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Effect of Different Tillage Techniques on Productivity of Wheat (*Triticum aestivum* L.)

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Abstract
A field trial was laid out to investigate the influence of different conservational tillage techniques on performance of wheat cultivar, Punjab 2011. Treatments were comprised of tillage practices viz: Zero tillage, Minimum tillage, Conventional tillage and Deep tillage. Sowing was performed with the help of hand drill keeping the row to row distance 22.5 cm. Experiment was conducted during winter season 2013-2014 at Agronomic Research Area, University of Agriculture Faisalabad. Different observations were recorded such as fertile tillers (m^2), thousand grain weight (g), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). Results showed that different tillage practices effect the plant growth and yield parameters in different ways. Among four tillage techniques zero tillage remained best and enhanced the growth and yield parameters significantly Germination count, no. of fertile tillers, spikelets per spike and no. of grains per spike were also observed more at zero tillage. After zero tillage deep tillage remained better over minimum and conventional tillage. Hence, it may be concluded that zero tillage could be useful, cost-effective and environmental friendly approach in order to enhance the wheat yield as compared to other techniques. Economic analysis also showed that zero tillage practice in wheat crop gave maximum net income and benefit cost ratio.

Key words: Zero tillage, Deep tillage, Grain yield, Biological yield

Introduction

Wheat (*Triticum aestivum* L.) belongs to family Poaceae and is the second most important cereal crop after rice around the globe. It was originated from the area of near East and Ethiopian highlands, but today it is cultivated throughout the world. It is grown under irrigated conditions having water requirements 20-21 inches per acre. Total area under wheat cultivation in Pakistan is about 8693 thousand hectares and the total production is about 24.2 million tons. Contribution in value addition in agriculture is 10.1% while in GDP is 2.2% (Govt. of Pakistan, 2013).

Wheat productivity can be enhanced by using better inputs, appropriate production technology and by adapting the appropriate tillage techniques. Tillage refers to the physical disturbance of soil. In tillage system the soil is manipulated by number of different operations to create a suitable seedbed for better crop establishment. Use of severe and excessive conventional tillage practices is often injurious to soil. Conventional tillage involves intensive soil manipulation, wastage of energy resources, lacks sustainability and results environmental hazards (Wang *et al*., 2012). Conservation tillage is a broader term that takes into account zero tillage, minimum or reduced tillage and no till. All types of conservation tillage deal with the minimum soil manipulation while leaving stubbles from previous crop on soil surface. Sometimes stubbles are also buried into soil, useful to enhance organic matter. Conservation tillage favors timely sowing of crops, minimizes cost, improves soil aggregate stability and protects environment on long term basis. It is economically feasible, environmentally sound, socially acceptable and sustainable (Fuentes *et al*., 2009). Higher soil humidity, moisture conservation are potential benefits that can be realized from conservation tillage techniques (Verch *et al*., 2009). No till technique involves direct sowing of seed into previous crop stubbles without any disturbance of soil. Reduced or minimum tillage deals with the reduction of total number of tillage operations required for sowing of a particular crop. Zero tillage deals with the manipulation of soil in narrow strip where seeds are placed. All these practices leave at least 30% stubbles on soil as mulch or add these into soil as source of organic matter. Wheat is usually sown late in rice-wheat cropping system due to edaphic conflict of rice and wheat. Similarly, in cotton-wheat cropping system, delayed sowing of wheat usually results from difficulties in managing cotton sticks and maximum pickings. Adaptation of conservation tillage practices might be resolve of late sowing of wheat in cotton-wheat and rice-wheat cropping systems. It will also reduce cost of production by reducing fuel cost together with improvement in soil physical, chemical and biological health.

Zero tillage (ZT) is referred as zero till, no till, direct sowing of crop and direct drilling (Erenstein *et al*., 2008). Zero-tillage technology improves wheat yield as compared to the other production techniques and facilities minimal use of machinery and hence energy can be stored through less fuel usage. Zero till technology produce higher grain yield than other tillage techniques (Saharawat *et al*., 2011). Zero tillage is also more economical as it has less cost of production, yields more than other techniques, sustainable and also diminishes environmental pollution (Nagarajan *et al*., 2002).

Zero is an umbrella term that includes varieties of tillage practices without inverting soil while maintain stubbles from previous crop as mulch or incorporate into soil. Potential benefits that can be obtained from reduced tillage are maintenance of crop residues as mulches, improvement of soil structure, enhancement of water holding capacity, higher soil pore spaces and breaking of host–pathogen cycle. Retained crop residues may prove useful to release allelochemicals and organic acids that ultimately decline colonization of root pathogens. Physical alterations in soil properties often causes increment in bulk density in the upper 0.1–0.2 m soil in case of reduced tillage. Zero tilled soil has different thermal regimes than conventionally ploughed soil owing higher moisture contents due to stubble retention (Trethowan *et al*., 2012).

Deep tillage inclines mineral nutrition, saturation percentage, hydraulic conductivity while diminishes soil bulk density. All these soil changes contribute towards yield. Conventional tillage is often helpful to break plough pan, improve infiltration, adding of organic and chemical amendments in light textured soils. As a consequence, organic matter decomposition is enhanced and mineral nutrients are readily available to crop (Higashida and Yamagami, 2003). Deep tillage inverts soil layers, exposes harmful pathogens to bird attack while also enhances aeration that rapids mineral nutrition (Khattak *et al*., 2004).

In crux, zero tillage practices are economically viable, environmentally 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.

Materials and methods

A field trial was conducted to study the feasibility of different tillage practices for enhancing wheat productivity (*Triticum aestivum* L.). Crop was sown in rice-wheat cropping system at the Agronomic Research Area, University of Agriculture, Faisalabad. Study was conducted during winter season 2013-14. The experiment was laid out in Randomized Complete Block Design having four blocks. Net plot area of experimental unit was 6.0 m × 3.6 m. The experiment was comprised of four tillage treatments viz. zero tillage (direct drilling), minimum tillage (1 ploughing and planking), conventional tillage (3 ploughings and plankings) and deep tillage (chisel plough and 2 ploughings with plankings). Sowing was performed on 21th November 2013. Sowing was done with the help of hand drill with R × R of 22.5 cm. Seed rate used during sowing was 125 kg ha^{-1}. Recommended amount of N:P was applied at rate of 125:100 kg ha^{-1}. Source used for nitrogenous fertilizer was urea while for phosphate fertilizer was diammonium phosphate. Half nitrogenous and full phosphate fertilizer was applied as basal dose while remaining half nitrogenous fertilizer was applied along with first irrigation. Four irrigations were applied at critical growth stages of wheat. Five spikes were randomly selected from each experimental unit to measure spike length, number of spiklets per spike and number of grains per spike. To determine number of tillers, five 30 cm row length were selected randomly. Number of tillers were counted and converted to per square meter by using unitary method. Weight of 1000 grains was determined by counting 100 grains from each seed lot and converted to 1000-grain weight using unitary method. Each experimental unit was harvested at harvesting maturity manually. It was sun dried and weighed biological yield using weighing balance and converted to tons per hectare. Grain yield was determined after threshing using a weighing balance and converted to tons per hectare. The grain yield was subtracted from biological yield to determine straw yield and converted to tons per hectare. Harvest index (H.I) for each plot was determined using the following formula.

$$\text{H.I} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield}} \times 100$$

Results and Discussion

Fertile tillers (m^2)

Different tillage practices significantly influenced number of fertile tillers. Zero tillage depicted highest number of fertile tillers (348.00) whereas conventional tillage manifested least number of fertile tillers (333.25. Conventional tillage was statistically non-significant to deep and minimum tillage (Table 1). Dao and Nguyen (1989) working on different tillage systems observed that highest number of tillers was recorded in Zero tillage.

Spike length (cm)

Spike length is indicator of number of grains and spikelets. Higher spikelets produce higher grain yield. Tillage practices did not differ significantly regarding spike length (Table 1). It can be attributed to same genotype used in experiment. Different cultivars produce dissimilar spike length while it is little affected by environment. It can be ascribed to genetic potential of cultivar that did not differ among treatments. Hemmat *et al*. (2001) recorded that tillage practices did affected spike length significantly.

Number of spikelets per spike

Spikelet being basic flowering unit of spike directly relates to number of grains thus an important yield contributing attribute for wheat crop. Different tillage systems significantly varied from each other regarding number of spikelets per spike. Zero tillage manifested highest number of spikelets per spike (17.4). All remaining tillage were statistically analogous to each other. Alijani *et al*. (2012) carried out a two-year field experiment to determine the influences of different amounts of soil disturbance using 3 different tillage techniques conventional tillage, zero tillage and deep tillage on wheat. Maximum number of spikelets per spike and consequently increased spike length was recorded in no tillage and deep tillage as compared to traditional methods.

Number of grains per spike

Number of grains per spike is indicator of 1000-grain weight, thus an important yield component. Different tillage treatment revealed significant difference for number of grains per spike. Zero tillage exhibited significantly higher number of grains per spike (47.00) than treatments. Zero tillage was followed by deep tillage (41.35). Deep tillage was statistically similar to minimum tillage (39.80) and conventional tillage (41.10) for number of grain per spike.

Different number of grains per spike among tillage practices can be defined in context unalike number of spikelets per spike. Different number of spikelets per spike might have contributed to dissimilar number of grains per spike. Maqsood (1998) observed that different tillage practices were evaluated for different yield attributed of wheat. Highest numbers of grains per spike were depicted by zero tillage technique.

1000-grain weight (g)

The weight of 1000 grains contributes toward yield and is an important attribute regarding farmers point of view. Tillage practices did not differ significantly from each other on basis of 1000-grain weight. Same genotypic makeup of cultivar in all tillage treatments might have contributed toward non significance of treatments. These results are in opposing to those of Chokkar *et al*. (2007). Weight of 1000 grains was not affected by dissimilar tillage operations. However, zero tillage depicted highest 1000-grain weight.

Biological yield (t ha^{-1})

Biological yield gives information regarding total biomass or dry matter produced by plants. Higher the biomass, more is the allocation towards grain and higher is grain yield. Tillage practices did not vary significantly from each other on basis of biological yield. No effect of treatments might be due to same genotypic potential of cultivars to photosynthesize and accumulate dry matter. These finding are in connate with Iqbal *et al*. (2005). An experiment was designed to evaluate whether different soil preparation techniques affect yield attributes or not. All tillage systems proved similar regarding biomass accumulation and produced similar biological yield. Whereas, highest biological yield was exhibited by zero tillage.

Grain yield (t ha^{-1})

Grain yield in wheat is usually determined by number of fertile tillers, number of grains per spike and 1000-grain weight. Tillage treatments significantly diverged from each other for grain yield. Significantly greater grain yield (5.83 t ha^{-1}) was observed for zero tillage than other three tillage practices. Conventional tillage exhibited 5.13 t ha^{-1}, deep tillage 5.17 t ha^{-1} and minimum tillage 5.03 t ha^{-1} grain yield. Conventional tillage, deep tillage and minimum tillage were statistically comparable to each other. Significantly more grain yield in zero tillage can be ascribed to higher fertile tillers, spiklets per spike grains per spike in this treatment. Fertile tillers, number of spikelets per spike and number of grains per spike are direct determinant of grain yield. These attributes might have consequence into significantly greater grain yield over other tillage treatments. These observations are parallel to those of Izaurralde *et al*. (1986). Zero tillage produced significantly more grain yield than other tillage techniques. An overall incline of 37% was observed in zero tillage over control (conventional tillage).

Straw yield (t ha^{-1})

Straw yield signifies plant capability to partition biomass between grains and vegetative tissues. Final plant height and biological yield are main determinants of straw yield. Dissimilar tillage treatments differ significantly from each other regarding straw yield. Maximum straw yield was depicted by minimum tillage (8.02 t ha^{-1}) and it was statistically alike to conventional (7.84 t ha^{-1}) and deep tillage (7.87 t ha^{-1}). Minimum straw yield was observed for zero tillage (7.37 t ha^{-1}). Lowest straw yield might be due to enhanced capability of plants to partition carbohydrates towards grains. Minimum tillage might have contributed to deep root system, plant flourished early, produced more number of grains per spike and spikelets per spike. Moreover, highest grain yield was exhibited by zero tillage whereas minimum in conventional tillage. Hassan *et al*. (2010) studied residual influence of tillage and growth of wheat crop. Four tillage practices (Zero, Reduced, Deep and Conventional tillage) were used. Maximum mean value of straw yield was found in reduced whereas the least straw yield was depicted by reduced tillage practices.

Harvest index (%)

Harvest index depicts physiological efficiency plants to convert assimilates into grain yield. Higher is harvest index, greater is capability of plants to convert dry mass to economic part. Different agronomic practices i.e. sowing time, method, seed rate, fertilizer application and irrigation application influence harvest index. Different tillage techniques significantly affected capability of plants to partition dry matter towards grains. Highest harvest index was manifested by zero tillage (44.21%). Zero tillage was followed by deep tillage (39.68%) which is statistically similar to minimum tillage (38.55%) and conventional tillage (39.58%). To look into the feasibility of different tillage techniques in wheat crop, economic analysis was carried out keeping in view the current market prices. It is clear from table 2 that maximum net income and benefit cost ratio can be obtained through zero tillage practice in wheat cultivar.

Conclusion

As bottom line, different tillage practices significantly differ on basis of soil manipulation systems. Zero tillage proved more promising than other techniques. Zero tillage produced higher number fertile tillers, no. of spikelets per spike, no. of grains per spike and 1000 grain weight. Higher yield attributes resulted into higher grain yield. Other potential benefits that can be attained using zero tillage include timely sowing, economic, environmental and sustainable benefits. The highest grain yield (5.83 t ha^{-1}) was recorded for zero tillage technique. Maximum net income and BCR were also obtained under the zero tillage practice in wheat cultivar. This can be supported Zero tillage practice to be adopted in rice- wheat cropping system.

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Table 1: Individual means comparison for some yield components

Treatments	Fertile tillers (m^2)	Spike length (cm)	Spikelet per spike	Grains per spike	1000-grain weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Zero Tillage	348.0 a	14.34	17.4 a	47.0 a	36.42	13.21	5.83 a	7.37 b	44.21a
Minimum Tillage	334.5 b	13.05	14.7 b	39.8 b	38.47	13.06	5.03 b	8.02 a	38.55 b
Conventional Tillage	333.2 b	12.90	15.6 b	41.1 b	38.19	12.97	5.13 b	7.84 a	39.58 b
Deep Tillage	335.7 b	12.92	15.7 b	41.3 b	37.97	13.05	5.17 b	7.87 a	39.68 b
LSD ≤ 0.05	4.31	NS	1.51	2.44	NS	NS	0.31	0.28	1.99

Table 2: Economic analysis of various treatments

Treatments	Zero Tillage	Minimum Tillage	Conventional Tillage	Deep Tillage
Net Income (Rs. ha^{-1})	116631	95120	90905	92383
BCR	2.19	1.94	1.85	1.86