www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(9): 1108-1113

www.thepharmajournal.com
Received: 09-06-2021
Accepted: 21-07-2021

Shailja Kumari
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Gopal Kumar
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Ragini Kumari
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Varsha Kumari
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Priyanka Kumari
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Rahul Raj
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Rajeev Padbhushan
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Corresponding Author:
Gopal Kumar
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Effect of STCR based application of organic and inorganic fertilizer on chemical properties of soils under rice based cropping system of Indo-Gangetic plains, India

Shailja Kumari, Gopal Kumar, Ragini Kumari, Varsha Kumari, Priyanka Kumari, Rahul Raj and Rajeev Padbhushan

Abstract
A field experiment was conducted during *kharif*, 2019 in Bihar Agricultural University, Sabour, Bhagalpur to study the effect of different approaches of fertilizer application on chemical properties of soil under rice based cropping system. Nine treatment were included in this experiment which comprised of control (without fertilizer application), farmers' practice, general recommended dose, soil test based yield targets 30, 40 and 50 quintal/ha replicated thrice in a randomized block design (RBD). The results revealed that Soil Test Crop Response (STCR) based fertilizer application significantly increased the available nitrogen (N), phosphorus (P), potassium (K) in soil as compared to other treatments without STCR. Although, the values of soil pH, EC and organic carbon (OC) was not significantly affected in comparison to its initial value with respect to different treatments. The content of available N, P and K statistically varied in the order; STCR with IPNS for high target yield> STCR without IPNS for high target yield> STCR with IPNS for medium target yield> STCR without IPNS for medium target yield> STCR with IPNS for low target yield> STCR without IPNS for low target yield> General fertilizer recommendation> Farmers' practice> Absolute control.

Keywords: Rice, soil test crop response, integrated plant nutrient system, available n, available p, available k

1. Introduction

The success from green revolution has been followed by declining soil health due to imbalanced use of fertilizers for longer period and this degradation has led to wide gap between crop removal and fertilizer application (Kumar *et al*., 2007) [11]. To narrow down this gap, balanced use of fertilizers is most crucial approach. Conventionally, fertilizer application based on soil testing is being commended throughout the world to know the nutrients status and their imbalances in the soil and apply required amount of the nutrients accordingly to overcome those imbalances (Gautam *et al*., 2013) [3]. However, in conventional soil testing method, the fertilizer recommendations are usually given by categorizing soil into low, medium and high fertility classes taking into consideration only the available nutrient status of soil prior to raising crop. But for an efficient fertilizer recommendation, available nutrient status of the soil as well as requirements of particular crop needs to be considered before applying the fertilizer (Tegegnework *et al*., 2015).

Therefore, in this context, prescription based fertilizer recommendation approach which considers every bit of nutrient present in soil for achieving targeted yield of crops under a particular agro-climatic situation is most suitable one. This approach is crop as well as variety specific. It provides scientific base for balanced fertilization not only between the fertilizer nutrients but also the available nutrients present in the soil (Ramamoorthy *et al*., 1967) [19]. Targeted yield concept focuses on a balance between 'fertilizing the crop and fertilizing the soil'. Therefore, this investigation was carried out to evaluate the effect of STCR approach based fertilizer application on soil chemical properties in rice based cropping systems under different fertilizer approaches of fertilizer application.

2. Materials and Methods

The field experiment was started in the year 2017 for "Developing and monitoring modified

STCR equations for prominent crops in Agroclimatic Zone II, IIIA and III B of Bihar". Geographically, the experimental field is located at 25°50'N latitude, 87°19'E longitude and at an altitude of 52.73 meter above mean sea-level. The present study was on the 3rd crop cycle (*Kharif* 2019) under rice based cropping systems. Taxonomically, the soils of the study fall in the order "Inceptisol" and sub group "Typic Ustifluvents" as per the taxonomic system of soil classification (Verma *et al*., 1976). These soils were slightly alkaline in nature. The field experiment was conducted in Randomized Block Design (RBD) with 9 treatments and 3 replications with plot size of 24 m^2 under Rice- Wheat and Rice-Maize cropping systems. The treatment details are as follows:

Table 1: Details of treatment

Treatments details		
T_1	-	General fertilizer recommendation (100:40:20 kg ha^{-1})
T_2	-	Farmers' practice (130:30:10 kg ha^{-1})
T_3	-	STCR with IPNS for low target yield(30 q ha^{-1})
T_4	-	STCR with IPNS for medium target yield(40 q ha^{-1})
T_5	-	STCR with IPNS for high target yield(50 q ha^{-1})
T_6	-	STCR without IPNS for low target yield(30 q ha^{-1})
T_7	-	STCR without IPNS for medium target yield(40 q ha^{-1})
T_8	-	STCR without IPNS for high target yield(50 q ha^{-1})
T_9	-	Absolute control

In rice, N, P and K was applied through urea, superphosphate and muriate of potash, respectively. In treatments comprising of STCR with IPNS approach, vermicompost was applied at the rate of 24 kg/plot in addition to inorganic fertilizers. For rice crop, recommended dose of fertilizers was 100:40:20 kg ha^{-1} of $N:P_2O_5:K_2O$ and for farmers' practice, fertilizer application rate was 130:30:10 kg ha^{-1} of $N:P_2O_5:K_2O$. Plot-wise composite soil samples were collected before sowing and after harvesting of rice crop in Kharif 2019 upto 0-15 cm from the experimental plots. Collected soil samples were left for drying under shade and then put in oven for 5 hours to remove the residual moisture content. After that, soil samples were processed using wooden pestle and mortar and passed through 2mm sieve and properly stored in polythene bags for further analysis. Methods for analysis of different soil properties are depicted in Table 2. Soil pH reading was taken with pH meter from the soil solution in the ratio 1:2.5. EC is determined from supernatant solution by EC meter. Oxidizable Organic carbon (OC) was estimated using Walkley and Black (1934) [31] rapid titration method with Ferrous Ammonium Sulphate (FAS). Available nitrogen (N) was estimated by alkaline potassium permanganate method in soil and result was expressed in kg N ha^{-1}.·For estimation of available phosphorus, Olsen's extractant was used. In this method, Ascorbic acid extractant was used and reading was taken at 660 nm in spectrophotometer. Available K was determined by using 1N Ammonium acetate taking soil: solution ratio 1:5.

STCR equations used to calculate fertilizer doses-

Without IPNS	**With IPNS**
$FN=4.54T-0.39S_N$	$FN = 5.66T - 0.55\ S_N - 0.46\ C_N$
$FP_2O_5=2.73T-2.92S_{P2O5}$	$F\ P_2O_5 = 2.89\ T - 2.18\ S_{P2O5} - 0.50\ C_{P2O5}$
$FK_2O=1.85T-0.24S_{K2O}$	$FK_2O = 2.83\ T - 0.55\ S_{K2O} - 0.32\ C_{K2O}$

Table 2: Methods used for determination of different properties of soil

Sr. No	Parameter	Method	Reference
1	pH	Soil: Water (1:2.5)	Jackson, 1973 [6]
2	Electrical Conductivity (dS m^{-1})	Soil: Water (1:2.5)	Jackson, 1973 [6]
3	Oxidizable Organic Carbon (g kg^{-1})	Wet digestion method	Walkley and Black, 1934 [31]
4	Available Nitrogen (kg ha^{-1})	Alkaline potassium permanganate method	Subbiah and Asija, 1956 [23]
5	Available Phosphorus (kg ha^{-1})	Olsen's method	Olsen *et al*., 1954 [16]
6	Available potassium (kg ha^{-1})	Flame photometric (Extraction with 1N NH_4OAc) neutral ammonium acetate method	Jackson, 1979 [7]

3. Results and Discussion
3.1 Soil pH
Data pertaining to soil pH after the harvest of rice in Kharif 2019 is shown in Table 3 and Table 4 for R-W and R-M cropping systems, respectively. The values of pH found to be varying from 8.07 in absolute control to 7.87 in high target yield under R-W, and from 7.63 in control to 7.52 in high target yield under R-M cropping system. The results showed that the soil pH did not change significantly in comparison to its initial value with respect to different treatments. However, marginal decrease in soil pH was recorded in all the treatments under both R-W and R-M cropping system. This might be attributed to the release of organic acids during decomposition of organic matter which was applied in the form of vermicompost. Similar non-significant results of pH were observed by Kumar *et al*. (2018) [12] and they further reported that pH was reduced to neutrality in treatments comprising of organic nutrient addition. This result was supported by Patil *et al*. (2003) [17], Katkar *et al*. (2005) [9] and Ojha *et al*. (2014) [15].

3.2 Soil Electrical conductivity (EC)
The result of EC was observed non-significant in comparison to its initial value with respect to different treatments for R-W and R-M cropping systems (Table 3 & Table 4). However, slight increase in EC value was observed than initial value especially in treatments with IPNS approach. Halemani *et al*. (2004) [5] reported a similar non-significant influence of organics and their combination on EC value. However, the slight increase in EC value might be due to the contribution of dissolved salts from soil and water. This contribution of salts may also be due to release of ionic species during reduction process which was reported by Sur *et al*. (2010) [24]. Gogoi *et al*. (2015) [4] reported that addition of organics favors more availability of soluble forms of K, Ca, Mg and Na which leads to development of some salts, hence increased EC.

3.3 Soil organic carbon (SOC)
The data of SOC content was found to be non-significant compared to its initial value with respect to different treatments for R-W and R-M cropping system (Table 3 & Table 4). However, there was a slight increase in SOC content than the initial amount in treatments receiving vermicompost after harvest of rice. Though a slight increase in value was observed in treatments receiving balanced application of organic source in addition to inorganic source. A similar non-

significant result of SOC was observed by Mittal *et al*. (2018) [14]. However, the increase in SOC value might be attributed to the direct addition of organic matter through vermicompost which resulted in better root growth and ultimately more addition of biomass to the soil. Similar results were reported by Stolyarenko *et al*. (1992) [22], Surekha and Rao (2009) [25], Vineela *et al*. (2008) [30], Mishra *et al*. (2008) [13].

Table 3: Effect of STCR based nutrient management on various soil parameters under R-W cropping system

	pH*		**EC*(dSm^{-1})**		**SOC(g kg^{-1})**	
	Before sowing	**After harvest**	**Before sowing**	**After harvest**	**Before sowing**	**After harvest**
T1: General fertilizer recommendation	8.15	7.95	0.11	0.11	4.2	4.1
T2: Farmers' practice	8.21	7.95	0.11	0.12	4.1	4.0
T3: STCR with IPNS for low target yield	8.23	7.95	0.12	0.13	4.3	4.2
T4: STCR with IPNS for medium target yield	8.18	7.99	0.12	0.14	4.4	4.5
T5: STCR with IPNS for high target yield	8.13	7.87	0.16	0.17	4.5	4.6
T6: STCR without IPNS for low target yield	8.28	7.99	0.11	0.14	4.2	4.1
T7: STCR without IPNS for medium target yield	8.24	7.99	0.13	0.15	4.4	4.4
T8: STCR without IPNS for high target yield	8.25	7.96	0.12	0.15	4.3	4.3
T9: Absolute control	8.27	8.07	0.11	0.11	4.0	3.8
S.Em(±)	0.03	0.04	0.03	0.02	0.05	0.04
LSD(P=0.05)	NS	NS	NS	NS	NS	NS

Table 4: Effect of STCR based nutrient management on various soil parameters under R-M cropping syste

	pH*		**EC*(dS m^{-1})**		**SOC(g kg^{-1})**	
	Before sowing	**After harvest**	**Before sowing**	**After harvest**	**Before sowing**	**After harvest**
T1: General fertilizer recommendation	7.99	7.59	0.14	0.11	4.1	4.0
T2: Farmers' practice	7.96	7.60	0.13	0.12	3.9	3.9
T3: STCR with IPNS for low target yield	7.96	7.62	0.15	0.15	4.3	4.1
T4: STCR with IPNS for medium target yield	7.98	7.58	0.14	0.16	4.3	4.4
T5: STCR with IPNS for high target yield	7.96	7.52	0.15	0.17	4.6	4.7
T6: STCR without IPNS for low target yield	7.97	7.54	0.15	0.15	4.2	4.1
T7: STCR without IPNS for medium target yield	8.04	7.54	0.11	0.14	4.4	4.3
T8: STCR without IPNS for high target yield	8.01	7.61	0.13	0.16	4.5	4.5
T9: Absolute control	8.09	7.63	0.12	0.11	3.5	3.3
S.Em(±)	0.03	0.04	0.03	0.02	0.05	0.04
LSD(P=0.05)	NS	NS	NS	NS	NS	NS

*Soil: Water:: 1:1.25

3.4 Soil available nitrogen

Application of fertilizers alone or in combination with organic manure significantly increased available nitrogen content over control (Table 5 & Table 6). The highest amount of available nitrogen content was observed in treatment T_5 which is STCR with IPNS for high target yield (279.5 kg ha^{-1} in R-W and 269.6 kg ha^{-1} in R-M) followed by treatment T_8 which was STCR without IPNS for high target yield (270.5 kg ha^{-1} in R-W and 267.4 kg ha^{-1} in R-M). However, the treatments receiving general fertilizer recommendation (GFR), farmers' practice as well as absolute control showed a decline in their amount from initial. The treatments with or without IPNS in case of low target yield also showed a decrease in their available nitrogen status after harvest of rice in both cropping systems. Minimum value of available nitrogen was found in treatment which did not receive any source of nutrients i.e., absolute control (156.9 kg ha^{-1} in R-W and 155.5 kg ha^{-1} in R-M). This increase in amount of available nitrogen content might be partly due to release of N from mineralization process by the application of organic matter and fertilizer releasing nitrogen, and partly due to release of native soil nitrogen as reported by Gogoi *et al*.(2015) [4]. Chesti *et al*. (2013) [2] and Baishya *et al*. (2015) [1] also reported similar findings. The available nitrogen content was significantly improved over general recommended dose and farmers' practice under both the cropping system of R-W and R-M which could be due to the reason that prescription based fertilizer application provides balanced nutrient status to the soil (Singh *et al*., 2016) [21].

3.5 Soil available phosphorus

The available P after harvest of rice differed significantly under different treatments in both R-W and R-M cropping systems (Table 5 & Table 6). In R-W cropping sequence, it varied from 26.3 kg ha^{-1} (T_9) to 48.9 kg ha^{-1} (T_5). The farmers' practice (T_2) as well as GFR (T_1) improved the available phosphorus over control and increased its content significantly by 17.1 and 23.0 per cent respectively in R-W and in R-M, the increase was 15.3 and 30.1 per cent respectively. The STCR with IPNS for high target yield was statistically similar with STCR without IPNS for high target yield. The available P in the treatment of STCR with high target yield for IPNS was significantly improved by 51.2 and 58.8 per cent over GFR and farmers' practice, respectively in R-W. However, under R-M, it was improved by 38.7 and 56.4 per cent, respectively. Sharma *et al*. (2016) [20] reported that this build-up of available phosphorus might be due to release of organic acids during degradation of fertilizers and organic manures which helped in releasing P by their solubilizing action. Similar were the findings reported by Tolanur and Badanur (2003) [27] and Verma *et al*. (2005) [29]. Another reason behind this increase may be that the organic matter forms a cover on sesquioxides which makes them inactive and ultimately reduces the phosphate fixing capacity of soil and makes phosphorus available. The considerable build up in available phosphorus might be also due to the influence of organic matter in increasing the labile form of phosphorus in soil through complexing of cation which are mainly responsible for fixation of phosphorus like Ca^{2+} as reported by Kharche *et al*. (2013) [10].

3.6 Soil available potassium

Likewise N and P, available K was also influenced significantly under different treatments in both the cropping systems (Table 5 & Table 6). In initial soil sample (before rice sowing) available K content of the soil varied from a minimum of 147.6 kg ha^{-1} under T_9 to a maximum of 219.6 kg ha^{-1} under T_5 (STCR with IPNS for high target yield) in R-W and 140.6 kg ha^{-1} under T_9 to 219.5 kg ha^{-1}, respectively in R-M. The available K significantly increased by 30.4 per cent and 35.4 per cent in R-W and R-M, respectively for farmers' practice over control. GFR treatment recorded a significant increase in its content by 31.7 per cent over control in R-W and 37.2 per cent in R-M. The treatment STCR with IPNS for high target yield was statistically at par with STCR without IPNS for high target yield. On the other hand, farmers' practice was found statistically at par with STCR with and without IPNS for low target yield in both cropping sequences. After harvest, the soil available K content varied from 135.2 kg ha^{-1} (T_9) to 224.5 kg ha^{-1} (T_5) in R-W and 137.2 kg ha^{-1} (T_9) to 219.9 kg ha^{-1} (T_5) in R-M. The lowest values of available K in T_9 was significantly inferior over all other treatments, while the highest value of T_5 was at par with T_8 (STCR approach without IPNS for high target yield) in R-M cropping system. Farmers' practice and GFR increased available K content in soil by 38.6and 42.3 per cent, respectively over control in R-W and similarly, 37.3 and 39.4 per cent, respectively over control in R-M. The treatments of target yield 30, 40 and 50 q ha^{-1} without IPNS increased the available K content by 1.2, 5.2 and 12.2 per cent respectively over GFR R-W and, 0.6, 4.9 and 12.3 per cent, respectively in R-M. A decrease in the amount of available K was observed in GRF and farmers' practice in comparison to the initial value and this reduction might be due to continuous mining of the native K pool in the soil that also caused reduction in crop yield (Katkar *et al*., 2011) [8]. Further, Tiwari *et al*. (2013) [6] and Ram *et al*. (2016) [18] reported that available K content improved when organic manure was added with inorganic fertilizers. Increase in available potassium under STCR including IPNS approach might be due to direct addition of available K to soil as well as reduction of potassium fixation and its further release due to interaction of organic matter with clay (Katkar *et al*., 2011) [8].

Table 5: Effect of STCR based nutrient management on available N, P and K status of soil (kg ha^{-1}) under R-W cropping system

Treatments	Available N		Available P_2O_5		Available K_2O	
	Before sowing	After harvest	Before sowing	After harvest	Before sowing	After harvest
T_1-General fertilizer recommendation	238.2	212.9	34.3	32.3	196.7	192.4
T_2-Farmers' practice	212.2	186.8	32.5	30.78	192.6	187.6
T_3-STCR with IPNS for low target yield	258.1	232.7	35.8	32.1	202.6	200.1
T_4-STCR with IPNS for medium target yield	261.1	266.1	43.6	47.3	209.5	212.9
T_5-STCR with IPNS for high target yield	273.5	279.5	45.2	48.9	219.6	224.5
T_6-STCR without IPNS for low target yield	247.8	243.4	41.8	38.1	197.6	194.7
T_7-STCR without IPNS for medium target yield	250.3	252.7	42.3	45.9	201.4	204.7
T_8-STCR without IPNS for high target yield	263.9	270.5	43.9	47.6	213.6	215.8
T_9- Control	182.3	156.9	28.3	26.3	147.6	135.2
S.Em(±)	2.9	2.1	2.5	2.0	2.9	4.8
LSD (P=0.05)	9.0	5.0	1.4	1.5	7.9	5.1

Table 6: Effect of STCR based nutrient management on available N, P and K status of soil (kg ha^{-1}) under R-M cropping system

Treatments	Available N		Available P_2O_5		Available K_2O	
	Before sowing	After harvest	Before sowing	After harvest	Before sowing	After harvest
T_1-General fertilizer recommendation	235.9	210.5	33.7	33.2	192.9	186.5
T_2-Farmers' practice	210.9	185.5	30.5	29.5	185.8	179.5
T_3-STCR with IPNS for low target yield	256.2	230.8	34.8	32.7	202.9	198.6
T_4-STCR with IPNS for medium target yield	260.7	265.7	41.7	43.9	206.7	208.7
T_5-STCR with IPNS for high target yield	267.6	269.6	44.6	46.1	215.9	219.9
T_6-STCR without IPNS for low target yield	242.9	238.5	41.5	37.4	193.5	191.9
T_7-STCR without IPNS for medium target yield	246.5	248.8	40.4	42.3	200.7	201.6
T_8-STCR without IPNS for high target yield	264.8	267.4	42.8	44.2	210.3	214.8
T_9- Control	180.9	155.5	26.9	25.5	140.6	137.2
S.Em(±)	6.4	5.8	2.8	1.9	2.8	2.6
LSD (P=0.05)	9.0	9.0	1.4	1.6	8.0	8.2

5. Conclusion

The present investigation suggested that application of fertilizer application on the basis of STCR based targeted yield treatments significantly improved the available N, P and K status in soil as compared to all the other approaches of fertilizer application. However, different approaches did not significantly influence the value of soil pH, EC and OC which was predictable in such a short duration of time. Also, different soil properties as well as fertility status of soil were improved under IPNS (Integrated Plant Nutrient Supply System) treatment for low, medium and high target yield as compared to other treatments.

6. References

1. Baishya LK, Rathore Singh SS, Sarkar D, Deka BC. Effect of integrated nutrient management on rice productivity, profitability and soil fertility. Annals of Plant and Soil Res 2015;17(1):86-90.
2. Chesti MH, Kohli A, Sharma AK. Effect of integrated nutrient management on yield of and nutrient uptake by wheat (*Triticum aestivum*) and soil properties under Intermediate Zone of Jammu and Kashmir. Journal of the Indian Society of Soil Science, 2013;61(1):1-6.
3. Gautam P, Srivastava A, Singh S, Saxena AK. STCR approach for optimizing integrated plant nutrient supply of pea in Mollisols of Uttarakhand. Pantnagar. Journal of Research 2013;11(1):100-104.
4. Gogoi B, Kalita B, Deori B, Paul SK. Soil properties under rainfed rice (*Oryza sativa*) crop as affected by integrated supply of nutrients. International Journal of Agriculture Innovations and Research 2015;3(6):1720-1725.
5. Halemani HL, Hallikeri SS, Nooli SS, Nandagavi RA, Kumar HS. Effect of organics on cotton productivity and physico-chemical properties of soil. In: International symposium on "Strategies for sustainable cotton production-A global vision". 2. *Crop production*, 23-25., VAS, Dharwad, 2004, 123-129.
6. Jackson ML. Soil Chemical Analysis. Prentice Hall India Private Limited, New Delhi 1973, 498.
7. Jackson ML. Soil Chemical Analysis- Advanced Course (2nd Edn.). Published by the author, Madison, WI 1979, 895.
8. Katkar RN, Sonune BA, Kadu PR. Long-term effect of fertilization on soil chemical and biological characteristics and productivity under sorghum (*Sorghum bicolor*)– wheat (*Triticum aestivum*) system in Vertisol. Indian Journal of Agricultural Sciences 2011;81(8):734–9.
9. Katkar RN, Wankhade ST, Turkhede AB, Lambe SP. Effect of integrated nutrient management in cotton growth on shallow soil on growth, seed cotton yield and physico-chemical properties. PKV Research Journal, 2005;29(2):210-214.
10. Kharche VK, Patil SR, Kulkarni AA, Patil VS, Katkar RN. Long term integrated nutrient management for enhancing soil quality and crop productivity under intensive cropping system on Vertisols. Journal of the Indian Society of Soil Science 2013;61(4):323-332.
11. Kumar A Tripathi HP, Yadav DS. Correcting nutrient for sustainable crop production. Indian Journal of Fertilisers. 2007;2(11):37-44.
12. Kumar GR, Konde NM, Tamgadge DB, Jadhao SD, Paslawar AN. Effect of STCR equation on soil characters and nutrient availability in cotton under Rainfed conditions in Vertisols. International Journal of Chemical Studies, 2018;6(3):723-726.
13. Mishra B, Sharma A, Singh SK, Prasad J, Singh BP. Influence of continuous application of amendments to maize – wheat cropping system on dynamics of soil microbial biomass in Alfisol of Jharkhand. Journal of the Indian Society of Soil Science 2008;56(1):71-75.
14. Mittal S, Singh M, Sharma SK. Soil physico-chemical properties under target yield approach based fertilizer recommendations in system of rice intensification (SRI). International Journal of Chemistry Studies 2018;2(2):01-04.
15. Ojha RB, Shah SC, Pande KR, Dhakal DD. Residual effects of farm yard manure on soil properties in spring season, Chitwan, Nepal. International Journal of Research in Agricultural Sciences 2014;1(8):165-171.
16. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Government Printing Office Washington D.C. USDA Circular 1954;939:1-19.
17. Patil PV, Nafade SD, Patel RM, Patel UG. Effect of organic soil amendments on the incidence of root rot of cotton. Journal of Cotton Research and Development, 2003;17(1):48-51.
18. Ram S, Singh V, Sirari P. Effects of 41 years of application of inorganic fertilizers and farm yard manure on crop yields, soil quality, and sustainable yield index under a rice-wheat cropping system on Mollisols of north India. Communications in Soil Science and Plant Analysis 2016;47:179-193.
19. Ramamoorthy B, Narasimhan RL, Dinesh RS. Fertilizer application for specific yield targets of Wheat, Sonara 64. Indian farming 1967;17:43-45.
20. Sharma VK, Pandey RN, Kumar S, Chobhe KA, Chandra S. Soil test crop response based fertilizer recommendations under integrated nutrient management for higher productivity of peral millet (*Pennisetum glaucum*) and wheat (*Triticum aestivum*) under long term experiment. Indian Journal of Agricultural Sciences 2016;86:1076-1081.
21. Singh YV, Dey P, Meena R, Varma SK. Effect of soil test based application on yield and economics of chickpea in inceptisol. Annals of Plant and Soil Research 2016;18:409-412.
22. Stolyarenko VS, Kovalenko VE, Samoshkin AA, Bondar, PS, Pashova VT, Skipnik LN. Growth development and macro element content in maize plantlets manured with organic waste bioconversion product. *Phiziologiy Abiokhini Yakulturm Ylehrastenii*. 1992;24:47.
23. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, 1956;25:259-266.
24. Sur P, Mandal M, Das DK. Effect of integrated nutrient management on soil fertility and organic carbon in cabbage (*Brassica oleracea* var. *capitata*) growing soils. Indian Journal of Agricultural Sciences 2010;80(8):38-41.
25. Surekha K, Rao KV. Direct and residual effects of organic sources on rice productivity and soil quality of Vertisol. Journal of the Indian Society of Soil Science 2009;57(1):53-57.
26. Tiwari LB, Mishra DD, Gupta J. Evaluation of integrated nutrient management options in rice (*Oryza sativa)*-wheat (*Triticum aestivum*) cropping system in reclaimed sodic land. Indian Journal of Agronomy 2013;58:137-14.
27. Tolanur SI, Badanur VP. Changes in organic carbon, available N, P and K under integrated use of organic manure, green manure and fertilizers on sustaining productivity of pearl millet-pigeon pea system and fertility of an Incetisol. Journal of Indian Society of Soil Science 2003;51(1):254-7.
28. Verma SD, Kaistha BP, Sharma PK. Soil top sequences studies on a landscape segment of temperate humid climate in Himachal Pradesh, morphological and physio-chemical properties and classification. Fertilizer Technology 1976;13:224-229.

29. Verma A, Nepalia V, Kanthaliya PC. Effect of continuous cropping and fertilization on crop yields and nutrient status of a Typic Haplustept. Journal of Indian Society of Soil Science 2005;53(3):365-8.
30. Vineela C, Wani SP, Srinivasarao CH, Padmaja B, Vittal KPR. Microbial properties of soils as affected by cropping and nutrient management practices in several long-term manurial experiments in the semi-arid tropics of India. Applied Soil Ecology 2008;40:165-173.
31. Walkley A, Black CA. An examination of wet acid method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 1934;37:29-38.