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Effect of tillage practices and integrated nutrient management (INM) on productivity, nutrient uptake and status of soil in late sown wheat (*Triticum aestivum* L.)

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Abstract
A field trial was conducted to study the Effect of tillage practices and integrated nutrient management (INM) on productivity, nutrient uptake and status of soil under late sown wheat (*Triticum aestivum* L.) at Students Instructional Farm (SIF), Department of Agronomy, Collage of Agriculture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002, (U.P.) for two consecutive years (2016-17 and 2017-18). The treatment consistent three tillage practices methods (Conventional tillage method- CT, Minimum tillage method- MT and Zero tillage method- ZT) in main plot and integrated nutrient management practices and six integrated nutrient management practices i.e. Control (No fertilizer)- T1, Farmer practice- T2 100% STR (Soil Test Recommendation NPK)- T_3, 100% STR + 5 tonnes FYM- T_4, 100% STR + PSB- T_5, 100% STR + PSB+ 5 tonnes FYM- T_6 in sub plots, replicated trice in a split plot design. The longest spike length 8.76 and 9.15 cm were found in first and second year, respectively, under conventional tillage, which was significantly superior over the other tillage practices methods. Significantly more number of grains/spike, higher spike weight and higher test weight were recorded under conventional tillage methods as compared to minimum and zero tillage. Highest yields of grain and straw were recorded under conventional tillage followed by minimum over zero tillage practices. Conventional tillage practices resulted in significantly higher content and their uptake of NPK by wheat plants as compared to other tillage methods. Maximum NPK uptake was recorded under Conventional tillage followed by minimum tillage while minimum NPK uptake was estimated under zero tillage through grain straw and total during first year. The plant height, dry matter accumulation and number of tillers per plant significantly increased with application of 100% STR + PSB+ 5 tonnes FYM. The maximum height was recorded under 100% STR + PSB+ 5 tonnes FYM followed by 100% STR + PSB, which might have resulted due to increased leaf area, higher photosynthetic rate and more carbohydrate accumulation in plants, thereby increasing dry matter production. integrated nutrient management application at 100% STR + PSB+ 5 tonnes FYM and 100% STR + PSB level produced significantly higher number of grains/spike, more spike length, spike weight and more test weight of grains as compared to 100% STR and farmer practices INM practices. The highest grain yield 36.74 and 39.51 q ha-1 and straw yield 45.56 and 48.83 q ha-1 were recorded with 100% STR + PSB+ 5 tonnes FYM which was 20.38% and 25.79% and 24.11% and 28.26% higher than the yield of control. Maximum NPK uptake was recorded by 100% STR + PSB+ 5 tonnes FYM which was higher than 100% STR + PSB and 100% STR + 5 tonnes FYM during first and second year of experimentation.

Keywords: Conventional tillage, INM, Uptake, Zero tillage, tillage methods, grain yield, yield attributes

Introduction
Rice-wheat is an important predominant cropping system in South Asia, which occupies 13.5 m ha area including 10 m ha in India (Tripathi *et al.*, 2015) [11]. In rice-wheat system, rice yield is the final output of the interaction between different methods of rice and wheat establishment, plant population and external environment including soil. About 55% of the world population depends on wheat for intake about 20% of food calories. Globally, wheat is being grown in 124 countries and occupies area of 218.61 million ha and production nearly 757.92 million tonnes of grain during 2017-18 (Anonymous, 2019) [2]. Total world consumption of wheat is around 672 million tonnes per year and this is expected to grow continuously over coming years. India is second largest wheat growing country after China in the world. In India the area under wheat increased since the start of green revolution

in 1967 along with production and productivity. The area under wheat increased from 13.7 million hectares in 1966-67 to 31.50 million hectares in 2017-18. In this period production has also increased from 11.4 to 99.78 million tonnes and the productivity increased from 887 to 3146 kg ha^{-1}

Different tillage practices suitable for wheat cropping system in the Indo-Gangetic plains are available, which could help to improve the system sustainability and productivity. Conventional tillage practices followed by farmers for raising wheat after rice, involve higher use of machines, labour and energy as it is done to change the low permeability soil structure created for rice to well aerated structure for wheat. Wheat production technology has systematically changed with the adoption of high yielding dwarf varieties. The tillage, residue management and nitrogen application were markedly different for tall varieties from the presently grown dwarf ones. Conventional tillage is often helpful to break plough pan, improve infiltration, adding of organic and chemical amendments in light textured soils. In crux, zero tillage practices are economically viable, environment friendly, socially acceptable and sustainable on long term basis. Flaws in reduced tillage techniques can be resolved by developing new tillage implements and field demonstration of technology. It will help the farmers directly through timely sowing of crops, reducing cost of production, saving time and fuel together with improvement in soil chemical, biological and physical properties.

Lack of manuring and balanced fertilization is one of the most important causes of low yield in late sown wheat. Integrating chemical fertilizers with organic manures has been found to be quite promising not only in maintaining higher productivity but also in improving soil fertility and providing greater stability in crop production. Nitrogen is the most limiting nutrient in crop production and its efficient use to increase food production more than any other input; therefore, proper use of nutrients is critical to optimize crop yield and minimize environmental damage. Bio-fertilizers being essential components of organic farming play vital role in maintaining long term soil fertility and sustainability by fixing atmospheric dinitrogen (N=N), mobilizing fixed macro and micro nutrients or convert insoluble P in the soil into available form to plants, thereby increases their efficiency and availability. Currently there is a gap of ten million tonnes of plant nutrients between removal of crops and supply through chemical fertilizers. In context of both the cost and environmental impact of chemical fertilizers, excessive reliance on the chemical fertilizers is not viable strategy in long run because of the cost, both in domestic resources and foreign exchange, involved in setting up of fertilizer plants and sustaining the production. In this context, organic manures (bio-fertilizers) would be the viable option for farmers to increase productivity per unit area.

Materials and Methods

An investigation was conducted at the Students Instructional Farm (SIF), Department of Agronomy, Collage of Agriculture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002, (U.P.) for two consecutive years (2016-17 and 2017-18). The soil of the experimental field was loamy in texture alkaline in nature having pH (8.10 and 8.00), EC (0.20 and 0.19 dsm^{-1}), medium in organic carbon (0.410 and 0.395%), low in available nitrogen (206.0 and 193.0 kg ha^{-1}), medium in phosphorus (13.40 and 12.70 kg ha^{-1}) and potash (141.0 and 137.0 kg ha^{-1}) with three tillage practices i.e Conventional tillage method- CT, Minimum tillage method- MT and Zero tillage method- ZT and six integrated nutrient management practices i.e. Control (No fertilizer)- T1, Farmer practice- T2 100% STR (Soil Test Recommendation NPK)- T_3, 100% STR + 5 tonnes FYM- T_4, 100% STR + PSB- T_5, 100% STR + PSB+ 5 tonnes FYM- T_6 in split plot design design with three replications. Recommended dose of fertilizers were applied according to treatments where as nitrogen, phosphorus, potash, through Urea, DAP, MOP, respectively. Field was prepared as per the given in the treatment i.e. conventional tillage (6 harrowing) followed by one roller and then finally field was leveled and minimum tillage (3 harrowing). But in case of zero tillage, wheat was sown directly without any tillage operation. Wheat variety Unnat Halna (K-9423) with 100 kg ha^{-1} seed rate was sown at spacing row to row 22.5 cm during both the years. In the zero tillage treatment the seeds were sown by Pant zero-till ferti-seed drill and in conventional system minimum tillage the seeds were sown manually. Data on various growth and yield attributes, grain and straw yields of wheat were recorded as per the standard procedures. The nutrient uptake (NPK) were estimated from both seed and stover separately during both the years and its uptake were estimated with the help of total seed and stover yield multiply with respective nutrient content. The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test and conclusions were drawn at 5% probability levels.

Results and Discussion

Yield and Yield Attributes

The data pertaining to yield contributing characters at harvest stage namely spike weight, spike length, number of spikelets per spike, number of number of grains $spike^{-1}$, spike weight per ear and thousand grain weight are presented in Table 1. Results shows that longest spike length 8.76 and 9.15 cm were found in first and second year, respectively, under conventional tillage, which was significantly superior over the other tillage practices methods. Significantly more number of grains/spike, higher spike weight and higher test weight were recorded under conventional tillage methods as compared to minimum and zero tillage. Perhaps this might have been possible due to the fact suitable condition for better growth and available more nutrients which benefited the plants in utilizing higher amount of inputs. The grain weight per ear was also affected significantly by tillage practices methods during both the years. It was 5.24 and 3.14 per cent higher under conventional tillage than that of minimum and zero tillage during first year and 5.37 and 3.41 per cent during second year. Similar results were reported by Yadav *et al.* (2010) [12].

It is clear from the data presented in Table 1 that integrated nutrient management application at 100% STR + PSB+ 5 tonnes FYM and 100% STR + PSB level produced significantly higher number of grains/spike, more spike length, spike weight and more test weight of grains as compared to 100% STR and farmer practices INM practices. The increase in yield attributing characters under 100% STR + PSB+ 5 tonnes FYM may be due to ever availability of nutrients even during later reproductive and grain filling stage, which resulted in increased rate of photosynthesis, which has direct bearing on yield components and yield. Increase in the ear head length may be due to better assimilation of carbohydrates. This find support the observations of Kumar *et al.* (2004), Singh *et al.* (2006) [7], Rather and Sharma (2010) [5] and Verma *et al.* (2014) [10].

Grain and straw yield

Tillage practices had significant effect on yield and recorded highest yields of grain and straw were recorded under conventional tillage followed by minimum over zero tillage practices in both the years. The increase in grains and straw yield may be attributed mainly to higher number of effective tillers and the production of grains per spike, which was highly favored under conventional tillage. Wheat establishment methods caused significant effect on the grain yield during both the years. The conventional tillage wheat yielded 11.71 and 4.61 per cent higher over minimum and zero tillage during 2016-17, respectively. The respective increase during 2017-18 was 11.54 and 5.38 per cent over zero tilled. The marked increase in grain yield in above treatments might be due to over all improvement on yield attributes. Similar results were reported by Singh *et al*. (2007) [8], Zamir *et al*. (2010) [13].

The straw yield is a function of number of shoots per unit area and height of the plant along with dry matter accumulation. In the present experiment, the straw yield was higher under conventional tillage during both the years. There was an increase of 13.69 and 10.72 per cent over minimum tillage and 6.84 and 5.24 per cent over zero tillage during 2016-17 and 2017-18, respectively.

A perusal of the data presented in table 3 clearly revealed that all the treatments significantly influenced the grain and straw yield over control during both the years. The highest grain yield 36.74 and 39.51 q ha^{-1} and straw yield 45.56 and 48.83 q ha^{-1} were recorded with 100% STR + PSB+ 5 tonnes FYM which was 20.38% and 25.79% and 24.11% and 28.26% higher than the yield of control during 1st year and 2nd year respectively. It was also observed that combined application of PSB + FYM produced higher grain and straw yield with 100% STR and farmer practice treatments in comparison control. Increases in grain and straw yields might be due to increasing in growth and yield attributes of wheat due to combined application of organic and bio-fertilizers with chemical fertilizers. Organics besides release of their own nutrients might have increase the nutrient use efficiency of applied inorganic fertilizers in wheat crop. The results of the present study are in agreement with those of several investigations.

Significant increase in biological yield with integrated nutrient management practices in present investigations over control. Maximum biological yield 82.89 and 87.15 q ha^{-1} recorded with 100% STR + PSB+ 5 tonnes FYM followed by 100% STR + PSB and + 100% STR 5 tonnes FYM and minimum in control during both the years.

A significant variation in NPK uptake by seed and straw was observed due to tillage practices method during both the years of experimentation. Treatment conventional tillage method noted highest total N uptake (grain + straw) (113.66 and 121.86 kg/ha) which was significantly higher than minimum tillage (104.19 and 112.86 kg/ha), P uptake (17.98 and 19.94 kg/ha) which was significantly higher than minimum tillage (16.37 and 18.14 kg/ha) and K uptake (125.56 and 136.96 kg/ha) which was significantly higher than minimum tillage (113.87 and 134.85 kg/ha) during 2016-17 and 2017-18, respectively. However, minimum total NPK uptake was removed by zero tillage during both the years. Alam *et al*. (2014) [1] reported similar results. Application of INM treatments had significant differences in K uptake by grain during both the years of experimentation. Maximum total N uptake (122.58 and 135.45 kg/ha), total P uptake (21.63 and 24.47 kg/ha) and total K uptake (135.97 and 152.24 kg/ha) was recorded by 100% STR + PSB+ 5 tonnes FYM and minimum in control treatment during first and second years of experimentation. Sharma and Rathore (2009) [6] confirms the results.

Table 1: Yield attributes of wheat as influenced by tillage practices and integrated nutrient management (INM)

Tillage practices	Spike weight (g)		Grain weight / Spike (g)		No of grains/ Spike		1000 grain weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Conventional tillage method (CT)	3.11	3.24	2.01	2.16	40.39	43.13	38.11	38.50
Minimum tillage method (MT)	3.04	3.12	1.97	2.12	39.75	42.63	37.12	37.65
Zero tillage method (ZT)	2.90	2.96	1.91	2.05	38.65	41.53	36.09	37.09
S. Em.±	0.01	0.01	0.008	0.010	0.19	0.19	0.17	0.18
CD at 5%	0.02	0.03	0.03	0.04	0.77	0.77	0.66	0.71
INM practices								
Control (No fertilizer) (T_1)	2.70	2.75	1.81	1.91	37.91	40.07	34.91	35.71
Farmer practice (T_2)	2.83	2.93	1.89	2.04	38.82	41.37	35.86	36.41
100% STR (Soil Test RDF NPK) (T_3)	2.95	3.09	1.91	2.11	39.44	42.50	36.74	37.12
100% STR + 5 tonnes FYM (T_4)	3.10	3.13	1.96	2.16	40.14	42.43	37.46	38.04
100% STR + PSB (T_5)	3.21	3.30	2.08	2.19	40.48	43.80	38.42	38.84
100% STR + PSB+ 5 tonnes FYM (T_6)	3.32	3.42	2.14	2.25	40.79	44.43	39.26	40.32
S.Em.±	0.02	0.02	0.013	0.012	0.21	0.22	0.19	0.24
CD at 5%	0.05	0.06	0.038	0.035	0.62	0.63	0.55	0.71

Table 2: Grain yield, straw yield, biological yield and harvest index as influenced by tillage practices and integrated nutrient management (INM)

Treatments	Grain yield (q/ha)		Straw yield (q/ha)		Biomass yield (q/ha)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices						
Conventional tillage method (CT)	35.38	37.12	43.86	46.07	79.24	82.99
Minimum tillage method (MT)	33.13	35.07	41.22	43.79	74.34	78.94
Zero tillage method (ZT)	31.67	33.28	38.58	41.61	70.25	72.86
S.Em.±	0.17	0.19	0.22	0.24	0.33	0.42
CD at 5%	0.69	0.77	0.89	0.97	1.32	1.69
INM practices						
Control (No fertilizer) (T_1)	30.52	31.41	36.71	38.07	67.22	69.93

Farmer practice (T_2)	31.49	33.39	38.44	40.17	69.93	72.84
100% STR (Soil Test RDF NPK) (T_3)	32.82	34.19	40.52	42.89	73.34	77.16
100% STR + 5 tonnes FYM (T_4)	33.72	35.26	42.47	45.55	76.18	79.44
100% STR + PSB (T_5)	35.07	37.17	43.61	47.45	78.68	83.05
100% STR + PSB+ 5 tonnes FYM (T_6)	36.74	39.51	45.56	48.83	82.29	87.15
S.Em.±	0.21	0.19	0.25	0.28	0.39	0.50
CD at 5%	0.62	0.55	0.73	0.82	1.13	1.46

Table 3: Total NPK by grain and straw as influenced by tillage practices and integrated nutrient management (INM)

Treatments	Total N uptake (kg/ha)		Total P uptake (kg/ha)		Total K uptake (kg/ha)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices						
Conventional tillage method (CT)	113.66	121.86	17.98	19.94	125.56	136.96
Minimum tillage method (MT)	104.19	112.86	16.37	18.14	113.87	124.85
Zero tillage method (ZT)	94.38	103.44	14.06	16.23	103.55	114.50
S.Em.±	0.57	0.62	0.08	0.09	0.55	0.57
CD at 5%	2.20	2.40	0.31	0.35	2.13	2.20
INM practices						
Control (No fertilizer) (T_1)	87.23	92.25	10.69	11.67	93.05	99.37
Farmer practice (T_2)	93.93	101.70	13.23	14.82	101.90	109.45
100% STR (Soil Test RDF NPK) (T_3)	100.60	107.38	15.04	16.77	110.30	119.48
100% STR + 5 tonnes FYM (T_4)	106.70	115.51	16.86	19.21	118.34	130.61
100% STR + PSB (T_5)	113.41	124.03	19.34	21.70	126.42	141.47
100% STR + PSB+ 5 tonnes FYM (T_6)	122.58	135.45	21.63	24.47	135.97	152.24
S.Em.±	0.66	0.71	0.11	0.12	0.61	0.66
CD at 5%	1.88	2.02	0.31	0.34	1.73	1.88

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