Effect of Inorganic Fertilizers and Organic Manures on Growth and Yield Parameters under Wheat-Maize Cropping Sequence Grown on Normal and Saline-Sodic Inceptisol

Abstract

The present study entitled “Effect of inorganic fertilizers and organic manures on physical properties of soils under wheat-maize cropping sequence grown on normal and saline-sodic Inceptisol” was conducted at PGI Research farm, Department of Soil Science and Agriculture Chemistry, Post Graduate Institute, MPKV., Rahuri during *Rabi*-2021 and *Summer*-2022. The experiment consist of eight treatments in wheat crop *viz.*, T_1: RDN (50% N) + 50% N through FYM, T_2: RDN (50% N) + 50% N through vermicompost, T_3: RDN (50% N) + 50% N through poultry manure, T_4: (50% N) + 50% N through press mud compost, T_5: (50% N) + 50% N through goat manure, T_6: (50% N) + 50% N through urban compost T_7: GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) + 10 t FYM ha^{-1} and T_8: absolute control. Whereas, in maize crop treatment from T_1 to T_6 RDN (50% N) is applied with residual N applied to wheat through FYM, vermicompost, poultry manure, goat manure and urban compost, respectively and T_7: GRDF (120:60:40 N: P_2O_5:K_2O kg ha^{-1}) + 5 t FYM ha^{-1} and T_8: Absolute control. These treatments replicated thrice in Randomized Block Design.. In wheat crop, the grain yield, straw yield, test weight, plant height and spike length recorded higher in treatment T_7 (GRDF 120:60:40 N: P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1}) under both normal and saline-sodic Inceptisol (27.87 q ha^{-1}, 41.00 q ha^{-1}, 43.72 g, 92 cm and 9.92 cm) and (34.43 q ha^{-1}, 44.02 q ha^{-1}, 42.40 g, 91 cm and 9.82 cm), respectively. Whereas, in succeeding maize crop, the treatment T_7 (GRDF 120:60:40 N: P_2O_5:K_2O kg ha^{-1} + 5 t FYM ha^{-1}) recorded highest grain yield, stover yield, test weight, plant height, length of cob and no. of grains per cob in both normal and saline-sodic Inceptisol (64.11 q ha^{-1}, 74.23 q ha^{-1}, 40.34 g, 237.82 cm, 19.99 cm and 633.02 g) and (52.52 q ha^{-1}, 61.82 q ha^{-1}, 38.63 g, 226.24 cm, 18.74 cm and 579.48 g), respectively. In wheat crop application of treatment T_7 (GRDF 120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t ha^{-1} FYM) recorded highest total uptake of nitrogen, phosphorous and potassium in both normal and saline-sodic Inceptisol (88.00, 16.00 and 100 N, P and K kg ha^{-1}) and (99.36, 17.20 and 103 N, P and K kg ha^{-1}), respectively. Whereas in succeeding maize crop, total uptake of nitrogen, phosphorous and potassium recorded highest in treatment T_7 (GRDF (120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 5 t ha^{-1} FYM) in both normal and saline-sodic Inceptisol (107.69, 10.77 and 94.67 N, P and K kg ha^{-1}) and (85.85, 8.58 and 75.47 N, P and K kg ha^{-1}), respectively.

1

The maize-wheat cropping system holds significant importance in addressing local food requirements and ensuring food security for India's ever-growing population. This system, featuring the cultivation of maize (*Zea mays L.*) and wheat (*Triticum aestivum*), is widely recognized as the primary and popular double cropping approach, especially in the irrigated regions of northwestern India [1]. Although maize is traditionally grown during the monsoon season, the maize-wheat combination remains the prevailing maize-based system, covering approximately 1.8 million hectares. This system ranks as the third major crop rotation in India and plays a vital role, contributing 3.0% to the nation's overall food production [2]. Additionally, it serves as a crucial factor in sustaining the country's food supply.

Chemical fertilizers have the advantage of rapidly restoring soil fertility, as the nutrients they contain become readily available to plants once the fertilizers dissolve in the soil [3]. Consequently, farmers have placed a strong emphasis on the use of chemical fertilizers to boost agricultural productivity [4]. Inorganic fertilizers, being water-soluble and containing all the essential nutrients in readily usable

forms, are particularly effective for promoting rapid plant growth. Their quick and efficient action is attributed to their high nutrient content, requiring only small quantities to enhance productivity [5].

Organic fertilizers encompass natural materials derived from both plant and animal sources, such as livestock manure, green manures, crop residues, household waste, compost, and other organic matter. These materials function directly as sources of essential plant nutrients while also exerting indirect effects on the physical, chemical, and biological characteristics of the soil [4]. Organic manures like farmyard manure (FYM), compost, vermicompost, poultry manure, and goat manure, among others, represent natural products that serve as valuable reservoirs of nutrients and moisture in the soil. Organic manures contribute to the improvement of soil structure and foster the growth and proliferation of beneficial soil microorganisms. This, in turn, increases the availability of nutrients for crop growth and aids in the detoxification of harmful chemicals present in the soil [6]; [7]; [8].

A well-balanced approach involving the combined use of fertilizers and manure stands as a highly effective strategy for preventing the depletion of organic matter and the rapid deterioration of soil's physical attributes, particularly its structure [9]; [10]. Integrated nutrient management practices have been developed as efficient methods to rejuvenate both soil's physical properties and chemical fertility while enhancing soil organic matter levels. The introduction of organic matter into the soil leads to an increase in its organic carbon content, which, whether directly or indirectly, impacts on growth and yield parameters of crops [11].

2. Material and Method

The research trials took place at the PGI Research Farm within the Department of Soil Science and Agricultural Chemistry at Mahatma Phule Krishi Vidyapeeth, Rahuri. The experimental plot selected was characterized as a level and uniform area with moderate soil depth, classified as an Inceptisol. Geographically, the experimental site was situated at a latitude of 19.034° N and a longitude of 74.064° E, with an elevation of 513 meters above sea level. This region is positioned on the Eastern side of the Western Ghats in Maharashtra. The climate in this area is categorized as a regional steppe climate, characteristic of a semiarid tropical region. It features dry and hot summers, along with cool winters, and falls within the agro-climatic zone known as the "Scarcity zone. The initial status of both normal and saline-sodic Inceptisol described in table 1.

Table 1. Initial Soil properties of normal and saline-sodic Inceptisol

Sr. No.	Soil properties	Values	
		Normal soil	Saline-sodic soil
A	**Chemical properties**		
1	pH (1:2.5)	8.32	8.41
2	EC (dS m^{-1})	0.29	2.1
3	Organic carbon (%)	0.42	0.46
4	Calcium Carbonate (%)	8.77	11.68
5	Available nitrogen (kg ha^{-1})	182.6	187.1
6	Available phosphorus (kg ha^{-1})	14.16	13.11
7	Available potassium (kg ha^{-1})	389.6	361.3
8	DTPA extractable Fe (mg kg^{-1})	4.09	4.01
9	DTPA extractable Mn (mg kg^{-1})	10.90	10.64
10	DTPA extractable Zn (mg kg^{-1})	0.323	0.307

11	DTPA extractable Cu (mg kg^{-1})	0.724	2.12
12	CEC (cmol(p^{+}) kg^{-1})	57	52
12	ESP (%)	0.25	17.69
B	**Heavy metals**		
1	Pb (mg kg^{-1})	Traces	Traces
2	Cd (mg kg^{-1})	Traces	Traces
3	Cr (mg kg^{-1})	Traces	Traces
4	Ni (mg kg^{-1})	Traces	Traces
C	**Saturation paste extract analysis**		
1	pHs	8.26	8.37
2	ECe	1.33	5.76
3	Ca^{2+} (meL^{-1})	7.19	24.92
4	Mg^{2+}(meL^{-1})	6.80	19.41
5	Na^{+}(meL^{-1})	0.11	11.28
6	K^{+}(meL^{-1})	0.15	0.16
7	CO_3^{2-}(meL^{-1})	-	-
8	HCO_3^{-}(meL^{-1})	5.6	9.4
9	Cl^{-} (meL^{-1})	5.8	24.6
10	SO_4^{2-} (meL^{-1})	2.2	22.3

The experiment consist of eight treatments in wheat crop *viz*., T_1: RDN (50% N) + 50% N through FYM, T_2: RDN (50%N) + 50% N through vermicompost, T_3: RDN (50% N) + 50% N through poultry manure, T_4: (50% N) + 50% N through press mud compost, T_5: (50% N) + 50% N through goat manure, T_6: (50% N) + 50% N through urban compost T_7: GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) + 10 t FYM ha^{-1} and T_8: absolute control. Whereas, in maize crop treatment from T_1 to T_6 RDN (50% N) is applied with residual N applied to wheat through FYM, vermicompost, poultry manure, goat manure and urban compost, respectively and T_7: GRDF (120:60:40 N: P_2O_5:K_2O kg ha^{-1}) + 5 t FYM ha^{-1} and T_8: Absolute control. The observations were recorded such as plant height, spike length, grain yield, straw yield and test weight in wheat crop under both normal and saline-sodic Inceptisol and plant height, length of cob and no. of grains per cob, grain yield, stover yield and test weight in maize crop under both normal and saline-sodic Inceptisol. The data were analysed statistically and results were interpreted by using methods suggested by [12] Panse and Sukhatme.

3. Result and Discussion

3.1 Effect of inorganic fertilizers and organic manures on yield and plant growth parameters of wheat crop in normal and saline-sodic inceptisol

Data pertaining to the significant results were observed for growth and yield of wheat by the application of various organic manures with inorganic fertilizers and presented in table 2 and 3 for normal and saline-sodic soil, respectively.

The treatment T_7, GRDF 120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t FYM ha^{-1} for normal soil was recorded significantly the highest value in term of grain yield, straw yield, test weight, plant height and spike length (27.87 q ha^{-1}, 41.00 q ha^{-1}, 43.72 g, 92 cm and 9.92 cm), respectively.. For grain and straw yield treatment T_3 and T_6 were at par with treatment T_7 and for the test weight and plant height treatments T_3, T_4 andT_6 while, for spike length treatment T_6 was found to be at par with treatment T_7.

Table 2. Effect of inorganic fertilizers and organic manures on yield and plant growth

parameters of wheat in normal Inceptisol

Tr. No.	Treatments	Yield and plant growth parameters				
		Normal soil				
		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Test weight (g)	Plant height (cm)	Spike length (cm)
T_1	**RDN (50% N) + 50% N through FYM**	24.34	27.61	39.44	78	6.67
T_2	**RDN (50% N) + 50% N through Vermicompost**	24.33	32.05	40.67	85	7.17
T_3	**RDN (50% N) + 50% N through Poultry manure**	26.33	40.23	41.88	85.7	7.33
T_4	**RDN (50% N) + 50% N through Press mud compost**	24.34	28.62	42.34	86	7.50
T_5	**RDN (50% N) + 50% N through Goat manure**	23.00	29.65	40.97	84	6.75
T_6	**RDN (50% N) + 50% N through urban compost**	27.81	40.00	42.56	89	9.47
T_7	**GRDF (120:60:40 N: P_2O_5 : K_2O kg ha^{-1} + 10 t ha^{-1} FYM**	27.87	41.00	43.72	92	9.92
T_8	**Absolute Control**	11.00	18.07	31.5	65	4.33
	SE (m)±	0.66	1.81	0.64	2.14	0.18
	CD at 5%	2.03	5.45	1.93	6.4	0.55

In saline-sodic soil the treatment T7, GRDF (120:60:40 N: P2O5: K2O kg ha^{-1} + 10 t FYM ha^{-1} was also recorded significantly the highest value in term of grain yield, straw yield, Test weight, plant height and spike length (34.43 q ha^{-1}, 44.02 q ha^{-1}, 42.40 g, 91 cm and 9.82 cm), respectively. For grain yield and straw yield, treatments T_2, T_3 and T_6 were found to be at par with treatment T_7 and for the test weight treatment T_4 and T_6 and for spike length treatment T_3 was found to be at par with treatment T_7.

Table 3. Effect of inorganic fertilizers and organic manures on yield and plant growth parameters of wheat in saline-sodic Inceptisol

Tr. No.	Treatments	Yield and plant growth parameters				
		Saline sodic soil				
		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Test weight (g)	Plant height (cm)	Spike length (cm)
T_1	**RDN (50% N) + 50% N through FYM**	25.61	39.04	37.82	80	6.8
T_2	**RDN (50% N) + 50% N through Vermicompost**	31.69	40.67	38.97	87	7.19
T_3	**RDN (50% N) + 50% N through Poultry manure**	34.17	42.12	40.61	86	9.40
T_4	**RDN (50% N) + 50% N through Press mud compost**	30.00	38.67	40.96	88	7.50

T_5	**RDN (50% N) + 50% N through Goat manure**	29.78	40.02	39.57	86	6.75
T_6	**RDN (50% N) + 50% N through urban compost**	30.99	42.53	40.94	89	8.17
T_7	**GRDF (120:60:40 N: P_2O_5 : K_2O kg ha^{-1} + 10 t FYM ha^{-1}**	34.43	44.02	42.40	91	9.82
T_8	**Absolute Control**	16.63	28.81	32.62	68	5.31
	SE (m)±	1.22	1.23	0.47	0.15	0.19
	CD at 5%	3.63	3.68	1.47	0.45	0.57

Wheat is moderately salt tolerant crop and tolerate salt upto much level and takes nutrients even after high salt concentration it might be one of the reason for high grain and straw yield of wheat crop in saline-sodic soil.

3.2 Effect of Inorganic Fertilizers and Organic Manures on Yield and Plant Growth Parameters of Maize crop in Normal and Saline-Sodic Inceptisol

The significant results were observed for total yield of maize by the application inorganic fertilizers and residual effect of organic manures and presented in table 4 and 5 for normal and saline-sodic soil, respectively.

In normal soil, the treatment T_7, GRDF (120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t FYM ha^{-1}) was recorded significantly the highest value in term of grain yield, stover yield,test weight, plant height, length of cob and no. of grain per cob (64.11 q ha^{-1}, 74.23 q ha^{-1}, 40.34 g, 237.82 cm, 19.99 cm and 633.02 g), respectively. For grain yield, stover yield, plant height, length of cob and no. of grain per cob treatment T_2 and T_3 were at par with treatment T_7 and for the test weight treatments T_2, T_3, T_4 andT_6 were found to be at par with treatment T_7.

Table 4. Effect of inorganic fertilizers and organic manures on yield and plant growth parameters of maize in normal Inceptisol

Tr. No.	Treatments	Yield and plant growth parameters					
		Normal soil					
		Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Test weight (g)	Plant height (cm)	Length of cob (cm)	No. of grain per cob (g)
T_1	**RDN (50% N)**	58.41	67.72	36.83	188.45	17.32	520.33
T_2	**RDN (50% N)**	62.28	70.44	39.72	224.85	18.93	596.33
T_3	**RDN (50% N)**	60.34	69.89	39.16	216.71	18.72	586.78
T_4	**RDN (50% N)**	58.66	67.64	37.92	198.32	17.74	533.63
T_5	**RDN (50% N)**	57.42	66.22	36.14	186.45	17.25	515.36
T_6	**RDN (50% N)**	59.36	68.44	38.72	208.32	18.03	543.78

T_7	**GRDF 120:60:40 + 5 t ha^{-1} FYM**	64.11	74.23	40.34	237.82	19.99	633.02
T_8	**Absolute control**	48.83	58.52	29.84	176.35	15.79	491.19
	SE (m)±	1.45	1.72	1.13	6.96	0.47	16.07
	CD at 5%	4.39	5.22	3.42	21.13	1.44	48.76

Table 5. Effect of inorganic fertilizers and organic manures on yield and plant growth parameters of maize in saline-sodic Inceptisol

Tr. No.	Treatments	Yield and plant growth parameters					
		Saline-sodic soil					
		Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Test weight (g)	Plant height (cm)	Length of cob (cm)	No. of grain per cob (g)
T_1	**RDN (50% N)**	47.18	56.43	34.96	184.68	16.31	476.85
T_2	**RDN (50% N)**	50.76	59.52	36.82	213.75	17.42	551.78
T_3	**RDN (50% N)**	49.28	58.77	36.23	206.23	17.33	533.63
T_4	**RDN (50% N)**	47.54	57.12	35.58	197.75	16.78	496.13
T_5	**RDN (50% N)**	46.64	55.53	34.37	179.46	16.08	468.86
T_6	**RDN (50% N)**	49.08	57.28	35.86	197.71	17.12	517.6
T_7	**GRDF 120:60:40 + 5 t ha^{-1} FYM**	52.52	61.82	38.63	226.24	18.74	579.48
T_8	**Absolute control**	38.47	49.35	26.49	168.45	14.23	393.74
	SE (m)±	1.12	1.39	1.05	6.97	0.48	16.07
	CD at 5%	3.40	4.21	3.18	21.14	1.44	48.76

In saline-sodic soil, the treatment T_7, GRDF (120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t FYM ha^{-1}) was recorded significantly the highest value in term of grain yield, stover yield, test weight, plant height, length of cob and no. of grain per cob (52.52 q ha^{-1}, 61.82 q ha^{-1}, 38.63 g, 226.24 cm, 18.74 cm and 579.48 g), respectively. For grain yield, stover yield, plant height, length of cob and no. of grain per cob treatment T_2 and T_3 were at par with treatment T_7 and for the test weight treatments T_2, T_3, T_4 and T_6 were found to be at par with treatment T_7.

The highest yield in maize crop was observed in treatment T_7, GRDF (120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t FYM ha^{-1}) for both normal and saline-sodic Inceptisol which is might be due to improvement of physical and chemical properties of soils that resulted in increased productivity by increasing avaibility of plant nutrients [13]. Further, the organic matter might have supplied macro and micro nutrients and resulted as chelating agent for enhancing the avaibility of nutrients in soil. These results are in conformity with the finding of [14] Urkurkar et al.; [15] Thakur et al..

3.3 Effect of inorganic fertilizers and organic manures on uptake of nutrients by wheat in

normal and saline-Sodic Inceptisol

The data for the uptake of NPK by wheat by the application of various organic manures with inorganic manures is presented in table 6. In wheat crop application of treatment T_7 (GRDF 120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t ha^{-1} FYM) recorded highest total uptake of nitrogen, phosphorous and potassium in both normal and saline-sodic Inceptisol *i.e.* (88.00, 16.00 and 100 N, P and K kg ha^{-1}) and (99.36, 17.20 and 103 N, P and K kg ha^{-1}), respectively.

Table 6. Effect of inorganic fertilizers and organic manures on nutrients uptake by wheat in normal and saline-sodic Inceptisol

Tr. No.	Treatments	Total uptake (kg ha^{-1})					
		Normal soil			Saline-sodic soil		
		N	P	K	N	P	K
T_1	RDN (50% N) + 50% N through FYM	74.44	9.24	80.81	95.88	10.90	86
T_2	RDN (50% N) + 50% N through Vermicompost	63.85	10.46	84.06	77.13	15.68	88
T_3	RDN (50% N) + 50% N through Poultry manure	86.48	14.00	94.10	97.59	15.39	96
T_4	RDN (50% N) + 50% N through Press mud compost	68.01	11.70	91.61	74.31	14.92	93
T_5	RDN (50% N) + 50% N through Goat manure	55.68	10.66	79.51	59.56	10.04	87
T_6	RDN (50% N) + 50% N through urban compost	85.92	10.40	94.7	73.20	13.41	100
T_7	GRDF (120:60:40 N: P_2O_5 : K_2O kg ha^{-1} + 10 t FYM ha^{-1}	88.00	16.00	100	99.36	17.20	103
T_8	Absolute Control	33.06	4.45	41.25	38.50	5.88	69.31
	SE(m)±	0.94	0.66	2.21	1.1	1.14	3.05
	CD at 5%	2.82	2.03	6.63	3.3	3.52	9.16

In normal soil treatment T_3 and T_6 were found to be at par with treatment T_7 for the uptake of total nitrogen and potassium while, for the uptake of phosphorus treatment T_3 was at par with treatment T_7. In saline-sodic soil for total nitrogen uptake treatment T_3 was at par with treatment T_7 and for total phosphorus treatments T_2, T_3 and T_4 while, for total potassium uptake treatments T_3 and T_6 were found to be at par with T_7.

The significant increase in the uptake of total N, P and K might be due to combined application of organic and inorganic fertilizers due to which availability of nutrients increased during crop growth. The findings are accordance with those reported by [16] Bahadur et al..

.

3.4 Effect of inorganic fertilizers and organic manures on uptake of nutrients by maize in normal and saline-sodic Inceptisol

The data for the uptake of NPK by maize by the application of inorganic fertilizers and residual effect of organic manures is presented in table 7.

Table 7. Effect of inorganic fertilizers and organic manures on nutrients uptake by maize in normal and saline-sodic Inceptisol

Tr. No.	Treatments	Total uptake (kg ha^{-1})					
		Normal soil			Saline-sodic soil		
		N	P	K	N	P	K
T_1	RDN (50% N)	96.58	9.66	84.90	76.09	7.61	66.89
T_2	RDN (50% N)	102.58	10.26	90.18	82.15	8.22	72.22
T_3	RDN (50% N)	100.31	10.03	88.18	78.98	7.96	70.26
T_4	RDN (50% N)	98.28	9.83	86.40	77.04	7.70	67.73
T_5	RDN (50% N)	96.13	9.61	84.51	74.77	7.48	65.74
T_6	RDN (50% N)	99.33	9.93	87.32	80.01	8.00	70.34
T_7	GRDF 120/60/40 + 5 t FYM ha^{-1}	107.69	10.77	94.67	85.85	8.58	75.47
T_8	Absolute control	79.49	7.95	69.88	61.72	6.17	54.26
	SE(m)±	2.88	0.29	2.54	2.28	0.23	2.01
	CD at 5%	8.75	0.87	7.69	6.93	0.69	6.09

In both normal and saline-sodic Inceptisol, in succeeding maize crop, total uptake of nitrogen, phosphorous and potassium recorded highest in treatment T_7 (GRDF (120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 5 t ha^{-1} FYM) (107.69, 10.77 and 94.67 N, P and K kg ha^{-1}) and (85.85, 8.58 and 75.47 N, P and K kg ha^{-1}), respectively and the lowest value for the uptake of NPK was recorded for treatment T_8 (Absolute control).

In normal soil treatment T_2, T_3 and T_6 were found to be at par with treatment T_7 for the uptake of total nitrogen, phosphorus and potassium. In saline-sodic soil for total nitrogen, phosphorus and potassium uptake treatment T_2, T_3 and T_6 were found to be at par with treatment T_7.

The significant increase in the uptake of total N, P and K might be due to releasing nutrients from sources and biological activity which resulted in more nutrient uptake. The findings are accordance with those reported by [17] Prajapati et al..

4. Conclusion

The growth parameters *viz*. plant height, spike length, test weight, grain and straw yield and total uptake of N, P and K were found to be significantly higher in the treatment GRDF 120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t ha^{-1} FYM under wheat crop in both normal and saline-sodic Inceptisol. The yield in GRDF 120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 10 t ha^{-1} FYM is increased by 23.53 % in saline-sodic soil compared to normal Inceptisol.

Application of GRDF 120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 5 t ha^{-1} FYM was found significantly higher under succeeding maize crop in both normal and saline-sodic Inceptisol in term of plant height, length of cob, No. of grains per cob, test weight, grain yield, stover yield and total uptake of N, P and K. The treatment RDN 50% N + Residual N is applied to wheat through vermicompost and RDN 50% N +

Residual N is applied to wheat through poultry manure were found at par for maize crop characteristics such as plant height, cob length, grain count, test weight, grain and stover yield, and nutrient uptake in both types of soils.

.

5. References:

1. Jat, M. L., Satyanarayana, T., Majumdar, K., Tetarwal, J. P., Jat, R. K. and Sharawat, Y. S. Fertilizer best management practices for maize systems. Indian Journal of Fertilizers. 2013;9: 80-94.

2. Jat, R. K., Sapkota, T.B., Singh, R.G., Jat, M.L., Kumar, M and Gupta, R.K. Seven years of conservation agriculture in a rice-wheat rotation of Eastern Gangetic Plains of South Asia. Field and Crop Research. 2014;164:199-210.

3. Scholl, L. and Nieuwenhuis, R. Soil Fertility Management. Agromisa Foundation, Wageningen, Netherlands. 2004.

4. Basel, N. and Sami, M. Effect of organic and inorganic fertilizers application on soil and cucumber (*Cucumis sativa L*.) plant productivity. International Journal of Agriculture and Forestry. 2014;4:166-170.

5. Han, S.H., Young, J., Hwang, J., Kima, S.B. and Parka, B. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of Yellow Poplar (*Liriodendron tulipifera Lin*.) in a Nursery System. Forest Science and Technology. 2016;12:137-143.

6. Turner, B.L., Richardson, A.E. and Mullaney, E.J. Inositol phosphates linking agriculture and environment, CAB, International Wallingford, U.K. 2007; Pp.304-308.

7. Hati, K.M., Swarup, A., Mishra, B., Manna, M.C., Wanjari, R.H., Mandal, K.G. and Misra, A.K. Impact of long-term application of fertilizer, manure and lime under intensive cropping on physical properties and organic carbon content of an Alfisol. Geoderma. 2008;148:173–179.

8. Bandyopadhyay, K.K., Misra, A.K., Ghosh, P.K. and Hati, K.M. Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. Soil and Tillage Research. 2010;110:115–125.

9. Singh, G., Jalota, S.K. and Singh, Y. Manuring and residue management effects on physical properties of a soil under the rice-wheat system in Punjab, India. Soil and Tillage Research. 2007;94:229-238.

10. Hati, K.M. and Bandyoopadhay, K. Fertilizers (mineral and organic) effect on soil physical properties. Encyclopedia of Agrophysics. 2014;6:296-299.

11. Rudrappa, L., Purakayastha, T.J., Singh, D., Bhadraray, S. Long-term manuring and fertilization effects on soil organic carbon pools in a Typic Haplustept of semi-arid sub-tropical India. Soil and Tillage Research. 2006;88:180–192.
12. Panse, V.G. and Sukhatme, P.V. Statistical Methods for Agricultural Workers. IVEd. ICAR, New Delhi; 1995.
13. Singh, V., Dixit, S.P., Kumar, P., Sharma, S.K. and Kaushal, S. Correlation Studies of soil properties under STCR approach with yield of maize (*Zea mays L*.) in an acid Alfisol. Journal of Pharmacognosy and Phytochemistry. 2019;2(1):94-96.
14. Urkurkar, J.S., Tiwari, A., Chitale, S. and Bajpai, R.K. Influence of long-term use of inorganic and organic manures on soil fertility and sustainable productivity of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Inceptisol. Indian Journal of Agriculture Sciences. 2010;80:208-212.
15. Thakur, R., Sawarkar, S.D., Vaishya, U.K. and Singh, M. Impact of continuous use of inorganic fertilizers and organic manure on soil properties and productivity under soybean-wheat intensive cropping of a Vertisol. Journal of the Indian Society of Soil Science. 2011;59: 74-81
16. Bahadur, L., Tiwari, D.D., Mishra, J. and Gupta, B.R. Effect of integrated nutrient management on yield, microbial population and change in soil properties under rice-wheat system in sodic soil. Journal of the Indian Society of Soil Science. 2012;60(4):326-329.
17. Prajapati, S., Kumar, V., Singh, S., Singh, A. and Kumar, A. Growth, yield and nutrient uptake of maize as affected by balanced nutrition under Western UP condition. The Pharma Innovation. 2022;11(4):1344-1347.