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Full Research Article

Effect of Tillage and Nutrient Management on Growth, Yield, Harvest Index and Nutrient Use Efficiency of Wheat (*Triticum aestivum* L.) in Indo-gangetic Plains of India

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Abstract

The present experiment was carried out during 2013–14 and 2014–15 at Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India representing the *Tarai* belt of Uttarakhand. The experiment was laid out in a split plot design with 18 treatments with 06 tillage options i.e. FIRBS, conventional tillage (CT), sub soiling (SS), zero tillage (ZT), minimum tillage with two pass of rotavator (MT) and permanent raised bed system (PRBS) in main plot and 03 nutrient levels i.e. 50% of recommended dose of fertilizers (50% RDF), site specific nutrient management (SSNM) and 100% recommended dose of fertilizer (RDF) in sub plot with three replications. The tillage options and nutrients levels influenced significantly most of the growth and yield attributes. Based on pooled values PRBS the highest grain yield that was statistically equal to FIRBS and SS. In general wheat grain yield was almost equal at PRBS, FIRBS and SS that was 9.5 and 16% and 32.5% greater than CT, MT and ZT respectively. The harvest index was also recorded significantly highest under FIRBS followed by PRBS and Nutrient use efficiency was recorded highest under PRBS followed by SS and FIRBS, though remained non significant on pooled basis. Similarly RDF produced highest grain yield on pooled basis that was 11.7 and 48.6% higher than SSNM and 50% RDF, respectively but the harvest index was found significantly highest under at 50% RDF. The Nutrient use efficiency was recorded significantly highest under 50% during growth stages.

1. Introduction

Wheat is an important *Rabi* crop in India, contributing towards food security to a large extent. Wheat occupies of 31.9 mha area with a production of 95.91 mt and productivity 3075 kg ha^{-1}. (Agricultural Statistics at a Glance, 2014). Due to revolution in tillage options like minimum tillage, zero tillage, FIRBS, raised bed planting, the paradigm shift in tillage has been observed in world over. Due to the availability of herbicides, insecticides and fungicides and also more mechanization, the farmers prefer new tillage options compared to conventional tillage that is required mainly for seedbed preparation and weed control (Mohanty et al., 2006). Similarly zero tillage promotes high aggregate stability, decreases soil temperature and maintains high carbon and nitrogen. FIRBS and raised bed planting reduces cost of cultivation and water and nutrient requirement in maize-wheat system and rice-wheat-systems and increased soil quality (Singh et al., 2011; Naresh et al., 2009). The sub soiling is an urgent need to break the hard pan and also improve the soil porosity and percolation. Therefore, some of the research findings have already indicated that the sub soiling may be beneficial to improve the productivity and profitability of the system, compared to adopting conventional tillage system. The knowledge on interaction of tillage and nutrient management on growth and yield of wheat is scanty in *Tarai* region of Uttarakhand, India. Therefore, the present study was carried out in *Tarai* region o Indo-Gangetic plains of India to study the effect of tillage and nutrient levels on growth and productivity of wheat.

2. Materials and Methods

The present experiment was carried out during 2013–14 and 2014–15 at Norman E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar District Udham Singh Nagar, Uttarakhand, India representing the *Tarai* belt of Uttarakhand to study the effect of tillage

options and nutrient levels on growth, yield and harvest index of grain in Indo-Gangetic plains of India. Geographically Pantnagar is situated at 29° N latitude, 79.5° E longitude and at an altitude of 243.84 m above mean sea level in the foot hills of Himalayas. The experimental site was silty clay loam having soil pH 7.21, organic carbon 0.684% and 242.42, 22.56 and 240.32 kg available N, P_2O_5 and K_2O ha^{-1}, respectively. The experiment was laid out in a split plot design with 18 treatments with 06 tillage options i.e. FIRBS, conventional tillage (CT), sub soiling (SS), zero tillage (ZT), minimum tillage with two pass of rotavator (MT) and permanent raised bed system (PRBS) in main plot and 03 nutrient levels i.e. 50% of recommended dose of fertilizers (50% RDF), site specific nutrient management (SSNM) and 100% recommended dose of fertilizer (RDF) in sub plot with three replications. Treatments were replicated thrice. The crop was grown as per recommended practices. The wheat varieties i.e. 2748 and PBW550 was planted on 2013 and 2014, respectively. The fertilizer dose was $N:P_2O_5:K_2O$:150:60:40 (100% RDF), 110:15:64 (SSNM) and 75:30:20 (50% RDF), kg ha^{-1}, respectively. One third of nitrogen and full dose of P_2O_5 and K_2O were applied as basal and remaining nitrogen was top dressed in four equal splits. The growth parameters like plant height, LAI, number of tillers and SPAD values, yield attributes like effective tillers, spike length, number of grains $spikes^{-1}$ and 1000 grain weight, grain yield, straw yield, nutrient use efficiency and harvest index were recorded as per the standard methods. The fertilizer dose under SSNM was estimated based on decision support system on nutrient management on wheat developed by IPNM and CIMMYT.

3. Results and Discussion

3.1. Effect of tillage options

3.1.1. Growth attributes

The growth parameters i.e. plant height, LAI, number of tillers and chlorophyll content (SPAD) was affected by tillage options (Table 1). The plant height was not influenced significantly by tillage options in 2013 but PIRBS produced the tallest plants. In 2014, PRBS produced the tallest plants

That was significantly similar to CT, SS and MT. As per the pooled values, PRBS had the tallest plants that were significantly at par with CT, SS and MT. The taller plants under FIRBS and PRBS were the result of greater availability

Table 1: Effect of tillage options and nutrient levels on Plant height (cm), SPAD reading, LAI and number of tillers m^{-2} during different crop growth stage on wheat

Treatments	Plant height (cm) at harvest			SPAD reading at 90 DAS			LAI at 90 DAS			Number of tillers at 90 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Tillage options												
FIRBS	89	68	76	41.9	40.4	41.2	3.25	3.20	3.21	480.00	530.67	505.33
CT	88	69	79	40.8	39.2	40.0	3.62	3.48	3.55	433.78	475.67	454.72
SS	89	70	79	41.1	39.9	40.5	3.90	3.80	3.82	532.45	501.56	517.00
ZT	88	66	77	41.3	38.7	40.1	3.10	2.96	3.02	399.78	397.44	398.66
MT	89	70	70	40.0	38.7	40.2	3.61	3.52	3.60	503.67	431.78	467.72
PRBS	90	70	80	42.8	40.4	41.5	3.58	3.50	3.54	459.56	454.78	457.18
SEm±	0.8	0.5	0.8	0.7	0.5	0.4	0.03	0.03	0.03	3.57	2.40	2.13
CD (p=0.05)	NS	02	02	NS	NS	NS	0.10	0.08	0.08	11.24	7.57	6.7
Nutrients level												
50% RDF	88	66.0	77.0	39.3	38.4	38.9	2.96	2.83	2.90	400.00	397.61	398.1
SSNM	89	69.0	79.0	41.1	39.8	10.4	3.53	3.44	3.50	462.44	460.89	461.67
RDF	90	71.0	81.0	43.6	41.2	42.4	4.02	3.93	4.00	542.17	537.44	539.81
SEm±	0.5	0.6	0.4	0.4	0.6	0.4	0.03	0.03	0.03	1.64	0.49	0.87
CD (p=0.05)	01	02	01	1.2 S	1.6 S	1.0	0.08	0.08	0.07	4.79	1.42	2.53
Interaction (T×N)	NS	NS	NS	NS	NS	NS	S	S	S	S	S	S

**FIRBS: Furrow irrigated raised bed system; CT: Conventional tillage; SS: Sub soiling; ZT: Zero tillage; MT: Minimum tillage; PRBS: Permanent raised bed system

of nutrient, water and space as well as better root development as supported by Bakht et al. (2004). The chlorophyll content as per the SPAD values remained non significant among the tillage options during both the years. However, the highest chlorophyll content was recorded under PRBS during both the years as well as pooled values followed by FIRBS. The higher SPAD value is an index of greenness or chlorophyll content that is essential for photosynthesis. The LAI at 90 DAS was recorded significantly highest under SS during both years but remained statistically at par with MT in 2014. The pooled value was also found significantly highest under SS followed by MT, CT and PRBS. Significantly highest numbers of tillers were recorded under SS and FIRBS during 2013 and 2014, respectively and lowest in ZT during both the years. The SS produced significantly highest numbers of tillers followed by FIRBS and lowest in ZT on pooled basis. Sub soiling made soil more pulverized up to deeper layers that might have helped better root development and greater tillering. Bhatt (2015) also reported lower numbers of tillers under ZT and compared to reduced and CT.

3.1.2. Yield attributes

Yield attributes i.e. effective tillers m^{-2}, spike length, number of grains $spike^{-1}$ and test weight were affected significantly by tillage options during all the stages except spike length in 2013, number of grains $spike^{-1}$ in 2014 and test weight in 2014 and pooled values (Table 2). The highest spike length was noticed under SS and PRBS though remained non significant among different tillage options in 2013. The FIRBS had highest spike length that remained non significant with PRBS and SS. Highest spike length pooled basis was recorded under PRBS that remained non significant with FIRBS and SS. The number of grain $spike^{-1}$ was counted maximum under FIRBS and PRBS in 2013 and under FIRBS in 2014. The pooled values was found the highest under FIRBS and PRBS that remained non significant with SS. Significantly highest test weight was weight under SS that remained non significant with PRBS and MT in 2013. The test weight was remained non-significant in 2014 and pooled basis but the highest value was recorded under FIRBS and SS, respectively. Effective tillers differed significantly among tillage options during both the years. In 2013 MT had significantly higher effective tillers that were non-significant with the values obtained under SS.

In 2014 and in pooled average FIRBS produced significantly higher effective tillers. ZT produced significantly lowest

Table 2: Effect of tillage option and nutrient levels on Effective tillers m^{-2} Spike length, Number of grain $spike^{-1}$ and Test weight during different crop growth stage on wheat

Treatments	Effective tillers m^{-2}			Spike length			Number of grain $spike^{-1}$			Test weight (1000 grain weight)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Tillage options												
FIRBS	319.56	402.00	366.78	8.9	8.9	8.9	47.0	35.0	41.0	39.89	39.22	39.55
CT	286.00	317.78	301.89	8.8	8.3	8.5	42.0	32.0	37.0	40.22	38.22	39.22
SS	349.11	343.11	346.11	9.3	8.6	8.9	45.0	33.0	39.0	43.33	38.22	40.77
ZT	237.00	236.44	236.72	8.8	8.2	8.5	39.0	31.0	35.0	39.60	35.33	37.44
MT	350.00	264.00	307.00	8.9	8.1	8.5	44.0	31.0	38.0	41.66	36.22	38.94
PRBS	246.11	290.67	268.39	9.3	8.7	9.0	47.0	34.3	41.0	42.33	38.77	40.55
SEm±	1.80	2.22	2.22	0.2	0.1	0.1	1.2	1.4	0.7	0.46	1.32	0.71
CD (p=0.05)	5.60	7.01	7.01	NS	0.5	0.3	3.9	NS	2.3	1.44	NS	NS
Nutrients level												
50% RDF	238.83	257.00	247.92	8.6	8.1	8.4	38.0	31.0	35.0	40.11	35.77	37.94
SSNM	289.89	312.06	300.97	9.1	8.5	8.8	45.0	33.0	39.0	41.05	37.55	39.31
RDF	365.17	357.94	361.56	9.2	8.8	9.0	49.0	34.0	42.0	42.33	39.66	41.00
SEm±	0.64	1.24	1.24	0.1	0.1	0.08	0.4	0.6	0.4	0.56	0.52	0.44
CD (p=0.05)	1.87	3.53	3.53	0.3	0.4	0.2	1.3	1.9	1.2	1.74	1.51	1.27
Interaction (T×N)	S	S	S	NS	NS	NS	S	NS	S	NS	NS	NS

**FIRBS: Furrow irrigated raised bed system; CT: Conventional tillage; SS: Sub soiling; ZT: Zero tillage; MT: Minimum tillage; PRBS: Permanent raised bed system

number of effective tillers at all the stages. Sharma et al. (2011) also reported same report.

3.1.3. Grain yield and harvest index

Tillage options had significantly effect on grain yield, straw yield and harvest index during both the years (Table 3). The highest grain yield was recorded under SS that remained non significant with PRBS, FIRBS and MT in 2013 but FIRBS had the highest value that was statistically at par with SS and PRBS in 2014. The pooled values had highest grain yield under PRBS that remained statistically equal to FIRBS and SS. The lowest grain yield was recorded under ZT followed by CT at all the stages. The pooled values also indicated that FIRBS and PRBS had almost equal grain yield that was more than 9.5 and 16% greater than CT and MT respectively. The higher yield achieved under PRBS because its favors growth parameters, plant height, LAI, SPAD reading by providing proper aeration, moisture, nutrient availability and less weed competition and finally yield. The same result was reported by Sharma et al. (2011). The straw yield was also affected significantly by tillage option and the highest value was recorded under SS in 2013.

Under PRBS in 2014. The pooled straw yield was found significantly greater under PRBS that remained non- significant with SS. The Harvest index was also recorded significantly highest under FIRBS followed by PRBS in 2013 and CT and SS in 2014.

3.1.4. Nutrient use efficiency

The NUE was recorded highest under PRBS followed by SS in 2013 but in 2014 significantly highest values was recorded under FIRBS that remained non significant with SS and PRBS. The pooled NUE thought was no significant among tillage option but the higher value was recorded under PRBS followed by SS. The higher NUE in PRBS might be due to because raised bed facilitates timelier placement of fertilizers (especially N) and lead to improve nutrient use efficiency.

3.2. Effect of nutrient levels

3.2.1. Growth attributes

The growth parameters i.e. plant height, LAI; number of tillers and chlorophyll content (SPAD) were significantly affected by nutrient levels during both years (Table 1). The tallest plants was observed under at RDF and remained non significant with SSNM during both years. Pooled data showed that RDF produced the significantly tallest plants. The chlorophyll

Table 3: Effect of tillage options and nutrient levels on Grain yield, Straw yield, Harvest index (%) and Nutrient use efficiency different crop growth stage on wheat

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Harvest index (%)			NUE		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Tillage options												
FIRBS	39.8	35.7	37.8	47.0	45.4	46.2	45.9	44.1	45.0	19.54	19.74	19.64
CT	36.8	32.2	34.5	51.8	43.2	47.5	41.6	42.8	42.2	19.82	17.83	18.83
SS	41.8	33.2	37.5	57.7	44.4	51.1	42.0	42.8	42.4	22.80	18.34	20.56
ZT	35.0	30.1	32.5	48.3	41.8	45.0	42.1	42.0	42.0	19.00	16.75	17.87
MT	39.0	31.1	35.0	54.4	42.9	48.7	41.9	42.0	42.0	20.93	17.52	19.23
PRBS	41.6	34.3	37.9	55.6	47.5	51.5	42.8	42.1	42.4	22.85	19.23	21.04
SEm±	0.9	0.8	0.6	0.7	1.0	0.5	0.004	0.004	0.003	1.15	0.53	0.70
CD (p=0.05)	3.1	2.6	1.9	2.3	3.0	1.7	0.014	0.01	0.01	NS	1.68	NS
Nutrients level												
50% RDF	29.0	27.4	28.2	37.9	35.9	36.9	43.4	43.3	43.4	21.97	21.94	21.96
SSNM	41.1	34.0	37.5	56.0	45.9	51.0	42.2	42.5	42.4	21.74	18.00	19.87
RDF	46.8	36.9	41.9	63.6	50.8	57.2	42.5	42.0	42.3	18.74	14.75	16.75
SEm±	0.6	0.6	0.4	0.5	0.8	0.3	0.004	0.01	0.003	0.80	0.31	0.45
CD (p=0.05)	1.9	1.6	1.2	1.4	2.2	1.0	NS	NS	0.01	2.26	0.91	1.28
Interaction (T×N)	NS	NS	NS	S	NS	NS	NS	NS	NS	NS	NS	NS

**FIRBS: Furrow irrigated raised bed system; CT: Conventional tillage; SS: Sub soiling; ZT: Zero tillage; MT: Minimum tillage; PRBS: Permanent raised bed system

content i.e. SPAD value was recorded significantly higher under RDF followed by SSNM and lowest value was noticed under 50% RDF at all the stages. LAI at 90 DAS was also recorded significantly highest under RDF followed by SSNM and 50% RDF at all the stages during both years. The number of tillers m^{-1} varied significantly under different nutrient management systems and significantly highest tillers were counted under RDF at all the stages. The higher value of growth attributes is the combined effect of better nutrient availability for crop growths and development (Kumar et al., 2013) also reported similar result.

3.2.2. Yield attributes

Yield attributes i.e. effective tillers m^{-2}, spike length, number of grains $spike^{-1}$ and test weight were affected significantly by nutrients levels at all the stages. RDF had the longest spike that remained non significant with SSNM during both the years and lowest value was recorded under 50% RDF during both the years and pooled values, similarly the number of grain $spike^{-1}$ was counted significantly highest under RDF at all the stage during both the year as well as pooled values but remained non-significant with SSNM in 2014. The test weight also followed the above trend with significantly highest value under RDF and the lower at 50% RDF. Significantly maximum effective tillers were counted under RDF and the minimum under 50% RDF during the both years. It might be due to 100% recommended dose of fertilizers (RDF) provides higher amount of N than the others i.e. SSNM and 50% RDF. The N is a constituent of the chlorophyll, which makes plant green and responsible for higher photosynthesis. The rate of photosynthesis and quality of photosynthates determine the plant health, which finally decide the yield attributes. Thereby yield directly correlated with photosynthesis, which might be higher under RDF. Honnali (2013) also reported same result.

3.2.3. Grain yield and harvest index

Nutrients level had significant effect on grain yield, straw yield and harvest index during both the years (Table 3). Grain yield was recorded significantly highest under RDF during both years. The pooled values was also recorded highest under RDF with 11.7% and 48.6% greater grain yield of wheat than SSNM and 50% RDF respectively. It might be due to 100% recommended dose of fertilizers (RDF) provides higher amount of N than the others i.e. SSNM and 50% RDF. The N is a constituent of the chlorophyll, which makes plant green and responsible for higher photosynthesis. The rate of photosynthesis and quality of photosynthates determine the plant health, which finally decide the grain growth and yield. Thereby grain yield directly correlated with photosynthesis, which might be higher under RDF. Honnali (2013) also reported same result. The similar trend was found for straw yield. The Harvest index was found significantly highest under 50% RDF followed by SSNM under lower RDF at all the stages.

3.2.4. Nutrient use efficiency

The nutrients level had significant influence on NUE, with the significantly highest value under 50% RDF followed by SSNM and RDF during all the stages; however, it remained significantly at par with SSNM only in 2013. The interaction between tillage options and nutrients levels observed significantly for LAI, number of tillers, effective tillers and number of grain $spike^{-1}$ during 2013 and in pooled values.

4. Conclusion

Wheat may be grown under permanent raised bed system and FIRBS with the application of 150 N, 60 P_2O_5 and 40 kg K_2O kg ha^{-1} for higher growth, yield and harvest index.

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