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Response of wheat (*Triticum aestivum*) genotypes to different tillage practices for improving productivity and seed quality in eastern Indo-Gangetic plains of India

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ABSTRACT

Quality seed, water, labour scarcity, rising cost of cultivation, diminishing farm profits and indecisive weather conditions are major challenges faced by the farmers under intensive tillage based conventional rice-wheat production system of eastern Indo-Gangetic plains (IGP). To address these challenges from last few years, conservation agriculture (CA) based crop management practices are being developed, demonstrated and promoted in the region. The field experiments were carried out during the winter (*rabi*) season of 2012-13 and 2013-14 at Indian Institute of Seed Science, Kushmaur, Mau, Uttar Pradesh to evaluate the effect of different tillage practices and genotypes on yield attributes, seed yield, seed quality, and economics of wheat (*Triticum aestivum* L.). Experiment was laid out in split-plot design consisting of 3 tillage systems, viz. Zero tillage (ZT), conventional tillage (CT) and raised beds (RB) as main-plots and 6 genotypes (KRL 213, HD 2733, PBW 550, HD 2967, KRL 210 and DBW 39) as sub-plots treatments and replicated thrice. Results revealed that among the tillage methods, the highest mean seed and biological yield (4.82 and 10.36 tonnes/ha) were found under ZT followed by CT (4.68 and 10.25 tonnes/ha) and least in RB (3.34 and 7.61 tonnes/ha), respectively. Among the genotypes, HD 2967 showed significantly higher mean seed and biological yield (4.72 and 10.28 tonnes/ha) over KRL 210 (3.76 and 8.92 tonnes/ha), PBW 550 (4.10 and 8.95 tonnes/ha) and HD 2733 (4.24 and 9.48 tonnes/ha), respectively. However, genotypes KRL 213 (4.46 and 9.88 tonnes/ha) and DBW 39 (4.42 and 9.42 tonnes/ha) were found on par with HD 2967. The highest tillers/m^2 as well as effective tillers/m^2 was recorded under ZT system with HD 2967 genotype. However, the highest seeds/spike, spike length and test weight were found under RB system with genotype HD 2967. There were no significant differences between the tillage systems concerning seed quality parameters, viz. germination %, seedling length, seedling dry weight, vigour index I and II. Moreover, the genotype HD 2967 showed significant difference among all seed quality parameters except germination (%) which was on par with HD 2733, KRL 213 and PBW 550. The maximum mean net returns was recorded under ZT (₹ 75 500/ha) followed by CT (₹ 65 600/ha) and RB (₹ 41 100/ha). The total net gain in income due to adoption of ZT system was ₹ 17 300 and ₹ 39 400/ha as compared to CT and RB, respectively.

Key words: Net returns, Seed quality, Tillage, Wheat genotypes

Seed is a “Miracle of Life”, a dime’s worth of power that no man can create and dime’s worth of mystery, destiny and fate (Yadav *et al.* 2014). It is also considered a vehicle to deliver improved technology and most critical input for sustainable agriculture production in a cost effective way. Despite the all-good research efforts, availability of improved seeds in adequate quantities is a major constraint for realizing the potential crop yields in many parts of world. It is estimated that the direct contribution of quality seed alone to the total production is about 15 to 25% depending upon the crops and it can be further raised up to 45% with efficient management of other inputs (Seednet 2016). Hence availability of quality seed of improved genotypes will consequently result in increased production and thereby provide food security and income to resource poor farmers of eastern IGP. Wheat is recognised as “king of cereals” and second important food grain crop in India. During 2014-15, it production was 88.90 MT from an area of 31.0 M ha and contributed to 13.5% of global wheat production (Anonymous 2015). Quality seed, water and labour scarcity, increasing cost of production, reducing farm profitability and aberrant weather events are major constraints faced by the farmers under conventional rice-wheat system in eastern IGP (Jat *et al.* 2014). Apart from these, problem of soil degradation is also a major issue and traditional deep inversion ploughing has been shown to promote the

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mineralization of soil organic matter (SOM) and thus its loss over time (Buchi *et al.* 2015). Intensive tillage also has negative impacts on soil physical and biological activity (Alvarez and Steinbach 2009). To mitigate these negative effects, resource conservation technologies (RCTs) likes zero tillage, bed planting and laser land levelling saved substantial quantity of irrigation water, reducing the cost of cultivation in terms of land preparation, timely sowing, decreased seed rate, improved water and nutrient-use efficiency, and left indirect effect on mitigating the adverse effect of climate changes (Jat *et al.* 2014). Moreover, 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). Hence, establishment of wheat through ZT technology not only facilitate the germination but also improve the soil fertility, soil physical properties and saves time (Franchini *et al.* 2007). ZT also reduces the cost of production and saves time for sowing of wheat by 10 to 15 days as compared to conventional tillage. Therefore, we planned present experiment to assess the feasibility of different tillage practices and better understanding of genotype × tillage (G × T) interactions in the context of sustainably increasing the wheat productivity.

MATERIALS AND METHODS

The field experiment was carried out at Indian Institute of Seed Science, Kushmaur, Mau, UP located at 25^0 89' N latitude and 83^0 46' E longitudes at an altitude of 209 feet above mean sea level during the winter season of 2012 and 2013. The average rainfall was 800 mm; of which more than 80% is received during the monsoon season. The experiment consisted of 18 treatment combinations comprising of 3 tillage systems, viz. Zero tillage (ZT), Conventional Tillage (CT) and Raised Beds (RB) as main plots while 6 wheat genotypes, viz. KRL 213, HD 2733, PBW 550, HD 2967, KRL 210 and DBW 39 were assigned in sub-plots in split plot design with three replications. The experiment was conducted in large plots, each experiment unit having 60 m^2 areas. The soil of the experimental field was clay loam in texture, slightly alkaline reaction (pH 7.8 to 8.2), low in organic carbon (0.30%) and available N (245 kg/ha), medium in available P (12.50 kg/ha) and available K (165.0 kg/ha). The wheat crop was sown under ZT after application of Glyphosate @ 0.5 kg *a.i.*/ha before sowing at proper moisture, while CT crop was sown as farmers practises with a tractor drawn seed drill using a seed rate of 100 kg/ha and a spacing of 20 cm. In RB, 2 rows of wheat on each beds (30 cm apart) were established using 75 kg/ha seed rate while under ZT plots, the crop was sown without any preparatory tillage using zero-till seed-cum-fertiliser drill with a seed rate of 100 kg/ha and spacing of 20 cm. The recommended dose of N:P:K (120:50:40 kg/ha) was applied through urea, diammonium phosphate and muriate of potash, respectively. Full dose of P and K along with half dose of N was applied as a basal and remaining N was applied in 2 splits at crown root initiation (CRI) and ear initiation (EI) stages of the crop. The weeds in experimental plots were controlled using post-emergence herbicides application through 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. A total of 3 to 4 irrigations were applied to crops. The data on crop inputs, i.e. number of tillage, irrigation, herbicide application, labour use *etc*. for each treatment were recorded as per standard procedure. The field observations were recorded from ten plants in each plot selected randomly and tagged and seed yield was determined by net area basis after boarder rows removed. Processed seed yield was computed based on the data on seed yield and expressed in tonnes/ha. The cost of cultivation and net returns were calculated by taking into account the prevailing cost of inputs, seed price (grain MSP+20% higher) and local market price of straw. Observations on seed quality parameters were observed as per standard procedure (ISTA 1993). One hundred seeds was put for germination in three replication, using top of the paper method. Vigour index of the seeds was assessed based on germination (%), seedling length and seedling dry weight as suggested by Abdul-Baki and Anderson (1973). For determination of the seedling dry weight, ten normal seedlings from each replication of the germinated seeds were selected randomly and kept for oven drying, overnight at 80^0C temperature (ISTA 1993). All the data were statistically analyzed using the analysis of the variance (ANOVA) technique (Cochran and Cox 1957). The critical differences at 0.05% level of probability were calculated to assess the significance between treatments if significant.

RESULTS AND DISCUSSION

Effect of tillage and genotypes on yield attributes

The results depicted that the tillage practices and genotypes had significantly affected the yield attributes of wheat. Among the tillage practices, zero tillage (ZT) had significant effect on the total number of tillers/m^2 and effective tillers/m^2 as compared to conventional tillage (CT) and raised beds (RB). The magnitude of increase in mean total no. of tillers and effective tillers/m^2 in ZT over CT and RB was 5.96, 5.73 and 14.36, 13.75%, respectively (Table 1). The least no. of effective tillers/m^2 under RB was due to compaction effect of wide tyres near root zone (Gathala *et al.* 2011), moisture stress and higher soil pH due to salt accumulation on top of beds (Jat *et al.* 2014). However, spike length, number of seeds/spike and 1000-seed weight was found significantly higher under RB as compared to ZT and CT. The performance of individual plant in terms of growth and yield attributes were significantly improved under RB due to wider spacing and less competition for resources (light, moisture and nutrients) which ultimately leads to higher spike length, number of seeds/spike and 1000-seed weight. However, lesser plant population per unit area under RB planting resulted in low total seed and biological yields. All the yield attributes were significantly

Table 1 Yield attributes, yields and economics of wheat, as affected by different tillage and genotypes in rice–wheat rotation (Pooled over 2 years)

Treatment	No. of tillers/m^2	No. of effective tillers/m^2	Seeds/spike	Spike length (cm)	1000-seed weight (g)	Seed yield (tonnes/ ha)	Biological yield (tonnes/ ha)	HI (%)	Cost of cultivation (₹×10^3/ha)	Net returns (₹×10^3/ha)
Tillage methods										
ZT	369	349	51	10.1	36.1	4.82	10.36	46.6	23.7	75.5
CT	347	329	49	10.0	35.7	4.68	10.25	45.7	31.1	65.6
RB	316	301	54	10.4	39.4	3.34	7.61	43.8	28.1	41.1
SEm	6.86	3.60	0.44	0.040	0.36	0.09	0.15	0.43		
LSD P=0.05	26.92	14.14	1.72	0.16	1.40	0.37	0.58	1.67		
Genotypes										
KRL 213	339	322	52	10.3	33.7	4.46	9.41	47.2	27.6	61.9
HD 2733	332	320	46	9.6	38.9	4.24	9.48	44.4	27.6	61.0
PBW 550	344	320	52	10.3	36.5	4.10	8.95	45.9	27.6	55.8
HD 2967	374	360	57	10.7	39.6	4.72	10.28	46.0	27.6	67.5
KRL 210	326	306	47	9.7	37.9	3.76	8.92	42.0	27.6	56.4
DBW 39	351	327	55	10.4	35.8	4.42	9.42b	46.7	27.6	61.5
SEm	7.41	4.54	0.74	0.061	0.34	0.09	0.19	0.83		
LSD P=0.05	21.41	13.11	2.14	0.17	0.99	0.26	0.55	2.39		

night higher in genotype HD 2967 as compared to other genotypes. The better yield attributes in HD 2967 be due to better seed germination, seedling length, seedling dry weight and vigour indices.

Effect of tillage and genotypes on yields and economics

Present findings revealed that tillage and genotypes had significant effect on seed yield of wheat (Table 1). The wheat seed and biological yield as well as harvest index (HI) were highest in ZT which was on par with CT but it was significantly higher than RB. The magnitude of increase in mean seed, biological yield and HI under ZT over CT and RB were 2.9, 0.8, 1.93; 30.7, 26.5 and 6.0%, respectively. This increment might be due to higher number of effective tiller/m^2 under ZT planted wheat as compared to CT and RB. Similar results were also reported by many other researchers which state that the zero-tillage increased the growth and yield (Munoz *et al*. 2010 and Ram *et al.* 2015). Seed yield of wheat in ZT was more than the CT and RB which could be attributed to the better utilization of soil moisture, nutrients uptake and less fluctuation in the soil temperature (Bauer *et al.* 2002). Further soil organic matter in the ZT was noticeably more due to residue retention which increased the soil water holding capacity, soil aggregation, microbial activity, soil porosity and reduced the water and wind erosion (Zamir *et al.* 2010).

Among the genotypes, HD 2967 performed better throughout the experiment and produced significantly higher seed yield (4.72 tonnes/ha) than the KRL 210 (3.76 tonnes/ha), PBW 550 (4.10 tonnes/ha) and HD 2733 (4.24 tonnes/ha). However, the genotypes KRL 213 (4.46 tonnes/ha) and DBW 39 (4.42 tonnes/ha) also performed better and were on par with HD 2967. Similar trends were also found in biological yield. Modern genotypes in contrast to old landraces often exhibit wide geographical adaptation as well as a broad adaptation to management practices (Reynolds *et al*. 2007). Although the 1000-seed weight is less under HD 2967 but number of effective tillers/m^2, seeds/spike and spike length were higher which leads to more seed yield in HD 2967 as compared to other genotypes. Significant G×T interaction for grain yield were found in the studies conducted by Joshi *et al.* (2007) and Kharub *et al*. (2008).

The maximum mean cost of cultivation was recorded under CT (₹ 31 100/ha) followed by RB (₹ 28 100/ha) and lowest in ZT (₹ 23 700/ha) while mean net returns was observed highest under ZT (₹ 75 500/ha) followed by CT (₹ 65 600/ha) and RB (₹ 41 100/ha). The saving in total cost of cultivation due to ZT was ₹ 7 400 and 5 000/ha, while under ZT an additional net returns gain was ₹ 9 900 and 34 400/ha as compared to CT and RB, respectively. Among the genotypes, HD 2967 recorded highest net returns followed by KRL 210 ₹ DBW 39 ₹ HD 2733 ₹ KRL 210 and PBW 550. The saving in cost of cultivation under ZT was mainly due to no-requirement of preparatory tillage unlike CT and RB, where intensive tillage operations were need before wheat seeding. Tillage and crop establishment shared a major part of total cost of cultivation (Jat *et al.* 2014). In case of wheat seed production, due to low cost of cultivation and higher means biological yields, the net returns were higher under ZT system than CT and RB. Similar finding were also reported by Jat *et al.* (2013) and Gathala *et al.* (2013).

Table 2 Seed quality parameters of wheat, as affected by different tillage and genotypes in rice–wheat rotation. (Pooled over 2 years)

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling dry weight (g)	Vigour index I	Vigour index II
Tillage methods							
ZT	88.6	17.5	14.1	31.5	16.3	2794	1442
CT	88.0	17.3	14.0	31.6	16.2	2781	1428
RB	88.7	17.7	14.4	31.8	16.7	2821	1480
SEm	0.59	0.16	0.14	0.34	0.20	46.4	23.8
LSD P=0.05	NS	NS	NS	NS	NS	NS	NS
Genotypes							
KRL 213	88.0	17.7	14.6	32.2	16.7	2839	1469
HD 2733	89.2	16.1	13.7	29.9	15.0	2666	1341
PBW 550	89.2	17.0	14.5	31.5	15.4	2809	1369
HD 2967	89.9	19.2	14.5	33.7	18.3	3030	1643
KRL 210	86.2	17.0	13.3	30.3	15.3	2611	1320
DBW 39	87.9	17.9	14.4	32.3	17.7	2840	1559
SEm	0.587	0.279	0.140	0.317	0.297	30.9	27.9
LSD P=0.05	1.70	0.81	0.40	0.92	0.86	86.5	80.5

Effect of tillage and genotypes on seed quality parameters

Seed quality is an important parameter that affects vegetative growth and frequently related to yield and harvest efficiency. The main cause for variability in seed quality is genetic variation in between genotypes. In present findings we observed that tillage practices had not affected significantly the seed quality parameters *viz*., germination %, seedling length, seedling dry weight, vigour index I and II (Table 2). This might be due to the fact that seed quality parameters are genetically governed and may not be manipulated by agronomic management. Among the genotypes, HD 2967 performed better and found significantly superior in terms of all seed quality parameters. However, in germination, % genotypes, viz. KRL 213, HD 2733 and PBW 550 were found on par with HD 2967. This might be due to HD 2967 genotype that produced significantly higher 1000-seed weight as compared to other genotypes. In wheat, seed size is positively correlated with seed vigour, larger seeds tend to produce more vigorous seedlings (Ambika *et al.* 2014) and bold seeded genotypes germinate quicker and would take lesser time to establishment.

The result obtained confirmed the validity of innovative tillage systems, like zero tillage had been proposed for energy conservation in broad sense (reduction of work time, fuel consumption and trampling surface) with the assurance of satisfactory quality seed production in rice-wheat cropping system. As far as varieties are concerned, HD 2967 could be adopted because it has higher genetic potential towards seed quality parameters resulted higher seed yield and hence adaptive to vast range of climates. From this study we could suggest that zero tillage system is pathway for improving wheat productivity, income and food security of eastern IGP to conventional system. However, more efforts will be needed to improve ZT technology a location/site specific basis for wheat seed production.

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