1}) irrespective of soil series and fertilizer application treatments.

Table 4: Total potassium uptake of maize as influenced by soil orders series and treatments at harvest.

Order/ Series	Total potassium uptake (Kg ha^{-1})						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Entisols S1	22.01	113.62	88.34	108.58	134.68	149.20	102.07
S2	14.35	90.06	63.30	82.68	123.15	146.35	86.65
S3	15.69	107.95	100.26	110.23	134.45	131.66	93.37
Mean	17.35	103.88	83.97	100.50	130.76	142.38	96.47
Inceptisols S1	30.05	112.53	105.63	133.23	165.47	162.69	103.27
S2	18.16	101.72	79.01	82.26	125.88	146.39	92.24
S3	18.79	118.68	88.15	113.05	143.77	169.47	108.65
Mean	22.34	110.98	90.93	109.51	145.04	159.51	106.38
Vertisols S1	25.21	114.05	96.44	105.40	146.86	191.34	113.22
S2	18.80	96.94	108.90	114.88	150.80	189.02	113.22
S3	16.11	108.47	68.85	112.45	150.19	187.57	107.27
Mean	20.04	106.49	91.40	110.91	149.28	189.31	111.24
Grand mean	19.91	107.11	88.76	106.97	141.69	171.52	105.44

	Entisols			Inceptisols			Vertisols		
	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.	Series	Treat.	Series x Treat.
S.E.±	0.04	0.17	0.10	0.09	0.24	0.15	0.08	0.20	0.12
C.D.@ 5 %	0.12	0.65	NS	NS	0.92	NS	NS	0.76	NS
Interaction	E Vs I			E Vs V			I Vs V		
t-test	0.184NS			0.751NS			0.588NS		

Vertisols soil order showed the maximum potassium uptake than the Inceptisols and Entisols. This might be due to different types of clay mineral contents and parent materials. Similarly, inherent potassium content in soils of Vertisols. Similar findings were also reported by Rao and Shaktawat (2002) [13]. Soil series of Entisols, Inceptisols and Vertisols soil orders were significantly vary in the uptake of potassium by grain maize. Soil series of Vertisols soil order viz., *Targaon, Ambulga* and *Babulgaon* were found to record the higher potassium uptake (113.22, 113.22 and 107.27 kg ha^{-1} respectively) followed by soil series of Inceptisols (103.27, 92.24 and 108.65 kg ha^{-1} respectively) and Entisols (102.07, 86.65 and 93.37 kg ha^{-1} respectively). Soil series of Vertisols and Inceptisols were found similar trend for potassium uptake by grain maize. Whereas, soil series of Entisols recorded the less amount of potassium uptake. These results revealed that fertilizer prescription equation for grain maize on Inceptisols was more suitable for Vertisols soil order than the Entisols.

Fertilizer treatment, **Soil series x Fertilizer treatment and Interactions within soil order**

Total potassium uptake by grain maize was significantly influenced by the fertilizer application in all the soil orders. However, the potassium uptake by grain maize was considerably higher in treatment fertilizer application as 80 q ha^{-1} yield target + 10 t FYM and 100 q ha^{-1} yield target + 10 t FYM in Entisols (130.76 and 142.38 kg ha^{-1}), Inceptisols (145.04 and 159.51 kg ha^{-1}) and Vertisols (149.28 and 189.31 kg ha^{-1}). It was significantly higher in Vertisols and closely followed by Inceptisol. These results indicated that fertilizer equations developed on Inceptisols for grain maize are suitable for fertilizer application to grain maize.

The interaction effects between soil series and fertilizer application treatments were found non-significant for total potassium uptake by the grain maize. The interaction between soil series of Entisols, Inceptisols and Vertisols and fertilizer application to grain maize as per 80 and 100 q ha^{-1} along with 10 t ha^{-1} FYM were recorded significantly higher amount of potassium uptake than control and fertilizer application as per soil test values. This might be associated with the addition of nutrient through chemical fertilizer with FYM increased the cation exchange capacity of soil, use efficiency of potassium and temperory improvement in soil conditions, Kotangale *et al.*,(2009) [10]. The interaction effects of soil orders between Entisols vs Inceptisols, Entisols vs Vertisols and Inceptisols vs Vertisols were non-significant for total potassium uptake by grain maize. The non-significant interaction effects indicated that the fertilizer application as per fertilizer prescription equations are suitable to all the types soil under study for potassium uptake. The non-significant effects within the soil orders for total potassium uptake by the grain maize indicated that combined effect of soil orders did not affect the potassium uptake.

Grain yield

Soil order, series, fertilizer treatments and their interactions were significantly influenced the maize grain yield (Table 5). 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) [11].

Table 5: 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) [16] and Bangar (2001) [3]. 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) [2]. 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) [17]. The differences between the yield targets and mean actual yields obtained in each case (60, 80 and 100 q ha^{-1}, respectively) were non-significant indicating that the yields targeted could be achieved through fertilizer application based on yield target concept. These results corroborate the findings of Tamboli *et al.* (1996) [18] and Tamboli and Sonar (1998) [19]. 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) [18].

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 6: 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).

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) [5]. 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 7, 8 and 9.

Table 7: 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 8: 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 9: 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

References

1. Anonymous. Agriculture Statistics at a Glance. Directorate of Economics and Statistics (Agricultural Statistic Division).Department of Agriculture and Co-operative Ministry of Agriculture Govt. of India. 2009, 24-28.
2. Banerjee M, Rai RK, Maiti D, Dhar S. Impact of chemical fertilizer and biofertilizers on the yield and fertility build-up of soil under maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system. Indian J Agric. Sci. 2006; 76(12):753-755.
3. Bangar AR. Modification of Yield targeting equations for fertilization of rainfed sorghum under semi-arid tropics. J Maharashtra. Agric. Univ. 2001; 26(1):001-006.
4. Bharambe AP, Tomar A. Effect of integrated nutrient management on soil and crop productivity and nutrient uptake of rice grown on Vertisol. PKV Res. J. 2004; 28(1):53-57.
5. Dahiya SS, Goel S, Karwaraja SPJ. Effect of FYM and cadmium on dry matter yield and uptake of nutrients by maize. J Indian Soc. Soil. Sci. 1987; 35(2):324-315.
6. El Swify SA, Pathak P, Rego TJ, Singh S. Soil management for optimize productivity under rainfed conditions in the semi-arid tropics. Adv. Soil Sci. 1985; 1:1-64.
7. Goswami NN, Sahrawant KL. Nutrient transformation in soils macronutrients. Rev. Soil Res. India, Part-I, 1982; 1:123-125.
8. Helkian J, Manickman TS, Naglakshmi K. Influence of organic manures alone and in combination with inorganics on properties of black soil and jowar yield. Madras agric. J. 1981; 68(6):360-365.
9. Jayprakash TC, Naglikar VP, Pujari BT, Shetty RA. Effect of organics and inorganics on growth and yield of maize under irrigation. Karnataka J Agric. Sci. 2005; 18(3):798-800.
10. Kotangale VS, Bharambe PR, Katore JR, Ravankar HN. Effect of long term fertilization on yield and uptake of nutrients under Sorghum-Wheat cropping sequence in Vertisols. J Maharashtra agric. Univ. 2009; 16(3):185-188.
11. Lal S, Mathur BS. Effect of long term fertilization, manuring and liming of an Alfisol in maize, wheat, and soil properties J Indian Soc. Soil Sci. 1989; 37(4):717-724.
12. Moshi DA, Natarajan R, Panjanisamy T, Natarajan R, Sripaul KB, Rajaraman C. Soil fertility evalution studies with rice varieties on major soil series of Thanjawar Dist. Oryza. 1975; 10 (2):51-75.
13. Rao SS, Shaktawat MS. Effect of organic manure, phosphorus and gypsum on groundnut (*Arachis hyogaea*) production under rainfed condition. Indian J of Agron. 2002; 47(2):234-241.
14. Ramamoorthy B, Narsimhan RL, Dinesh RS. Fertilizer application for specific yield targets of Sonora-64. Indian Fmg. 1967; 27(4):43-44.
15. Srinivas A, Rao BRC, Reddy KCK, Maruthi GR. Soil test based fertilizer prescription for maximum and economic yields under Rice-Rice cropping sequence in Vertisols of Andhra Pradesh. J Res. ANGRAU. 2001; 29(2&3):61-68.
16. Suri VK, Verma TS. Targeted Yield concept for efficient use in a Maize-Wheat Cropping system and build-up of Native fertility in a Typic Hapludalf. J Indian Soc. Soil Sci. 1999; 47(1):67-72.
17. Suryavanshi VP, Chavan BN, Jadhav VT, Baig MIA. Response of maize to nitrogen and phosphorus application in Vertisols. Int. J Trop. Agric. 2008; 26(3&4):293-296.
18. Tamboli BD, Patil YM, Bhakare BD, Kadu PP, Somawanshi RB, Patil TN *et al*. Yield targeting approach for fertilizer recommendations to wheat on Vertisols of Maharashtra. J Indian Soc. Soil Sci. 1996; 44(1):81-84.
19. Tamboli BD, Sonar KR. Soil Test-Based Fertilizer Requirement for specific yield Targets of Wheat and Chickpea in Vertisols. J Indian Soc. Soil Sci. 1998; 46(3):472-473.
20. Venkateshwarlu J. Efficient resource management systems for drylands of India. Adv. Soil Sci. 1976; 7:765-221.