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Effect of tillage practices and genotypes on growth, seed yield and nutrient uptake in wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted to evaluate the effect of tillage practices on growth, seed yield and nutrient uptake of promising wheat (*Triticum aestivum* L.) genotypes during winter seasons of 2012–13 to 2014–15 at the research farm of the Indian Institute of Seed Science, Mau, India. Based on mean data over three years we observed that contrasting tillage practices, zero tillage (ZT) treatment recorded significantly higher LAI, CGR, RGR, NAR and no. of effective tillers/m^2 over conventional tillage (CT) and raised beds (RB). However, significantly higher no. of seeds/spike and test weight was recorded in RB followed by ZT and lowest in CT. Significant effect of tillage practices was also recorded for seed yield and nutrient uptake. Significantly higher seed yield was recorded under ZT (47.9 q/ha) and CT (45.3 q/ha) as compared to RB (33.0 q/ha). The maximum mean net return was obtained under ZT (₹ 78.1 $\times 10^3$/ha) followed by CT (₹ 65.6 $\times 10^3$/ha) and least in RB (₹ 43.9 $\times 10^3$/ha). The total nutrient (NPK) uptake was significantly higher under ZT followed by CT and least in RB. Genotype variations were also found in respect to growth parameters, seed yield and nutrient uptake. Genotype, HD 2967 performed significantly better in all growth parameters, viz. LAI, CGR, RGR and NAR over KRL 213, HD 2733, PBW 550, PBW 502 and DBW 39. The no. of effective tillers/m^2, seeds/spike and test weight were also significantly superior over other genotypes. Among genotypes, HD 2967 proved as paramount in realizing the highest seed yield (46.54 q/ha), net returns (₹ 70.5 $\times 10^3$/ha), B: C ratio (2.57) and nutrient uptake (NPK) indicating their better adaptability and yield advantage over other genotypes.

Key words: Genotypes, Net returns, Seed yield, Tillage

Wheat is recognised as "king of cereals" and second most important food grain crop in India besides largest sources of protein. During 2017-18, wheat production in India was recorded about 98.40 mt from an area of 30.6 mha that contributed to 13.5% of global wheat production (Anonymous 2018). The major factors that affect the productivity of wheat are quality seed, decreasing water table, increasing cost of production, reducing farm profitability, reducing soil health, out-break of secondary insect-pest, diseases and aberrant weather events under conventional rice-wheat system in eastern IGP (Jat *et al.* 2014). Conventional tillage (CT) systems invert soil during primary tillage operations to control weeds, incorporate organic material and loosen top soil. CT in general, increases porosity on short term but decreases stable soil aggregates over long term (Bronick and Lal 2005) and can reduce soil organic matter (SOM), deteriorates soil structure, decreases water-holding capacity, and compacts sub-soil (Lal *et al.* 2007, Munkholm *et al.* 2008). Reduced tillage like ZT, can improve soil physical health by less soil disturbance, leaving organic matter at the soil surface, decreasing risk of drought and waterlogging and stimulating soil biological activity (Crittenden *et al.* 2015), besides these saved substantial quantity of irrigation water, reducing the cost of cultivation, timely sowing, improved water and nutrient-use efficiency, and left indirect effect on mitigating the adverse effect of climate changes (Jat *et al.* 2014). Furthermore, the sowing of wheat in between the rice stubble can improve the organic matter, microbial diversity, available water holding capacity of the soil; decrease the soil temperature fluctuation and water erosion (Derpsch 1999), improve the soil fertility, soil physical properties, time saving and facilitate the germination (Franchini *et al.* 2007). To exploit the better production environment under contrasting tillage practices, it is essential to evaluate the tillage responsive genotypes and seed quality traits and phenology with regard to adaptation under contrasting tillage were well studied by several authors (Joshi *et al.* 2007). Significant genotype ×

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tillage (G × T) interactions for wheat crop under CA were reported by several authors (Joshi *et al.* 2007). Yield gain can be realized through improved agronomy, better and adapted cultivars and positive interaction between genotype × management (G × M) interaction. Genotypes response under different management can also be worked out to identify specific adaptation similar to soil physical quality index (Bhardwaj *et al.* 2011). It is also important to mention here that there are many promising wheat cultivars having wider adoption in IGP region but they may have differential response to applied inputs and agronomic management especially tillage systems. Similarly, replacement of low-yielder wheat genotypes with recently developed promising cultivars is direly needed. The response of different wheat genotypes to tillage operations can support the expression of ZT–responsive, CT-responsive and RB-responsive genotypes. Keeping in view, the present experiment was undertaken to assess the feasibility of different tillage practices and better understanding of genotype × tillage (G×T) interactions in the context to yield improvement and assess the nutrient acquisition behavior of different genotypes of wheat.

MATERIALS AND METHODS

The field experiment were carried out during *rabi* seasons (November–April) of 2012–13 to 2014–15 at ICAR-Indian Institute of Seed Science, Kushmaur, Mau, India located at 25^0 89' N latitude and 83^0 46' E longitudes at an altitude of 209 m above mean sea level. The climate of the site is characterized by hot and humid summer and cold winters with an average annual rainfall of 800 mm, 70-80% of which is received between July to September. Soils are alluvium derived clay loam (*Typic Ustochrept*) in texture. The soil (0–30 cm layer) had pH 8.0 (1:2.5 soil and water ratio), SOC 0.30%, available N 245.5 kg/ha, P 12.5 kg/ha and K 265.0 kg/ha. The experiment was conducted in split-plot design with three replications for 3 years. Three contrasting tillage systems, viz. zero tillage (ZT), conventional tillage (CT) and raised Beds (RB) were taken in main plots. Six promising wheat genotypes, viz. KRL 213, HD 2733, PBW 550, HD 2967, PBW 502 and DBW 39 were assigned as sub-plot treatments. However, during 2012-13 KRL 213 was used instead of PBW 502. The allocation of the treatments was done by the randomization following Fisher and Yates random number table. The plot size is used for experiment purpose was 60 m^2. The conventional tilled wheat was sown through seed drill with 100 kg seed/ha. In ZT plots, after application of glyphosate @ 0.5 kg *a.i.*/ha before 1-2 days of sowing, wheat was sown with zero-till seed-cum-fertilizer planter having inclined-plate seed metering system and a row spacing of 20 cm. The seeding depth of 3–4 cm was maintained using the depth control wheel. In RB, 2 rows of wheat (30 cm apart) were established on each raised bed using a raised bed planter and a seed rate of 75 kg/ha. The recommended dose of nitrogen (N) at 120 kg/ha as prilled urea (46% N) was applied in all the treatments in three equal splits, ½ at the time of sowing, ¼ at maximum tillering and ¼ at booting stage. Phosphorus @ 50 kg P_2O_5/ha as diammonium phosphate (46% P and 18% N) and 40 kg K/ha as muriate of potash (60% K) were applied at sowing time. The weeds in experimental plots were controlled by using post-emergence herbicides 2,4-D (500 g *a.i.*/ha) and sulfosulfuron (25 g *a.i.*/ha) at 25 to 30 DAS. The first irrigation was given 20 to 25 days after sowing and thereafter the experiment plots were irrigated every 20 to 25 days until the end of the season (3 to 4 irrigations). Leaf area (cm^2) was measured through leaf area meter from the plants selected for recording the dry matter accumulation. The leaves were separated from the stem and cleaned with tap water and with de-ionized water and then dried with tissue paper. Leaf area index (LAI) was calculated at 90 DAS by using the formula as suggested by Evans (1972). Relative growth rate (RGR) expresses the dry weight increase in a time interval in relation to initial weight. It is calculated from the measurements taken at times T_1 and T_2. RGR was calculated using following equation:

$$\text{Mean RGR} = \frac{\text{Log}_e W_2 - \log_e W_1}{T_2 - T_1} \ \text{(mg/g/day)}$$

where, W_1 and W_2 are the dry weight values at time T_1 and T_2, respectively. T_1 and T_2 are time in days. The crop growth rate (CGR) is calculated using following formula:

$$\text{Mean CGR} = \frac{W_2 - W_1}{T_2 - T_1} \ \text{(g/m/day)}$$

Net assimilation rate (NAR): It is the increase in dry wt. of plant per unit leaf area per unit time. NAR is calculated using following formula:

$$\text{Mean NAR} = \frac{(W_2 - W_1)(\text{Log}_e L_2 - \log_e L_1)}{(T_2 - T_1)(L_1 - T_2)} \ \text{(g/g/day)}$$

whereas, L_1 and L_2 are total leaf are at time T_1 and T_2, respectively. W_1 and W_2 are total dry weight at time T_1 and T_2, respectively.

Ten spikes were randomly selected at the time of harvest and their weight was taken and threshed manually. The seeds so obtained were cleaned and counted manually. The mean value of seeds per spike was calculated and expressed as number of seeds/spike. The 1000 seeds taken from sampled spikes were first counted by a seed counter and then weighed to compute the test weight. After harvesting, threshing, cleaning and drying, the seed yield of wheat estimated at 12% moisture content. Likewise, straw yield was recorded by subtracting grain yield from the total biomass yield. The cost of cultivation, gross and net returns were calculated by taking into account the prevailing cost of inputs, seed price (20 % higher than minimum support price of grains) and local market price of straw. The benefit-cost (B:C) ratio was calculated by using following expression: net returns (₹/ha) /cost of cultivation (₹). The data obtained from study for 3 years were analyzed statistically using the F-test, as per the procedure given by Gomez and Gomez (1984). LSD values at P =0.05 were used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Physiological parameters

Significant effect of tillage was observed in physiological parameters like LAI, CGR, RGR and NAR in wheat (Table 1). ZT was found significantly superior over CT and RB with respect to LAI, CGR and NAR. The maximum values of LAI (4.79), CGR (12.13) and NAR (6.33) were recorded with ZT. However, The possible causes of increasing these parameters under ZT is potentially improved physical, chemical and biological properties of soil after decomposition of crop residues (Kumar *et al.* 2015) resulted more favorable micro-environment increasing higher foliar biomass as compared to CT and RB.

Non-significant variations were also observed in LAI, CGR, RGR and NAR under different wheat varieties (Table 1). HD 2967 had highest LAI (4.94), CGR (12.10), RGR (36.28) and NAR (6.44) at 60-90 DAS. The highest LAI, exhibited with HD 2967 closely followed by DBW 39, KRL 213 and HD 2733 at 90 DAS. The genotype, DBW 39 was also similar to HD 2967 in all the parameters, which were significantly superior over PBW 550 and KRL 210 in CGR, RGR and NAR at 60-90 DAS. The difference in growth parameters among genotypes may be due to different genetic makeup and wider adaptability to agro-ecological conditions.

Yield attributes

The results depicted that the tillage practices and genotypes had significantly affected the yield attributes of wheat (Table 1). With respect to tillage practices ZT (347) treatment had significantly maximum no. of tillers/m^2 followed by CT (329) and lowest in RB (299). The magnitude of increase in mean total no. of tillers/m^2 in ZT over CT and RB were 5.18, and 13.83%, respectively (Table 1). However, reverse trend was observed in seeds/spike and 1000-seed weight, which is significantly highest in RB followed by ZT and lowest in CT indicating that wider spacing in RB might have improved yield characteristics of individual plant. Among the six promising wheat varieties studied, HD 2967 had the highest no. of tillers, and seeds/spike. However, 1000-seed weight was highest in HD 2733. Among the rest of genotypes, the tillers/m^2 was on par with the DBW 39, KRL 213, HD 2733 and PBW 550. The similar trends were also found in seeds/spike and 1000-seed weight. The genotype HD 2967 produced significantly higher physiological parameters, viz. LAI, CGR, RGR and NAR resulted in improvement of yield attributes. Similar findings also reported by Ram *et al.* (2017).

Seed yield

The significant higher seed and biological yield as well as HI were recorded in ZT. However, ZT was at par with CT in seed and biological yield but it was significantly higher in seed, biological yield and HI than RB (Table 2). The magnitude of increase in mean seed, biological yield and HI under ZT over CT and RB were 5.42, 2.94, 2.55, 31.11, 25.37 and 7.87%, respectively. The increments of yields under ZT might be due to higher LAI, CGR, NAR and number of effective tillers/m^2. Besides these, under ZT, improved soil physical properties, better seed germination and elongated rooting of wheat (Gathala *et al* 2011). Wheat crop was particularly suffered after puddling for rice which can be attributed to poor rooting due to soil compaction and poor aggregation as reported by other researchers in the region (Jat *et al.* 2009, Kumar and Ladha 2011). Among the six genotypes, HD 2967 produced significantly higher

Table 1 Growth and yield attributes of wheat as influenced by different tillage practices and genotypes (Mean over 3 years)

Treatment	LAI	CGR (g/day)	RGR (mg/g/day)	NAR (g/g/day)	No. of effective tillers/m^2	Seeds/spike	1000-seed weight (g)
Tillage methods							
ZT	4.79	12.13	35.96	6.33	347.0	48	35.9
CT	4.62	11.55	34.76	6.13	328.5	46	35.6
RB	4.10	9.39	30.37	5.43	298.7	50	39.2
SEm±	0.02	0.17	0.30	0.03	5.25	0.37	0.32
LSD (P =0.05)	0.08	0.67	1.18	0.11	20.62	1.46	1.25
Genotypes							
KRL 213	4.61	11.19	34.00	6.01	321.5	49	34.1
HD 2733	4.55	11.11	33.92	5.97	315.3	43	38.2
PBW 550	4.11	10.21	31.63	5.59	316.6	49	36.2
HD 2967	4.94	12.10	36.28	6.44	360.7	53	39.0
PBW 502	4.18	10.30	31.84	5.70	308.6	45	37.7
DBW 39	4.64	11.25	34.49	6.05	325.7	51	36.0
SEm±	0.08	0.20	0.51	0.09	4.86	0.68	0.24
LSD (P =0.05)	0.23	0.59	1.46	0.27	14.03	1.96	0.70

ZT: Zero tillage; CT: conventional tillage; RB: raised beds; LAI: leaf area index; CGR: crop growth rate; RGR: relative growth rate; NAR: net assimilation rate.

Table 2 Seed yield and economic profitability of wheat as influenced by different tillage practices and genotypes (Mean over 3 years)

Treatment	Seed yield (q/ha)	Biological yield (q/ha)	Harvest Index	Cost of cultivation (₹×10^3 /ha)	Net returns (₹×10^3/ha)	B:C ratio
Tillage methods						
ZT	47.9	102.1	47.0	24.2	78.1	3.23
CT	45.3	99.1	45.8	31.8	65.6	2.06
RB	33.0	76.2	43.3	28.2	43.9	1.56
SEm±	0.71	1.19	0.40			
LSD (P = 0.05)	2.80	4.68	1.56			
Genotypes						
KRL 213	43.27	91.71	46.9	28.1	62.9	2.30
HD 2733	41.34	91.27	45.0	28.1	61.3	2.23
PBW 550	40.01	88.88	45.0	28.1	57.9	2.12
HD 2967	46.54	101.26	45.9	28.1	70.5	2.57
PBW 502	38.81	89.74	43.1	28.1	60.2	2.21
DBW 39	42.57	92.07	46.0	28.1	62.3	2.27
SEm±	0.69	1.37	0.58			
LSD (P = 0.05)	2.01	3.97	1.68			

seed yield (46.54 q/ha) over rest of genotypes followed by KRL 213 (43.27 q/ha), DBW 39 (42.57 q/ha), HD 2733 (41.34 q/ha), PBW 550 (40.01 q/ha) and lowest in PBW 502 (38.81 q/ha). Similar trends were also found for biological yield. However, in HI, KRL 213 recorded highest value of HI (46.9) followed by DBW 39 (46.0), HD 2967 (45.9) and lowest in PBW 502 (43.1). The genotypes HD 2967 was performed better in growth and yield parameters, i.e. LAI, CGR, RGR, NAR, effective tillers/m^2, and seeds/spike which ultimately reflected in higher seed yield. Significant G×T interaction for grain yield were found in the studies conducted by Joshi *et al.* (2007) and Kharub *et al.* (2008). Besides, better growth and yield attributes in HD 2967 also found better seed germination, seedling length, seedling dry weight and vigour indices (Ram *et al.* 2017).

Economic profitability

The farmers income may increase by two ways; either increasing production or by reduction cost of cultivation. The major advantage of ZT is reduction cost of cultivation due no-requirement of preparatory tillage unlike CT, where intensive tillage operations were need before seeding. On the basis of three year mean data (Table 2) we observed that maximum mean cost of cultivation was recorded under

Table 3 Nutrients uptake as influenced by different tillage practices and genotypes (Mean over 3 years)

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Tillage methods									
ZT	82.54	29.27	111.81	16.17	2.83	19.01	24.13	88.16	112.29
CT	77.74	27.95	105.69	15.21	2.76	17.97	22.25	86.10	108.35
RB	56.63	23.91	80.54	11.17	2.25	13.42	17.01	70.71	87.72
SEm±	1.20	0.43	1.46	0.24	0.04	0.26	0.38	1.20	1.43
LSD (P = 0.05)	4.72	1.69	5.73	0.95	0.16	1.01	1.48	4.70	5.60
Genotypes									
KRL 213	74.35	26.23	100.58	14.58	2.51	17.09	21.72	78.41	100.13
HD 2733	70.88	26.76	97.64	13.93	2.60	16.53	20.70	81.24	101.94
PBW 550	68.61	26.34	94.95	13.49	2.52	16.01	20.07	78.73	98.80
HD 2967	80.15	29.14	109.29	15.69	2.84	18.53	23.48	89.13	112.61
PBW 502	66.73	27.38	94.11	13.09	2.64	15.73	19.44	82.13	101.57
DBW 39	73.10	26.41	99.52	14.34	2.57	16.91	21.36	80.29	101.65
SEm±	1.19	0.66	1.41	0.23	0.06	0.25	0.36	1.74	1.85
LSD (P = 0.05)	3.43	1.91	4.06	0.67	0.16	0.72	1.03	5.02	5.35

CT (₹ 31.8×10^3/ha) followed by RB (₹ 28.2×10^3 ha) and lowest in ZT (₹ 24.2×10^3/ha), while mean highest net returns was observed under ZT (₹ 78.1×10^3/ha) followed by CT (₹ 65.6×10^3/ha) and lowest in RB (₹ 43.9×10^3/ha). The saving in total cost of cultivation due to adoption of ZT was ₹ 8.6 and 4.0×$10^{3/}$ha, while under ZT an additional net returns gain was ₹ 12.5 and 34.2×10^3/ha as compared to CT and RB, respectively. Almost, similar trend was also observed in B:C ratio. The genotypes HD 2967, was most remunerative and gave highest net returns as well as benefit cost ratio (B:C), followed by KRL 213> DBW 39> HD 2733> 502 and lowest in PBW 550.

Nutrient uptake

Tillage practices significantly affect nutrient (NPK) uptake. Significantly higher N and P uptake by seeds and straw was recorded under ZT. However, significant higher K uptake was recorded under CT, which is at par with ZT. The possible cause of higher nutrient uptake under ZT may be due to better crop growth, low weed infestation and higher biomass production resulted higher nutrient uptake. The genotype HD 2967 recorded significantly higher N, P and K uptake by seed, straw and total uptake as compared to rest of genotypes (Table 3). Since nutrient uptake is the outcome of the nutrient concentration and the crop output, the highest seed and straw yield was recorded in HD 2967 thereby higher values of NPK uptake were recorded in this genotype. Significant variation in different varieties with respect to macronutrient concentrations might be due to differential capability of varieties to acquire and utilize nutrient from the soil. Nawaz *et al.* (2015) and Ghasal *et al.* (2017) also reported significant differences in nutrient uptake in different wheat varieties.

Conclusions

On the basis of 3 years experimentation, it can be concluded that wheat genotype HD 2967 in conjunction with recommended agronomic practices under zero tillage condition proved as a viable option in realizing higher productivity and profitability.

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