International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 1394-1398

Received: 22-03-2019
Accepted: 24-04-2019

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Impact of tillage practices and integrated nutrient management (INM) on growth and productivity of late sown wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted 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) to study the productivity of wheat (*Triticum aestivum* L.) under different 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)- T_1, Farmer practice- T_2 100% 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. Conventional tillage method produced taller plants, higher dry matter accumulation and maximum number of tillers/m^2 at 90 DAS as compared to other treatment. Zero tillage produced shorter plant height, minimum dry matter and less number of tillers per m^{-2}. tillage practices methods on yield contributing characters, spike length, spike weight, number of grains/spike, number of spikelets per spike, 1000 seed weight, were positively influenced (Table 2). 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. 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.

Keywords: Conventional tillage, zero tillage, tillage methods, grain yield, INM, 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) [10]. 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) [1]. 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 Crop Research Center is located between latitude of $25^0$28' to $26^0$58' north and $79^0$31' to $80^0$34' east with an elevation of 125.9mtr from the sea level. The total rainfall during the crop season is about 320 mm. 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)- T_1, Farmer practice- T_2 100% 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

Tillage practices methods had significant effect on plant height, dry matter accumulation and number of shoots m^{-2} recorded maximum value under conventional tillage closely followed by minimum tillage method. This ultimately led to more fresh and dry matter production under these techniques as compared to other treatment. At early stage of crop, conventional tillage method improved plant growth due to better availability of nutrient at 45 DAS. There was significant variation in tillers production at all the growth stages during both the seasons. Higher tiller production was observed at 90 DAS in both the years. Conventional tillage method produced the maximum number of tillers/m^2 at 90 DAS as compared to other treatment. This significant increase in tillers number was due to fact that crop utilized most of the quantities of applied fertilizer under Conventional tillage method practices. Zero tillage produced less number of tillers per m^{-2} area due to slow availability fertilizer from soil during the early stages of crop growth causing nutrient deficiency in the succeeding crop. Pradhan *et al.* (2005) [4] confirmed that growth parameters like plant height, tiller density and dry matter production at harvest, leaf area indices, crop growth rates conventional tillage respectively over zero tillage

Integrated nutrient management practices exhibited greater influence on the height of the plant, fresh and dry matter production and leaf area index during crop growth. The plant height significantly increased with application of 100% STR + PSB+ 5 tonnes FYM. It is attributed due to the said nutrient increased the availability of plant in root zone and brought an increase in plant height, because of its immense effects on cell enlargement. 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.

The dry matter production in plants increased with integrated nutrient management at all the stages of crop growth (Table 4.5). The maximum dry weight was produced with 100% STR

+ PSB+ 5 tonnes FYM, which was significantly higher over 100% STR + PSB and farmer practices. The increased dry matter production in plants due to various rates of nitrogen application would appear to have resulted due to more chlorophyll formation and its ultimate effect on photosynthesis. The fact, that, there was an improvement in dry matter production by wheat plants at 100% STR + PSB+ 5 tonnes FYM application. Tillers production increased significantly with application of INM treatments at all the stages of crop growth (Table 4.5). The lowest tillers/m^2 was recorded under control plots which was significantly lesser than others INM treatments. In other words 100% STR + PSB+ 5 tonnes FYM produced maximum number of tillers/m2 during both the years. Such finding get full support from the studies of Verma *et al*. (2014) [9], AND Verma *et al*. (2015) [10].

Yield and Yield Attributes

As regards the influence of tillage practices methods on yield contributing characters, spike length, spike weight, number of grains/spike, number of spikelets per spike, 1000 seed weight, were positively influenced (Table 2). 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. 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) [11].

An examination of the data presented in table 4.8 and fig. 4.10, clearly shows 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) [6], Rather and Sharma (2010) [5] and Verma *et al*. (2014) [9].

Grain and straw yield

Results in Table 3 reveals that over all effect of tillage practices methods on grain and straw yield was quite appreciable. 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) [7], Zamir *et al.* (2010) [12].

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.

Table 1: Growth parameters as influenced by tillage practices and integrated nutrient management (INM)

Treatments	Plant height (cm)		Dry matter accumulation/plant		Productive tillers per (m2)		Leaf area (cm2)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage practices								
Conventional tillage method (CT)	76.91	80.08	17.48	17.76	382.83	385.65	3.70	3.74
Minimum tillage method (MT)	76.14	77.59	17.12	17.54	376.22	378.82	3.55	3.59
Zero tillage method (ZT)	74.92	75.40	16.16	17.32	365.39	373.42	3.39	3.45
S.Em.±	0.36	0.37	0.025	0.035	1.29	0.91	0.012	0.007
CD at 5%	1.46	1.47	0.102	0.142	5.22	3.66	0.048	0.028
INM practices								
Control (No fertilizer) (T_1)	73.13	73.18	15.20	15.43	352.78	352.20	2.87	2.91
Farmer practice (T_2)	74.62	75.77	16.12	16.53	363.00	363.73	3.16	3.28

100% STR (Soil Test RDF NPK) (T_3)	75.42	77.08	16.83	17.73	369.22	374.33	3.46	3.47
100% STR + 5 tonnes FYM (T_4)	76.41	78.03	17.33	18.03	378.89	383.47	3.65	3.61
100% STR + PSB (T_5)	77.29	80.43	17.78	18.45	386.78	393.07	3.93	4.00
100% STR + PSB+ 5 tonnes FYM (T_6)	79.07	81.64	18.27	19.06	398.22	408.97	4.20	4.27
S.Em.±	0.41	0.42	0.094	0.113	1.93	2.67	0.021	0.023
CD at 5%	1.19	1.22	0.272	0.329	5.60	7.75	0.060	0.067

Table 2: Yield attributes of wheat as influenced by tillage practices and integrated nutrient management (INM)

	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**
Tillage practices								
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 3: 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

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