www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(7): 1054-1058
© 2021 TPI
www.thepharmajournal.com
Received: 06-04-2021
Accepted: 13-05-2021

Shailendra Kumar Singh
Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India

PJ George
Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India

Amitesh Kumar Singh
Scientist- Agronomy, GVT-Krishi Vigyan Kendra, Chakeshwari Farm, Godda (Jharkhand), India

Amit Kumar Singh
Research Assistant, Department of Economic, IAS, BHU, Varanasi, Uttar Pradesh, India

Corresponding Author:
Shailendra Kumar Singh
Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India

Effect of sowing methods and nutrient resources on growth, yield attributes, grain yield and soil health of wheat (*Triticum aestivum* L.)

Shailendra Kumar Singh, PJ George, Amitesh Kumar Singh and Amit Kumar Singh

Abstract
A field experiment conducted during 2014-15 and 2015-16 at Agricultural research farm Department of Agronomy, SHUATS, Prayagraj; to effect of sowing methods and nutrient resources on growth, yield attributes, grain yield and soil health of wheat. Data revealed that sowing methods; system of wheat intensification (SWI) found significantly higher tillers/hill, leaf area index, plant dry matter accumulations (g/hill), crop growth rate (g/hill/day), spike length, spikes/hill, grain yield, biological yield, gross return, net return and soil health of wheat over to FRIBS and conventional method of sowing. Application of nutrient sources *viz.* 75% inorganic fertilizers and 25% vermicompost was recorded maximum tillers/hill, leaf area index, plant dry matter accumulations (g/hill), crop growth rate (g/hill/day), spike length, spikes/hill, grain yield, biological yield, gross return, net return and soil health over to 100% inorganic fertilizers, 50% inorganic fertilizers and 50% vermicompost, 25% inorganic fertilizers and 75% vermicompost and 100% vermicompost.

Keywords: Crop growth rate, grain yield, net return, soil health, sowing methods, spike length

Introduction
Wheat is the dominant cereal crop of world commerce and second after rice in India. It is occupying a significant part of the daily diet of millions of people. In India, increasing the productivity of wheat becomes a must to overcome the unusual increase in population. Methods of sowing plays a significant role in providing for the proper space required by the plant for efficient utilization of air, water, solar energy, and nutrients; therefore, the crop yield and quality of the product may be improved to a great extent (Raghuvanshi *et al.* 2021) [8]. India, being blessed and enriched with a diverse agro ecological condition, ensuring food and nutrition security to a majority of the Indian population through production and steady supply particularly in the recent past, is the second largest producer of wheat worldwide (Sharma and Sendhil, 2015) [15], (Sharma and Sendhil, 2016) [16] and (Sharma *et al.* 2015) [13]. The crop has been under cultivation in about 30 million hectares (14% of global area) to produce the all-time highest output of 99.70 million tonnes of wheat (13.64% of world production) with a record average productivity of 3371 kg/ha (Anonymous, 2018) [2]. Having a significant share in consumption of food basket with a 36% share in the total food grains produced from India and ensuring not only food security but also nutrition security, wheat is extensively procured by the government and distributed to a majority of the population; it ensures not only food security but also nutrition security. The cereal is one of the cheapest sources of energy, provides a major share of protein (20%) and calorie intake (19%) from consumption. Wheat is accessible across the country and consumed as various processed forms from prehistoric times (Sharma *et al.* 2014) [14].
The extrapolated methodology of System of Wheat Intensification (SWI) warrants investigation to see to what extent the reports of its advantages – agronomic, economic, social, and environmental - can be validated under experimental conditions. The experience of farmers in Bihar and some other states of India who have undertaken SWI crop management suggests that it over opportunities for higher production per unit of inputs, such as seeds, water, fertilizer, land, labor, and capital and (Abraham *et al.*, 2014) [1]. But there has been no systematic scientific evaluation of SWI with appropriate controls and replications. The principles of SRI, which include early and healthy plant establishment with either direct seeding or transplanting, reducing competition among crop plants through wider spacing,

careful application of water to maintain moist aerobic soil conditions, increasing soil organic matter, and active soil aeration to promote the growth of roots and beneficial soil organisms, have been shown to increase the productivity of a number of crops (Dhar *et al.* 2016) [5]. Production strategies for SRI when applied to wheat (SWI) have often been considered as labor-intensive for widespread adoption. But resource-poor farmers who can achieve more yields from their small landholdings find that the additional effort and care in crop management with these alternative agronomic systems is compensated for by higher net returns and improvements in food security. Moreover, the concepts and principles of SRI and SWI are amenable to a considerable degree of mechanization, as demonstrated in Pakistan Punjab (Sharif *et al.* 2014) [12]. SWI plants are reported by farmers to be more robust, more resistant to pests and diseases, and more tolerant of adverse climatic conditions like drought and hail storm, which are increasingly important considerations. But thus far, there has been no rigorous evaluation of SWI methods applied to wheat, a crop of worldwide importance and great significance in India. This prompted a 2-year, on-station experiment using standard methods of agronomic evaluation conducted at the Indian Agricultural Research Institute (IARI) in New Delhi. This study compared the performance of standard recommended practices (SRP) currently recommended by Indian wheat scientists with the methods of SWI management for growing a widely planted improved variety of wheat. Because SWI is an innovation of recent origin, the literature that can be cited on it is unfortunately sparse. However, this made a proper empirical evaluation all the more important to conduct and report, since if there would be positive results, these should encourage further research and the build-up of a substantial literature on SWI. Present investigation of research main objective on the sowing methods and nutrient resources influenced of growth, yield attributes, grain yield and soil health of wheat.

Materials and Methods

A field experiments was conducted during *Rabi* seasons of the 2014-15 and 2015-16 at the research farm of Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.) located at 25^0 24' 42" N latitude and 81^0 50’ 56" E longitude, and 98 m above mean sea level (MSL). The experimental site was generally sandy loam in texture (61.5% sand, 17.8% silt, and 20.7% clay), slightly alkaline in reaction (pH 7.60), with an electrical conductivity value of 0.24 dS/m. The soil was low in organic carbon (0.38%), nitrogen (182.4 kg/ha and 185.6 kg/ha), medium in phosphorous (11.8 kg/ha and 12.4 kg/ha) and fairly high in ammonium acetate extractable potassium (163.3 kg/ha and 165.0 kg/ha).

Three sowing methods in main plot and five nutrient management practices in sub plot treatments were tested in a split plot design with three replications. Sowing methods are namely system of wheat intensification (SWI); furrow-irrigated raised bed system (FIRBS); and conventional method (CM) with direct-seeded crop establishment planted with spacing 20 × 20 cm, having just 25 plants/m^2. In the planned set of experiments, FIRBS was included for comparison with SWI because it conserves seed, water and nutrients while having comparable yield with conventional method. In this system, three rows of wheat are sown on raised beds of 55 cm width and 15 cm height. A furrow of 30 cm was prepared between the beds for irrigation. Nutrient management practices are 100% RDN through inorganic fertilizer; 75% RDN + 25% RDN through Vermicompost; 50% RDN + 50% RDN through Vermicompost; 25% RDN +75% RDN through Vermicompost; 100%RDN through Vermicompost. The plot sizes were all 4m × 5m (20 m^2). The SHUATS improved variety of wheat ‘AAI-4’ was sown on 15 and 17 November, during the 2014 and 2015 and harvested on 19 and 21 March during the 2015 and 2016 seasons, respectively. During the 2014-15 crop season, 40.8 mm of rainfall was received, while in 2015-16 an unusually high rainfall of 176.3 mm was recorded.

Statistical analysis

Data were subjected to analysis of variance (ANOVA). A combined ANOVA over two growing seasons was performed for growth, yield and different indices. The ANOVA was performed using a split plot design with 15 treatment combinations and replicated three times. Treatment mean differences were separated and tested by Fisher’s protected least significant difference (LSD) at a significance level of p = 0.05. The values are reported as means of the two growing seasons (Cochran and Cox, 1957) [3].

Result and Discussion

Growth and yield attributes

System of wheat intensification (SWI) sowing methods found significantly higher growth *viz.* tillers/hill, leaf area index at 60 DAS, plant dry matter accumulations (g/hill) and crop growth rate (g/hill/day) at 80 DAS of wheat (table 1) over to FRIBS and conventional method of sowing during both the year of experimentation. Relative growth rate (g/g/day) at 80 DAS and days to maturity of wheat crop (table 1) non-significant effect of sowing methods during crop growth period of both the years. Effect of sowing methods (table 2) *viz.*, system of wheat intensification (SWI) found significantly maximum spike length and spikes/hill of wheat over to FRIBS and conventional method of planting during both the year of experimentation. The higher yield attributes of SWI planting may be ascribed to higher dry matter production and translocation and the conversion of photosynthates in to reproductive parts. Fine tilth and better aeration causing less penetration impedance was responsible for better root development there by producing higher yield attributes. Similar beneficial effect of bed planting on yield attributes of wheat has been reported by Jani *et al.*, (2008) [6].

Application of nutrient sources *viz.* 75% inorganic fertilizers and 25% vermicompost was recorded maximum growth *viz.* tillers/hill, leaf area index at 60 DAS, plant dry matter accumulations (g/hill) and crop growth rate (g/hill/day) at 80 DAS (table 1) over to 100% inorganic fertilizers, 50% inorganic fertilizers and 50% vermicompost, 25% inorganic fertilizers and 75% vermicompost and 100% vermicompost during both the year of experimentation. Relative growth rate (g/g/day) at 80 DAS and days to maturity of wheat crop (table 1) non-significant effect of nutrient sources during crop growth period of both the years. Application of nutrient sources *viz.* 75% inorganic fertilizers and 25% vermicompost was recorded taller spike length and higher spikes/hill over to 100% inorganic fertilizers, 50% inorganic fertilizers and 50% vermicompost, 25% inorganic fertilizers and 75% vermicompost and 100% vermicompost during both the years. It thus indicated that combined use of organic manure (vermicompost) and fertilizer was more useful than chemical fertilizers alone, particularly with respect to tillers/m^2 in wheat. Our findings confirm the results of Singh *et al.*, (2013) [18]. In SWI number of tillers per plant is found 4-5 times more than conventional methods as well as higher test weight were recorded respectively. This may be due to wider spacing and proper aeration under SWI. Higher effective tillers grains per spike and 1000 grain weight of wheat were observed in SWI over conventional method. Thus, it evident that combined use of RDN and vermicompost favored better plant growth parameters, which eventually reflected in improved values of yield attributes in our study. Our results confirm the findings of Rathor and Sharma (2010) [9].

Grain and biological yield (kg/ha)

Effect of sowing methods *viz*., system of wheat intensification (table 2) found significantly grain yield (4.7 and 5.1 t/ha) of wheat over to FRIBS (4.6 and 4.9 t/ha) and conventional method (4.3 and 4.5 t/ha) of planting during both the year of experimentation. Biological yield of wheat was found significantly sowing methods *viz.* system of wheat intensification (SWI) over to FRIBS and conventional method of planting during both the year of experimentation. Abraham *et al.*, (2014) [1] reported an increase of 18-67% grain and 9-27% straw yield of wheat at farmer field in SWI as compare to broadcast method. The results of experiments represent that SWI methods are superior than conventional line sowing of wheat with improved recommended practices and far superior to usual farmers practice. The total amount of irrigation water used in conventional line sowing of wheat was 60mm more than SWI method. It was due to higher irrigation depth. Summarized the results from wheat sown under SWI in farmers field reported that a 30% water saving is observed in SWI in comparison with conventional method of sowing. The increase in grain yield of wheat under SWI could be attributed to higher yield attributes whereas; the increase in biological yield was due to higher plant height, dry matter accumulation. Similar results were also reported by Sagar and Naresh (2019) [10].

Application of nutrient sources *viz*. 75% inorganic fertilizers and 25% vermicompost (table 2) was recorded maximum grain yield (5.3 and 5.5 t/ha) over to 100% inorganic fertilizers (5.2 and 5.5 t/ha), 50% inorganic fertilizers and 50% vermicompost (4.6 and 4.6 t/ha.), 25% inorganic fertilizers and 75% vermicompost (4.0 and 4.5 t/ha) and 100% vermicompost (3.7 and 3.9 t/ha) during both the years of experiment. Application of nutrient sources *viz.* 75% inorganic fertilizers and 25% vermicompost was recorded maximum biological yield over to 100% inorganic fertilizers, 50% inorganic fertilizers and 50% vermicompost, 25% inorganic fertilizers and 75% vermicompost and 100% vermicompost during both the year of experimentation. Overall, combined application of RDN and organic manure like vermicompost helped wheat crop better in enhancing the grain yield and harvest index over sole application of chemical fertilizers (RDN). Shah and Ahmad (2006) [11] and Singh *et al.*, (2012) [17].

Economics

Data showed on table 2 effect of sowing methods *viz*., system of wheat intensification (SWI) found significantly gross and net return of wheat over to FRIBS method and conventional method of planting during both the year of experimentation. Effect of nutrient sources *viz*. 75% inorganic fertilizers and 25% vermicompost was recorded maximum gross and net return over to 100% inorganic fertilizers, 50% inorganic fertilizers and 50% vermicompost, 25% inorganic fertilizers and 75% vermicompost and 100% vermicompost during both the years. Even application of organic manure (vermicompost) with RDN proved much better over RDN alone, particularly with respect to the gross income and net income. Yadav and Kumar (2009) [19] and Devi *et al.* 2011) [4] also reported similar results.

Soil health

Effect of sowing methods *viz*., system of wheat intensification (SWI) found significantly higher organic carbon, available soil nitrogen, phosphorus and potassium of wheat over to FRIBS method and conventional method of planting during both the year of experimentation. Effect of nutrient sources *viz*. 75% inorganic fertilizers and 25% vermicompost was recorded maximum organic carbon, available soil nitrogen, phosphorus and potassium over to 100% inorganic fertilizers, 50% inorganic fertilizers and 50% vermicompost, 25% inorganic fertilizers and 75% vermicompost and 100% vermicompost during both the years (Pandey *et al.*, 2009) [7].

Table 1: Effect of sowing methods and nutrient resources on growth and physiological character of wheat

Treatment	Tillers/hill at 60 DAS		Leaf area index at 60 DAS		Plant dry matter accumulation (g/hill) at 80 DAS		Crop growth rate (g/hill/day) at 80 DAS		Relative growth rate (g/g/day) at 80 DAS		Days to maturity	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Sowing methods												
System of Wheat Intensification		13.1	3.3	3.4	57.4	60.3	0.7179	0.7256	0.04842	0.0468	122	125
Furrow Irrigation Raised Bed System	11.2	12.4	2.9	3.2	55.8	58.7	0.6985	0.7089	0.04840	0.0470	122	125
Conventional Method	7.2	7.9	2.6	2.8	52.3	54.9	0.6537	0.6635	0.0480	0.0465	121	124
S.Em±	0.23	0.27	0.10	0.11	0.73	0.76	0.0091	0.0105	0.000002	0.00001	0.57	0.61
C.D.(P = 0.05)	0.92	1.06	0.38	0.43	2.86	3.00	0.0358	0.0413	NS	NS	NS	NS
Nutrient sources												
100% RDN through inorganic fertilizer	11.7	12.9	3.6	3.7	61.9	65.0	0.7742	0.7834	0.04840	0.0469	122	125
75% RDN + 25% RDN through VC	12.5	13.8	3.6	3.8	62.6	65.7	0.7828	0.7918	0.04846	0.0465	122	125
50% RDN + 50% RDN through VC	9.6	10.6	2.8	3.02	55.5	58.2	0.6933	0.7037	0.04842	0.0462	121	125
25% RDN +75% RDN through VC	8.8	9.7	2.5	2.7	49.8	52.4	0.6233	0.6327	0.04839	0.0459	121	124
100% RDN through VC	8.0	8.9	2.2	2.4	46.1	48.4	0.5763	0.5850	0.04835	0.0460	120	123
S.Em±	0.29	0.33	0.10	0.10	0.72	0.76	0.0090	0.0091	0.000002	0.00001	0.70	0.75
C.D.(P = 0.05)	0.85	0.96	0.28	0.30	2.11	2.21	0.0263	0.0267	NS	NS	NS	NS

Table 2: Effect of sowing methods and nutrient resources of yield attributes and yield attributes of wheat

Treatment	Spike length (cm)		Spikes/hill		Grain yield (t/ha)		Biological yield (t/ha)		Gross return (INR 103/ha)		Net return (INR 103/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Sowing methods												
System of Wheat Intensification	9.53	10.11	12.69	13.31	4.8	5.1	11.96	12.46	138.7	145.3	88.1	94.6
Furrow Irrigation Raised Bed System	9.28	9.85	12.47	13.05	4.6	4.9	11.62	12.09	134.8	141.0	82.6	88.9
Conventional Method	8.54	9.06	11.67	12.24	4.3	4.5	10.78	11.27	124.6	130.9	72.1	78.4
S.Em±	0.07	0.10	0.09	0.15	0.32	0.34	0.07	0.09	0.81	0.98	0.80	0.98
C.D. (P = 0.05)	0.29	0.40	0.36	0.57	1.25	1.33	0.27	0.34	3.2	3.8	3.1	3.9
Nutrient sources												
100% RDN through inorganic fertilizer	10.26	10.9	13.46	14.10	5.2	5.5	12.90	13.50	149.7	157.3	101.4	109.0
75% RDN + 25% RDN through Vermicompost	10.47	11.11	13.67	14.31	5.2	5.6	13.06	13.65	151.6	159.2	101.5	109.2
50% RDN + 50%RDN through Vermicompost	9.17	9.74	12.37	12.94	4.6	4.9	11.52	12.01	133.4	139.9	81.7	88.1
25% RDN +75% RDN through Vermicompost	8.20	8.70	11.40	11.90	4.1	4.3	10.33	10.73	119.5	125.0	66.0	71.5
100% RDN through Vermicompost	7.47	7.93	10.48	11.09	3.7	3.9	9.46	9.79	109.3	114.0	54.0	58.7
S.Em±	0.07	0.11	0.8	0.14	0.30	0.32	0.06	0.08	0.70	0.92	0.70	0.92
C.D.(P = 0.05)	0.22	0.33	0.23	0.41	0.88	0.94	0.18	0.24	2.0	2.6	2.1	2.7

Table 3: Effect of sowing methods and nutrient resources on organic carbon and available nutrients in soil

Treatment	Organic carbon (%)		Available nutrients in soil (kg ha-1)					
			N		P		K	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Sowing methods								
System of Wheat Intensification	0.372	0.395	220.55	225.51	13.36	14.03	174.08	179.66
Furrow Irrigation Raised Bed System	0.365	0.388	215.69	220.20	12.59	13.22	169.79	175.22
Conventional Method	0.324	0.345	199.88	206.36	10.66	11.19	149.62	155.59
S.Em±	0.006	0.008	2.80	2.99	0.20	0.27	2.12	2.35
C.D.(P = 0.05)	0.023	0.032	11.01	11.73	0.80	1.05	8.34	9.21
Nutrient sources								
100% RDN through inorganic fertilizer	0.404	0.430	237.68	241.27	15.32	16.09	200.97	207.81
75% RDN + 25% RDN through Vermicompost	0.413	0.440	242.05	247.25	15.83	16.63	206.05	212.39
50% RDN + 50% RDN through Vermicompost	0.357	0.380	221.92	226.69	12.16	12.77	166.92	172.12
25% RDN +75% RDN through Vermicompost	0.312	0.331	188.46	192.51	9.72	10.21	133.46	137.62
100% RDN through Vermicompost	0.280	0.299	170.09	179.08	7.98	8.37	115.09	120.86
S.Em±	0.005	0.007	2.59	3.25	0.19	0.25	2.06	2.60
C.D.(P = 0.05)	0.016	0.021	7.55	9.47	0.56	0.72	6.00	7.58
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

It can be thus concluded that, the system of wheat intensification (SWI) with combined application of 75% inorganic fertilizers and 25% vermicompost application of 75% RDN + 25% RDN vermicompost was observed higher growth, yield attributes, grain yield and soil health with proved more productive, remunerative and the best option for wheat cultivation.

Acknowledgement

The authors are thankful to Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh for financial assistance and technical support during the experimentation.

Reference

1. Abraham B, Araya H, Berhe T, Edwards S, Gijja B, Khadka RB *et al*. The system of crop intensification reports from the field on improving agricultural production, food security and resilience to climate change for multiple crops. Agriculture and food security 2014;3(4):1-12.
2. Anonymous. Ministry of Agriculture and Farmers Welfare, Government of India [Internet] 2018. https://eands.dacnet.nic.in/Advance_Estimate/4th_Adv_Estimates2017-18_Engpdf [Accessed: 25 December 2018]
3. Cochran WG, Cox GM. Experimental designs. 2nd ed. New York: Wiley publication 1957.
4. Devi KN, Singh MS, Singh NG, Athokam HS. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). Journal of Crop and Weed 2011;7(2):23-27.
5. Dhar S, Barah BC, Vyas AK, Uphoff N. Comparing system of wheat intensification with standard recommended practices in northwestern plain zone of India. Archives of Agronomy and Soil Science 2016;62(7):994-1006.
6. Jani PP, Tanwar SPS, Singh SM. Performance of durum wheat (*Triticum durum*) varieties under varying sowing methods and input levels. Indian Journals of Fertilizers 2008;4(7):71-73.
7. Pandey IB, Dwivedi DK, Pandey RK. Integrated nutrient management for sustaining wheat (*Triticum aestivum*) production under late sown condition. Indian J Agron 2009;54:306-09.
8. Raghuvanshi N, Singh BN, Kumar V. Study of growth and yield of wheat (*Triticum aestivum* L.) with different sowing method and nitrogen management under the semi-arid region of India. The Pharma Innovation Journal 2021;10(6):184-190.
9. Rathor SA, Sharma NL. Effect of integrated nutrient

management on productivity and nutrient uptake in wheat and soil fertility. Asian Journal of Soil Science 2010;4(2):208-210.

10. Sagar VK, Naresh RK. Effect of crop-establishment methods and irrigation schedules on growth and yield of wheat (*Triticum aestivum* L.). Indian Journal of Agronomy 2019;64:210-217.
11. Shah Z, Ahmad MI. Effect of integrated use of farm yard manure and urea on yield and nitrogen uptake of wheat. Journal of Agricultural and Biological Science 2006;1(10):60-65.
12. Sharif A, Styger F, Uphhoff N, Verma A. The system of crop intensification reports from the field on improving agricultural production, food security and resilience to climate change for multiple crops. Agriculture and food security 2014;3(4):1-12.
13. Sharma I, Sendhil R, Catrath R. Regional disparity and distribution gains in wheat production. In: Souvenir of 54th AIW&B Workers Meet, Sardarkrushinagar Dantiwada Agricultural University, Gujarat 2015.
14. Sharma I, Sendhil R, Chatrath R. Deciphering the role of wheat production and protection technologies for food and nutrition security. 53rd All India Wheat & Barley Research Workers' meet and International Seminar on Enhancing Wheat & Barley Production with special emphasis on Nutritional Security, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur (M.P.) 2014.
15. Sharma I, Sendhil R. Domestic production scenario of wheat. In: Souvenir of Roller Flour Millers Federation of India Platinum Jubilee Celebration 2015, 18-20.
16. Sharma I, Sendhil R. Wheat Production in India-A Decadal Synopsis [Internet] 2016. Available from: http://www.FnBnews.com
17. Singh JP, Kaur J, Mehta DS, Narwal RP. Long-term effect of nutrient management on soil health and crop productivity under rice-wheat cropping system. Indian Journal of Fertilisers 2012;8(8):28-48.
18. Singh V, Singh SR, Singh S, Shivay YS. Growth, yield and nutrient uptake by wheat (*Triticum aestivum* L.) as effected by bio fertilizers, FYM and nitrogen. Indian Journal of Agricultural Sciences 2013;83(3):110-111.
19. Yadav DS, Kumar A. Long-term effect of nutrient management on soil health and productivity of rice-wheat system. Indian Journal of Agronomy 2009;54(1):15-23.