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Effect of different tillage practices and precision nutrient management on energy use efficiency, economics and yield of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment wasconducted during the *rabi* season of 2014-15 in GBPU&T, Pantnagar to study the effect of different tillage and precision nutrient management on nutrient content, Nitrogen uptake, energy, economics and yield of wheat. The result revealed that among the tillage practices, there was no significant difference in grain yield but the reduced tillage produced slightly higher grain yield than conventional and zero tillage. Since it incurred a low cost of cultivation besides resulting in a marginal increase in yield attributes and grain yield, it could be preferred over the conventional tillage. The recommended dose of fertilizers recorded the highest grain and straw yield, energy use efficiency, benefit cost ratio and total N uptake more than that of the SSNM and SSNM+ Green seeker based nutrient management, but SSNM saved 37 % nitrogen as compared to the recommended NPK, which shall be helpful in to protect environment. Thus, application of the recommended dose of NPK could be made for realization of the yield potential, but SSNM could be taken as a step to make the present day agriculture eco- friendly. As the results were based on one year data, one more year of experimentation shall be made for further confirmation.

Keywords: Tillage, Precision nutrient management, Energy use efficiency, Wheat productivity, Economics

Introduction
Wheat (*Triticum aestivum* L.) is the important cereal crop in the World and stands next to rice in India. Wheat cover an area of about 31.2 million hectare with total production of 95.9 million tonnes in India. The average national productivity is about 3.08 tonnes per hectare as against the theoretical yield potential of 6.0 tonns per hectare (USDA, 2013-14). Modern agriculture uses substantial amounts of fossil energy in the form of fertilizers, pesticides, and fuel for field operations. The environmental consequences of these agricultural practices include increased emissions of greenhouse gases (GHG) to the atmosphere, from sources both direct (e.g., fuel use during tillage and other field operations) and indirect (e.g., fuel used off-site to produce seeds and agricultural chemicals). Recently, the prospect of biofuel production on a large scale has focused attention on energy efficiencies associated with different agricultural systems and production goals. Generally more and more tillage practices and fertilizer application are required in rice- wheat system, which increases the cost of cultivation and affect the soil health.

Material and Methods
The present study was undertaken to identify the better tillage and nutrient management practices for wheat to save energy and reduced the cost of cultivation without decline the grain yield in *tarai* region of Uttarakhand. An experiment was conducted during *rabi* season of the year 2014-15 for evaluating the effect of different tillage practices and the precision nutrient management on energy, nutrient uptake, total N uptake, economics and yield of wheat under *tarai* region at Norman E. Borloug Crop Research Center of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. It is situated at 29 N^{o} latitude, 79.29 E^{o} longitude and an altitude of 243.84 m above the mean sea level. The soil of experimental field was silty clay loam in texture with 236 kg/ha available N (Subbiah and Asija, 1956) [13], 22.60

kg/ha available P **(**Olsen *et al*., 1954) [9], 209 kg/ha available K (Jackson, 1958) [7], 0.78 organic carbon and soil pH of 7.4 (1:2.5 soil: water ratio). The experiment was laid out in Strip plot design, containing three tillage practices *viz.* conventional tillage, reduced tillage and zero tillage in horizontal strip; and precision nutrient management practices *viz* recommended NPK (150 :60 :40 kg/ha), SSNM based nutrient management, and SSNM+ Green Seeker based nutrient management in vertical strip was used for the study. The SSNM doses were calculated by the nutrient expert software. The wheat variety DPW 621-50 was used in the experiment. The treatments were replicated thrice and the crop was sown on 13 November, 2014, and harvested on 15 April, 2015.

Results and Discussion

Nutrient Content

The tillage practices and the precision nutrient management significantly influenced the nutrients contents in grain and straw (Table 1). The percentage of N, P and K content in grain was significantly more in the reduced tillage than the conventional tillage, while N content was at par with the reduced tillage. In case of straw, the percentage of N, K and P was found significantly superior in reduced tillage and conventional tillage, respectively because of better aeration provided by reduced tillage which leads to nutrient availability. Among the precision nutrient management, the percentage of N content in grain was significantly superior in the recommended NPK, however the percentage of P and K content was found significantly higher in the SSNM based nutrient management than the recommended NPK and SSNM+GS based nutrient management. In case of straw, the content of N, K and P was significantly higher in reduced and conventional tillage, respectively. The total uptake of nitrogen is significantly influenced by the different tillage practices and the nutrient management practices. Under the different tillage practices, the maximum uptake was found in the reduced tillage which was significantly superior then the conventional tillage and zero tillage, while the zero tillage also had significant difference from the conventional tillage. Among the precision nutrient management, the nitrogen uptake found significantly higher in the recommended NPK than the SSNM and the SSNM+GS based nutrient management. This might be due to high amount of N. However, the SSNM based nutrient management also gave significant result with SSNM+GS based nutrient management.

Energy Parameters

Energy of treatments were calculated with the help of energy equivalent (Table 3). Among the different tillage practices, total input energy was found maximum in conventional tillage due to more number of tillage practices (Table 2). The total output energy was found higher in the reduced tillage as compared to the conventional and zero tillage. Although, zero tillage recorded maximum energy use efficiency followed by reduced tillage then conventional tillage, because reduced tillage produced more yield and spent lesser energy than the other treatments. The energy productivity was highest in zero tillage and lowest in conventional tillage. The net energy was also found maximum in reduced tillage. The Same results also reported by (Farahmandpour *et al*., 2008 and Kosutic *et al*., 2005) [4]. In case of precision nutrient management practices, the recommended NPK was found highest in all parameters of energy studies viz. total input energy, total output energy, energy use efficiency, energy productivity and net energy followed by SSNM based nutrient management then SSNM+ Green seeker based nutrient management.

Yield

The reduced tillage produced maximum grain yield, (46.2 q/ha) which was at par with the conventional tillage and the zero tillage but the reduced tillage produced 2.66 % and 6.70 % higher yield than the conventional tillage and the zero tillage, respectively (Table 4). The higher grain yield achieved under reduced tillage. This might be due to proper aeration and moisture provided by reduced tillage, if proper moisture is available in the soil for seed then seed will germinate timely and better aeration leads to optimum oxidation. Since oxidation results help in nutrient availability. Oxidation is also responsible for the activity of microorganism which plays a vital role in the decomposition of organic matter. If adequate nutrients are available in soil then plant can fulfill their requirement according to their needs. Thereby increasing plant growth and yield. The same result also reported by (Sharma *et al*., 2002; Ernstein & Laxmi, 2008 and Sharma *et al*., 2011) [12, 13, 3].The maximum straw yield (64.6 q/ha) produced in the reduced tillage followed by the zero tillage and then the conventional tillage. The reduced tillage was produced 14.74 % and 8.20 % higher straw yield than the conventional tillage and the zero tillage, respectively. The harvest index was found nonsignificant due to the treatment.

On the other hand, the recommended NPK produced significantly more grain yield (49.1 q/ha) than the SSNM and the SSNM+GS based nutrient management. The recommended NPK produced 11.84 % and 19.17 % higher grain yield than SSNM and SSNM+ Green Seeker based nutrient management, respectively. Because of recommended NPK provides higher amount of N than the other the other nutrient management practices, which enhanced the photosynthesis rate thereby increases the grain yield. However, the SSNM and SSNM+ GS based nutrient management gave nonsignificant results. The precision nutrient management were found failed to give significant result in case of straw yield. The recommended NPK produced maximum straw yield (67.6 q/ha) followed by the SSNM and SSNM+GS based nutrient management. Because the recommended NPK provides higher amount of N than the other the other precision nutrient management practices. N is a constituent of chlorophyll, which makes plant green and responsible for photosynthesis. The rate of photosynthesis and quality of photo synthetes determine the plant health, which finally decided the grain growth. Thereby grain yield directly correlated with photosynthesis, which might be higher under recommended NPK. The same result also reported by Honnali (2013) [5].

The SSNM and SSNM+ GS based nutrient management practices produced 11.83 % and 19.97 % lower yield than the recommended NPK, respectively. The harvest index was found nonsignificant due to the treatments.

Economics

The conventional tillage had significantly highest cost of cultivation (22,950 ₹/ha) than the reduced and zero tillage (Table 4). This may be due to more number of tillage operations was performed in conventional tillage. The conventional tillage and the zero tillage was also found significant to each other. However, the zero tillage had minimum cost of cultivation (20,876 ₹/ha). The gross return recorded significantly higher in the reduced tillage (83,159 ₹ /ha) as compared to conventional tillage (79,655 ₹/ha) and the

zero tillage (77,405 ₹/ha). The net return was found significantly maximum in the reduced tillage (61,670 ₹/ha) as compared to the conventional tillage (56,731 ₹/ha) and zero tillage (56,526 ₹/ha). This might be due to lower input and higher yield was obtained in the reduced tillage. Among the different tillage practices, the highest B:C ratio obtained in the reduced tillage as compared to the conventional and zero tillage, because of higher net return and lower cost of inputs. Among the precision nutrient management, the cost of cultivation was recorded significantly highest in recommended NPK (22,497 ₹/ha) than the other treatments (Table 4). The Gross return was recorded significantly maximum in recommended NPK (88,195 ₹/ha) than the SSNM (78,650 ₹/ha) and the SSNM+GS based nutrient management (73,375 ₹/ha). The higher gross return is due to the more grain and straw yield which fetched more income from the market. However, the net return significantly higher (65,696 ₹/ha) over the SSNM based nutrient management (57,108 ₹/ha). The least net return was recorded in the SSNM+GS based nutrient management. The benefit cost ratio was recorded in recommended NPK followed by SSNM based nutrient management then SSNM+GS based nutrient management.

Conclusion

From the present study it may be concluded that for realization of the yield potential application of the recommended dose of NPK could be made, however Site Specific Nutrient Management could be taken as a step to make the present day agriculture eco- friendly and future of agriculture sustainable. The results are based on one year data, thus further experimentation shall be made for validation of results.

Table 1: The N, P and K content in grains and straw as influenced by the tillage practices and the precision nutrient management

Treatments	N content		P content		K content		N uptake (kg/ha)		Total N uptake (kg/ha)
Tillage practices	**Grain**	**straw**	**Grain**	**straw**	**Grain**	**Straw**	**Grain**	**straw**	
Conventional	1.53	0.35	0.26	0.19	0.59	1.18	67.56	20.23	87.79
Reduced	1.63	0.43	0.28	0.12	0.67	1.27	71.59	28.25	99.84
Zero	1.63	0.36	0.27	0.17	0.64	1.22	70.57	20.82	91.39
SEm	0.01	0.00	0.00	0.00	0.00	0.008	0.04	0.22	0.32
CD (P=0.05)	2.08	0.002	0.002	0.008	0.002	0.03	1.59	0.87	1.25
Precision nutrient management practices									
Recommended NPK	1.70	0.34	0.27	0.16	0.65	1.30	76.82	23.45	100.28
SSNM	1.56	0.40	0.28	0.19	0.70	1.22	69.64	24.09	93.73
SSNM+ GS	1.53	0.40	0.26	0.12	0.54	1.14	63.25	21.76	85.01
SEm	0.02	0.00	0.00	0.00	0.00	0.004	0.45	0.22	0.31
CD(P= 0.05)	0.04	0.01	0.002	0.008	0.009	0.21	1.58	0.87	1.39

Table 2: The total energy input, energy output, energy ratio, energy intensity, energy production and energy use efficiency as influenced by the different tillage practices and the precision nutrient management

Treatments	Total input energy(MJ) X 10^{-3}	Total output energy (MJ) X 10^{-3}	Energy use efficiency (MJ)	Energy productivity (kgha/MJ) X 10^{-3}	Net energy (MJ) X 10^{-3}
Tillage practices					
Conventional tillage	80.3	137.9	1.71	5.53	57.5
Reduced tillage	58.4	148.7	2.53	7.83	90.3
Zero tillage	49.0	137.6	2.79	8.73	88.3
Nutrient management practices					
Recommended NPK	65.0	156.7	2.51	7.76	91.7
SSNM	61.5	139.1	2.34	7.40	77.5
SSNM+GS	61.2	128.3	2.18	6.93	67.1

Table 3: Equivalent for direct and indirect source of energy

	Input	Unit	Equivalent energy (MJ)
1.	Human labour	Man hour	1.96
2.	Seed	Kg	14.7
3.	Grain	Kg	14.7
4.	Straw	Kg	12.5
5.	Farm machinery	Kg	62.70
6.	Diesel	Litre	56.31
7.	Electricity	KWH	11.93
8.	Chemicals	Kg	120
9.	**Chemical fertilizer**		
	N	kg	60.60
	P_2O_5	kg	11.1
	K_2O	kg	6.7
10.	Water	m^3	1.02

Source:- Devasenapathy *et al.* (2009)

Table 4: The grain and straw yield, cost of cultivation, gross return, net return and B:C ratio as influenced by the different tillage practices and the precision nutrient management

Treatments	Yield (kg/ha)		Cost of cultivation(₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
	Grain	Straw				
Tillage Practices						
Conventional Tillage	45.0	56.3	22950	79655	56731	2.46
Reduced Tillage	46.2	64.6	21488	83159	61670	2.85
Zero	43.1	59.3	20876	77405	56536	2.70
SEm±	0.77	1.34	6.40	17.42	17.41	0.001
CD (P=0.05)	NS	5.26	25.17	68	68.39	0.006
Nutrient management practices						
Recommended NPK	49.1	67.6	22497	88195	65696	2.92
SSNM	43.9	59.6	21546	78650	57108	2.64
SSNM+GS	41.2	54.1	21270	73375	52131	2.45
SEm±	0.85	1.91	35.33	0.00	19.14	0.001
CD (P=0.05)	4.1	NS	35.59	108.13	52.27	0.005

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