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

Keywords: *Inorganic fertilizer, organic manures, saline-sodic soil, plant height, no.of grains per cob. Uptake ofN, P and K*

1. Introduction

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 (*Triticumaestivum*), 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 PhuleKrishiVidyapeeth, 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 Inceptisolis 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	**Chemicalproperties**		
1	pH(1:2.5)	8.32	8.41
2	EC(dS m^{-1})	0.29	2.10
3	Organiccarbon(%)	0.42	0.46
4	CalciumCarbonate(%)	8.77	11.68
5	Availablenitrogen(kgha^{-1})	182.60	187.10
6	Availablephosphorus(kgha^{-1})	14.16	13.11
7	Availablepotassium(kgha^{-1})	389.60	361.30

8	DTPAextractable Fe($mgkg^{-1}$)	4.09	4.01
9	DTPAextractableMn ($mg\ kg^{-1}$)	10.90	10.64
10	DTPAextractableZn($mgkg^{-1}$)	0.323	0.307
11	DTPAextractableCu($mgkg^{-1}$)	0.724	2.12
12	CEC($cmol(p^{+})\ kg^{-1}$)	57.00	52.00
13	Exchangeable Na^{+}($cmol(p^{+})\ kg^{-1}$)	3.84	9.68
14	ESP(%)	6.73	18.61
B	**Heavymetals**		
1	Pb($mgkg^{-1}$)	Traces	Traces
2	Cd($mgkg^{-1}$)	Traces	Traces
3	Cr($mgkg^{-1}$)	Traces	Traces
4	Ni($mgkg^{-1}$)	Traces	Traces
C	**Saturationpasteextractanalysis for**		
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 experimentconsists of eight treatments in wheat crop *viz*., T_1: RDN (50% N) + 50% N through FYM, T_2: RDN (50%N)+50%Nthroughvermicompost,T_3:RDN(50%N) +50% Nthroughpoultrymanure, T_4: (50% N) + 50% N through press mud compost, T_5: (50% N) + 50% N throughgoat 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}andT_8: absolute control". [21] 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}andT_8: Absolute control. The observations were recorded such as plant height, spike length, grain yield, straw yield and test weight in wheat cropsunder 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 Effectofinorganicfertilizersandorganicmanuresonyieldandplantgrowth parameters of wheat crop in normalandsaline-sodicinceptisol

Data onthe growth and yield of wheat by the application ofvariousorganic manures with inorganicfertilizers and presentedinTables 2 and 3 fornormalandsaline-sodic soil,respectively.

The treatment T7, GRDF (120:60:40 N: P2O5: K2O kg ha-1 + 10 t FYM ha-1) recorded significantly the highest values in terms of grain yield (27.87 kg ha-1), straw yield (41 kg ha-1), test weight (43.72 g), plant height (92 cm) and spike length (9.92 cm) in normal soil. For grain and straw yield treatment T3 and T6 were at par with treatment T7 and for the test weight and plant height treatments T3, T4 and T6 while, for spike length treatment T6 was found to be at par with treatment T7.

Table 2. Effectofinorganicfertilizersandorganicmanuresonyieldandplantgrowth parameters of wheatinnormalInceptisol

Tr. No.	Treatments	Yieldand plantgrowthparameters				
		Normalsoil				
		Grain yield (qha^{-1})	Straw yield (qha^{-1})	Test weight (g)	Plant height(cm)	Spike length (cm)
T_1	RDN(50%N)+50%Nthrough FYM	24.34	27.61	39.44	78	6.67
T_2	RDN(50%N)+50%Nthrough Vermicompost	24.33	32.05	40.67	85	7.17
T_3	RDN(50%N)+50%Nthrough Poultrymanure	26.33	40.23	41.88	85.7	7.33
T_4	RDN(50%N)+50%Nthrough Pressmudcompost	24.34	28.62	42.34	86	7.50
T_5	RDN(50%N)+50%Nthrough Goatmanure	23.00	29.65	40.97	84	6.75
T_6	RDN(50%N)+50%Nthrough urbancompost	27.81	40.00	42.56	89	9.47
T_7	GRDF(120:60:40N:P_2O_5:K_2O $kgha^{-1}$+ 10t ha^{-1} FYM	27.87	41.00	43.72	92	9.92
T_8	AbsoluteControl	11.00	18.07	31.5	65	4.33
	SE (m)±	0.66	1.81	0.64	2.14	0.18
	CDat 5%	2.03	5.45	1.93	6.4	0.55

The treatment T7, GRDF (120:60:40 N: P2O5: K2O kg ha-1 + 10 t FYM ha-1), also demonstrated superior performance in saline-sodic conditions, with highest values recorded for grain yield (34.43 kg ha-1), straw yield (44.02 kg ha-1), test weight (42.40 g), plant height (91 cm) and spike length (9.82 cm) in saline-sodic Inceptisol. The treatments T2, T3 and T6 were found to be at par with treatment T7 for grain yield and straw yield whereas, for test weight treatment T4 and T6 and for spike length treatment T3 was found to be at par with treatment T7.

Table 3. Effectofinorganicfertilizersandorganicmanuresonyieldandplantgrowth parameters of wheatinsaline-sodic Inceptisol

Tr. No.	Treatments	Yieldand plantgrowthparameters				
		Salinesodicsoil				
		Grainyield(qha^{-1})	Strawyield(qha^{-1})	Testweight(g)	Planthieght(cm)	Spikelength(cm)
T_1	RDN(50%N)+50%Nthrough FYM	25.61	39.04	37.82	80	6.8
T_2	RDN(50%N)+50%NthroughVermicompost	31.69	40.67	38.97	87	7.19

T_3	**RDN(50%N)+50%N through Poultrymanure**	34.17	42.12	40.61	86	9.40
T_4	**RDN(50%N)+50%Nthrough Pressmudcompost**	30.00	38.67	40.96	88	7.50
T_5	**RDN(50%N)+50%Nthrough Goatmanure**	29.78	40.02	39.57	86	6.75
T_6	**RDN(50%N)+50%Nthrough urbancompost**	30.99	42.53	40.94	89	8.17
T_7	**GRDF(120:60:40N:P_2O_5:K_2O $kgha^{-1}$+ 10t $FYMha^{-1}$**	34.43	44.02	42.40	91	9.82
T_8	**AbsoluteControl**	16.63	28.81	32.62	68	5.31
	SE (m)±	1.22	1.23	0.47	0.15	0.19
	CDat 5%	3.63	3.68	1.47	0.45	0.57

"The highest yield in wheat crop was observed in treatment T7, GRDF (120:60:40 N: P2O5: K2O kg ha-1 + 10 t FYM ha-1) for both normal and saline-sodic Inceptisol which might be due to the application of organic with inorganic fertilizers was found to be quite promising not only in maintaining higher productivity as well as in providing greater stability in crop production by synergistic effect of FYM on improving efficiency of optimum dose of NPK"[13]. These results conform with the findings of [14]Singh et al.Wheat is a moderately salt-tolerant crop and tolerates salt upto many levels and takes nutrients even after high salt concentration it might be one of the reasons for the high grain and straw yield of wheat crop in saline-sodic soil.

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

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

The grain yield (64.11 kg ha-1) and stover yield (74.23 kg ha-1) along with test weight (40.34 g), plant height (237.82 cm), length of cob (19.99 cm) and number of grains per cob (633.02 g) were significantly higher in treatment T7, GRDF (120:60:40 N: P2O5: K2O kg ha-1 + 10 t FYM ha-1) in normal soil. For grain yield, stover yield, plant height, length of cob and no. of grain per cob treatment T2 and T3 were at par with treatment T7 and for the test weight treatments T2, T3, T4 and T6 were found to be at par with treatment T7.

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 growthparameters					
		Normalsoil					
		Grain yield (qha^{-1})	Stover yield (qha^{-1})	Test weight(g)	Plant height (cm)	Length of cob (cm)	No. of grain per cob (g)
T_1	RDN (50% N) + Residual effect of FYM	58.41	67.72	36.83	188.45	17.32	520.33
T_2	RDN (50% N) + Residual effect of vermicompost	62.28	70.44	39.72	224.85	18.93	596.33
T_3	RDN (50% N) + Residual effect of poultry manure	60.34	69.89	39.16	216.71	18.72	586.78
T_4	RDN (50% N) + Residual effect of press mud compost	58.66	67.64	37.92	198.32	17.74	533.63
T_5	RDN (50% N) + Residual effect of goat manure	57.42	66.22	36.14	186.45	17.25	515.36
T_6	RDN (50% N) + Residual effect of urban compost	59.36	68.44	38.72	208.32	18.03	543.78
T_7	GRDF(120:60:40N: P_2O_5: K_2Okgha^{-1}+ 5t 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
	CDat 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 growthparameters of maize in saline-sodic Inceptisol

Tr. No.	Treatments	Yield and plant growthparameters					
		Saline-sodic soil					
		Grain yield(qha^{-1})	Stover yield(qha^{-1})	Test weight(g)	Plant height (cm)	Length of cob (cm)	No. of grain per cob (g)
T_1	RDN (50% N) + Residual effect of FYM	47.18	56.43	34.96	184.68	16.31	476.85
T_2	RDN (50% N) + Residual effect of vermicompost	50.76	59.52	36.82	213.75	17.42	551.78
T_3	RDN (50% N) + Residual effect of poultry manure	49.28	58.77	36.23	206.23	17.33	533.63
T_4	RDN (50% N) + Residual effect of press mud compost	47.54	57.12	35.58	197.75	16.78	496.13
T	RDN (50% N) +	46.64	55.53	34.37	179.4	16.0	468.8

T_5	**Residual effect of goat manure**				6	8	6
T_6	**RDN (50% N) + Residual effect of urban compost**	49.08	57.28	35.86	197.71	17.12	517.6
T_7	**GRDF(120:60:40N: P_2O_5: K_2Okgha^{-1}+ 5t 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
	CDat 5%	3.40	4.21	3.18	21.14	1.44	48.76

The treatment T7, GRDF (N: P2O5: K2O kg ha-1 + 10 t FYM ha-1), recorded significantly the highest values for grain yield (52.52 kg ha-1), stover yield (61.82 kg ha-1), test weight (38.63 g), plant height (226.24 cm), length of cob (18.74 cm), and number of grains per cob (579.48 g) in saline-sodic Inceptisol. Treatment T2 and T3 were at par with treatment T7 for grain yield, stover yield, plant height, length of cob and no. of grain per cob and for the test weight treatments T2, T3, T4 and T6 were found to be at par with treatment T7.

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 might be due to improvement of physical and chemical properties of soils that resulted in increased productivity by increasing availability of plant nutrients [15]. Further, the organic matter might have supplied macro and micronutrients and resulted as a chelating agent for enhancing the availability of nutrients in soil. These results conform with the findings of [16]Urkurkar et al. and [17] Thakur et al..

3.3Effect 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 ofvariousorganicmanureswithinorganicmanuresispresentedinTable6. The significantly higher NPK uptake was observed in treatment T7,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, compared to treatment T8 (Absolute control) which exhibited the lowest uptake.

Table 6. Effectofinorganicfertilizersandorganicmanuresonnutrientuptakebywheatin normal and saline-sodicInceptisol

Tr. No.	Treatments	Totaluptake(kg ha^{-1})					
		Normalsoil			Saline-sodicsoil		
		N	P	K	N	P	K
T_1	RDN(50%N)+50%NthroughFYM	74.44	9.24	80.81	95.88	10.90	86
T_2	RDN(50%N)+50%Nthrough Vermicompost	63.85	10.46	84.06	77.13	15.68	88

T_3	RDN(50%N)+50%NthroughPoultry manure	86.48	14.00	94.10	97.59	15.39	96
T_4	RDN(50%N)+50%NthroughPress mudcompost	68.01	11.70	91.61	74.31	14.92	93
T_5	RDN(50%N)+50%Nthrough Goat manure	55.68	10.66	79.51	59.56	10.04	87
T_6	RDN(50%N)+50%Nthroughurban compost	85.92	10.40	94.7	73.20	13.41	100
T_7	GRDF(120:60:40N:P_2O_5:K_2Okgha^{-1} +10 tFYMha^{-1}	88.00	16.00	100	99.36	17.20	103
T_8	AbsoluteControl	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
	CDat 5%	2.82	2.03	6.63	3.3	3.52	9.16

Analysis of nutrient uptake in normal soil revealed that T3 and T6 were found to be at par with treatment T7 for the uptake of total nitrogen and potassium while, for the uptake of phosphorus treatment T3 was at par with treatment T7. In the case of saline-sodic Inceptisol for total nitrogen uptake treatment T3 was at par with treatment T7 and for total phosphorus treatments T2, T3 and T4 while, for total potassium uptake treatments T3 and T6 were found to be at par with T7.

The highest nutrient uptake in the wheat crop was observed in treatment T7, GRDF (120:60:40 N: P2O5: K2O kg ha-1 + 10 t FYM ha-1) for both normal and saline-sodic Inceptisol which might be due to combined application of organic and inorganic fertilizers due to which availability of nutrients increased during crop growth. The findings are as per those reported by [18] Bahadur et al.

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3.4Effect 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 inorganicfertilizers and the residual effect of organic manuresispresentedinTable7.

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

Tr. No.	Treatments	Totaluptake(kg ha^{-1})					
		Normalsoil			Saline-sodicsoil		
		N	P	K	N	P	K
T_1	RDN (50% N) + Residual effect of FYM	96.58	9.66	84.90	76.09	7.61	66.89
T_2	RDN (50% N) + Residual effect of vermicompost	102.58	10.26	90.18	82.15	8.22	72.22
T_3	RDN (50% N) + Residual effect of poultry manure	100.31	10.03	88.18	78.98	7.96	70.26
T_4	RDN (50% N) + Residual effect of press mud compost	98.28	9.83	86.40	77.04	7.70	67.73
T_5	RDN (50% N) + Residual effect of goat manure	96.13	9.61	84.51	74.77	7.48	65.74
T_6	RDN (50% N) + Residual effect of urban compost	99.33	9.93	87.32	80.01	8.00	70.34
T_7	GRDF(120:60:40N: P_2O_5: K_2Okgha^{-1}+ 5t ha^{-1}	107.69	10.77	94.67	85.85	8.58	75.47

	FYM						
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
	CDat 5%	8.75	0.87	7.69	6.93	0.69	6.09

The treatment T7, GRDF (120:60:40 N: P_2O_5: K_2O kg ha^{-1} + 5 t ha^{-1} FYM was recorded significantly the highest NPK uptake and the lowest value for the uptake of NPK was recorded for treatment T8 (Absolute control) in both normal and saline-sodic Inceptisol. In normal soil, treatments T2, T3 and T6 were found to be at par with treatment T7 for the uptake of total nitrogen, phosphorus and potassium. However, in the case of saline-sodic Inceptisol for total nitrogen, phosphorus and potassium uptake treatment T2, T3 and T6 were found to be at par with treatment T7.

The highest nutrient uptake 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-sodicInceptisolwhich might be due to releasing nutrients from sources and biological activity which resulted in more nutrient uptake. The findings are as per those reported by [19] Prajapati*etal*.. The higher uptake increased due to better root development which resulted in better absorption of nutrients which led to the yield. The uptake response also shows plant metabolic activity earlier reported similar response in nutrient uptake by [20] Singh *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 terms 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 was 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.

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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 (*Cucumissativa 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 TypicHaplustept 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. Priyanka, C., Sharma, S.K., Singh, A. and Sharma, J.K. Effect of INM on nutrient uptake and yield of maize-wheat cropping sequence and change in nutrient availability in TypicHaplustepts. Bioscan(2019); 14(2): 145-150.

14. Singh, S., Bhat, Z.A. and Rehman, H.U. Influence of organic and integrated nutrient management on physico-chemical properties of soil under basmati-wheat cropping sequence. The Bioscan(2014); 9(4): 1471-1478.

15. 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.

16. 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 (*Oryzasativa*) and wheat (*Triticumaestivum*) in Inceptisol. Indian Journal of Agriculture Sciences. 2010;80:208-212.

17.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

18. 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.

19.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.

20. Singh, V., Pant, A.K., Bhatnagar, A. and Bhatt, M. Evaluation of nutrient expert based fertilizer recommendation for growth yield and nutrient uptake of maize hybrid and soil properties in maize-wheat cropping system in Mollisol. International Journal of Current Microbiology and Applied Sciences (2017); 6(10): 3539-3550.
21. SM Bhaisare, NJ Ranshur, PS Bodhare, R Gurjar and PS Gochar. Effect of inorganic fertilizers and organic manures onbiological properties of soil for wheat grown on Normaland Saline Sodic Inceptisol. The Pharma Innovation Journal 2023; 12(2): 496-499