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Full Length Research Paper

Comparative performance of various wheat (*Triticum aestivum* L.) cultivars to different tillage practices under tropical conditions

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Various tillage practices can overcome the delay sowing of wheat in the rice-wheat cropping system of Pakistan to sustain the grain yield by increasing the nutrients and water use efficiency. A field experiment was conducted to evaluate the effect of different tillage practices (zero tillage and conventional) on growth and yield of four wheat (*Triticum aestivum* L.) cultivars viz. Inqalab-91, Chenab-2000, Bhakkar-2002, and Iqbal-2002 under tropical conditions at the University of Agriculture Faisalabad, Punjab, Pakistan. The treatments comprised of zero tillage and conventional tillage with four wheat cultivars having 23 cm row spacing. Zero-tillage practices and response of different wheat varieties significantly ($p<0.05$) affected plant height, the total number of tillers m^{-2} spike length, number of grains per spike, 1000-gain weight, grain yield, straw yield and harvest index. Higher grain yield was recorded in zero tillage due to more number of tillers per unit area than the conventional tillage. The results obtained suggested adoption of zero-tillage practices for Pakistan and Inqalab-91 with the assurance of satisfactory yield production in rice-wheat cropping system in the tropical areas.

Key words: Zero tillage, grain yield, growth, wheat, Pakistan, biological yield, conventional tillage, number of tillers.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop in Pakistan and is adapted to a wide range of soil and climatic conditions. Being a good source of food and feed, it also provides raw material for agro-based industries and preparation of many other byproducts. It accounts for 24% for the GDP and employs 48.4% of the total work force. Agriculture contributes to growth as supplier of raw material to industry as well as market products and contributes substantially to Pakistan's export earnings (Anon, 2007). Managerial practices sustain the crop production at higher level without deteriorating natural resources. The main viewpoints of sustainable agriculture are increased productivity, greater resource conservation and profitability. Wheat is usually planted either by drilling closely spaced rows (10 - 30 cm) apart on the flat seed bed or by broadcasting the seed on a leveled soil surface and then incorporating it by means of a shallow tillage operations. This involves a high cost of seedbed preparation and also needs 7-12 days for preparation of land which results in delay in sowing of wheat. In the rice track of the Punjab, Pakistan, mostly wheat is sown after the harvesting of rice; hence the sowing of wheat is delayed due to preparation of soil for wheat crop. It has been reported that with every single day delayed sowing of wheat after 15th November onward in Punjab (Pakistan) can decrease the grain yield at 15 - 20 kg ha^{-1} d^{-1}.

The sowing of wheat in between the rice stubble can increase the organic matter, microbial activity, water holding capacity of soil; decrease the soil temperature fluctuation and water erosion (Ortega, 1991; Franzluebbers et al., 1999; Derpsch, 1999). Hence sowing of wheat in residual moisture through zero tillage technology not only facilitate the germination but also improve the soil fertility, soil physical properties and saves time hence increases net return on sustained basis (Malhi et al., 2006; Franchini et al., 2007). Halvorson et al. (2000) reported that no-tillage yield of wheat is greater

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than minimum tillage and conventional tillage. Zero-tillage can provide enough water for germination of wheat seed, ensure the provision of water moisture on lone-term basis than heavy tilled field and also increase the tillering capacity of the wheat plant (Sayre and Ramos, 1997) due to more favorable time is available for physiological process. Zero-tillage also reduces the cost of production and saves time for sowing of wheat by 10 -15 days (Erenstein and Laxmi, 2008) as compare to conventional tillage. The number of tillers was significantly decreased by delay sowing due to less time are available for the physiological growth and development and high temperature trigger the grain filling stage (Bahera et al., 1994). Zero-tillage technology is being rapidly adopted by the farmers in India but comparatively very slow progress is observed in Pakistan (Erenstein and Laxmi, 2008; Erenstein et al., 2007). Mostly researchers recommended the sowing of wheat by zero-tillage after rice harvesting in rice-wheat cropping system in India and Pakistan (Erenstein and Laxmi, 2008, Gupta et al., 2004; Sarwar and Goheer, 2007). The main objective of the present experiment was to study the feasibility of zero-tillage in rice-wheat cropping system and to examine the growth and yield response of different wheat cultivars in zero-tillage system as compared to conventional tillage system. Thus, this study is planned to check the success of zero-tillage technology in rice-wheat cropping system of Punjab (Pakistan) conditions with respect to different cultivars of wheat.

MATERIALS AND METHODS

Experimental site and treatments

Studies on comparative performance of various wheat cultivars (*Triticum aestivium* L.) viz. Inqlab-91, Chenab, 2000, Bhakkar, 2002 and Iqbal, 2002 as V_1, V_2, V_3, V_4 and different tillage practices as T_1 = Zero tillage and T_2 = conventional tillage were conducted at the Agronomic Research Area, University of Agriculture, Faisalabad in winter season during the year 2005-06 after rice harvesting. The experiment was laid out in a randomized complete block design (RBCD) with split arrangement (tillage practices were in the main plots and wheat cultivars were in the subplots) having three replications. Net plot size was 3 x 6 m. Conventional tillage was comprised of three cultivations and planking with the help of wood planker followed each.

Crop husbandry

The crop was sown with the help of zero-tillage drill maintaining the row to row spacing 11 cm after rice harvesting field with no land preparation while in the conventional method the crop was sown with the help of single row hand drill maintaining row to row 11 cm after three ploughing followed by planking. The recommended seed rate at 125 kg ha^{-1} was maintained by proper weighing for all cultivars and treatments. Urea and diammonium phosphate (DAP) were used as source of nitrogen and phosphorus respectively. Half of the nitrogen and full dose of phosphorus was applied at the time of sowing. The remaining half of the nitrogen was broadcasted, with first irrigation. The canal water + tube well were used as source of irrigation water during the whole crop duration for all treatments. The proper weed control practices were adopted to control the weeds. All other agronomic practices were kept normal and uniform for all the treatments. Harvesting of crop was done manually on its physiological maturity. Observations on growth and yield parameters of the crop were recorded using standard procedures.

Parameters measurements

Data on plant height, spike length, number of spikelets per spike, number of grains per spike was recorded from twenty randomly selected plants from each plot at harvest. Total number of tillers at random from each plot were taken from an area of 1 m^2 were counted, averaged and recorded. After complete crop harvesting manually and then threshed by wheat thresher, Biological, straw and grain yield of wheat plants were measured from each plot after air blowing and then converted into t ha^{-1}. 1000-grain weight was measured with help of electric balance at random from the grain yield of each plot. Harvest index was calculated by using the following formula.

H.I. = Grain yield/ Biological yield × 100.

Statistical analysis

Data collected on various growths and yield parameters of the crop were subjected to analysis of variance techniques using appropriate statistical package. The treatments means were separated using LSD test at 5% probability level (Steel et al., 1997).

RESULTS

Plant height, number of tillers and spike length

The data in the table indicated that the effect of different tillage practices on plant height, number of tillers per m^{-2} and spike length was significant. Plant height was significantly increased in the zero tillage (101.73 cm) as compared to conventional tillage (89.75 cm). Among the varieties, maximum plant height was recorded in V_1 (102.59 cm) and V_4 (99.77 cm) while the minimum was in V_2 (91.64 cm) and V_3 (88.65 cm). Moreover the total number of tillers was significantly higher in the conventional tillage than the zero tillage practices. As regarding the cultivars, the V_1 (546.22) produced the higher number of tillers per unit area (1 m^{-2}) as compared to the other three cultivars, while the minimum number of tillers was in V3 (404.03). In case of spike length, longer spike length was obtained in the zero tillage (14.82cm) than the conventional tillage (13.75 cm). However, higher spike length was obtained in V4 (16.01 cm) and the other three cultivars were statistically at par with each other. The interaction between the tillage practices and varieties (T×V) on plant height, number of tillers and spike length was non-significant.

Number of grains per spike, 1000-grain weight and grain yield

The data regarding number of grains per spike, 1000-

Table 1. Comparison of yield and related parameters of four wheat cultivars.

Treatment	1	2	3	4	5	6	7	8
A: Tillage								
T_1 = Zero	101.7a	442.08b	14.82a	52.11a	45.63a	4.69a	6.04a	43.62b
T_2 = Conventional	89.75b	467.36a	13.75b	42.37b	41.06b	4.22b	4.72b	47.20a
$LSD_{(0.05)}$	5.379	25.82	1.201	2.419	0.211	0.2869	0.2668	1.118
B: Varieties								
V1 = Inqlab-91	102.59a	546.22a	13.62b	48.12b	44.40a	4.78a	6.33a	43.36b
V1 = Chenab-2000	91.94b	429.01bc	13.60b	44.69c	43.47b	4.40b	5.23b	45.86a
V3 = Bakhar-2002	88.65b	404.03c	13.90b	44.89c	42.32b	4.24b	4.97b	46.17a
V4 = Iqbal-2002	99.77a	439.61b	16.01a	51.37a	43.52b	4.41b	4.99b	46.25a
$LSD_{(0.05)}$	5.379	25.82	1.201	2.419	0.211	0.2869	0.2668	1.118
C: Interaction (A × B is non-significant)								

1 = Plant height (cm), 2 = Total number of tillers m^{-2}, 3 = Spike length (cm), 4 = Number of grains per spike, 5 = 1000-Grain weight (g), 6 = Grain yield (tha^{-1}), 7 = Straw yield (tha^{-1}), 8 = Harvest index (%), NS = Non-significant.

grain weight (g) and grain yield (tha^{-1}) as influenced by different tillage practices and wheat cultivars are presented in Table 1. Zero tillage had significantly higher number (52.11) of grains per spike as compare the conventional tillage (42.37); similarly 1000-grain weight and grain yield was also higher in the zero tillage practices than the conventional tillage. Among the cultivars, V_4 (51.37) produced the higher number of grains per spike, which was followed by the V1 (48.12), and the lowest number of grains per spike was recorded in the V_3 (44.89) which was statistically at par with V_2 (44.69). However the 1000-grain weight was not significantly differ among all the studied cultivars. As regarding to the grain yield, the cultivars showed the significant response towards the tillage practices giving the higher grain yield in the V_1 (4.78 t ha-1) where Inqlab-91 cultivar was sown while all other three cultivars V_4, V_2 and V_3 are statisticcally at par with each other showing no response towards different tillage practices. Hence the zero tillage and the V_1 (Inqlab-91) cultivar performed better in among the all treatments. The interaction between tillage practices and wheat cultivars (T×V) on number of grains per spike, 1000-grain weight and grain yield was found non-significant.

Straw yield and harvest index

Data pertaining to straw yield (tha^{-1}) and harvest index (%) presented in Table 1 reveals that there are significant differences between different tillage practices and among wheat cultivars. Sowing of wheat by zero tillage significantly affected the straw yield than by the conventional tillage. But in case of harvest index, the results trend just different from that of straw yield as conven-tional tillage produced higher harvest index than of the zero tillage practices due to more biomass in the zero tillage practices. Zero tillage produced more straw yield (6.04 tha^{-1}) as compared to the conventional yield (4.72 tha^{-1}). Among the cultivars, V1 (Inqlab-91) respond the tillage practices significantly more than the other three cultivars, therefore, it produced the higher straw yield (6.33 tha^{-1}) then the rest of three cultivars viz. V_2, V_4 and V_3 which was statistically at par with each other. As data regarding to harvest index, the higher value was recorded in the conventional tillage (47.20%) than the zero tillage (43.62%). But in case of the cultivars, the V4 (Iqbal-2002) produced higher harvest index (46.25%) showing better response to the different tillage practices which was statistically at par with V_3 and V_2. Cultivar V_1 (Inqlab-91) produced lower harvest index (43.36%) among the all other cultivars. Again the interaction between tillage practices and cultivars (T×V) on straw yield and harvest index was non-significant.

DISCUSSION

This study depicted that the tillage practices had significantly increased the growth and yield parameter of wheat plant. Among the tillage practices, zero tillage had significant effect on the growth and yield components of plant such as plant height, total number of tillers per m^2, spike length, number of grains per spike, 1000-grain weight, grain yield and straw yield. The results of the experiment are in close agreement with many studies which state that the zero-tillage increased the growth and yield of plant (Tessier et al., 1990; Bonfil et al., 1999; Malik et al., 2000; Antonelli et al., 2001; Sen et al., 2002; Iqbal et al., 2002; Munoz et al., 2010) but in contrast with Singh et al. (1997), Rao and Dao (1996) and Leibhard (1995) who were in the favor of conventional tillage with some limitations. Growth and yield of wheat plants in zero tillage practice was more than the conventional tillage could be attribute to the better utilization of soil moisture, water use efficiency, nutrients up take and less fluctuation in the soil temperature (Chan et al., 2002; Bauer et al., 2002). Zero-tillage cause's minimal disturbances of the soil structure and texture ultimately increased the size of soil aggregate (Bear et al., 1994). Regular soil disturbance in conventional tillage destroys the soil aggregates formation process (Green et al., 2007). Soil organic matter in the zero-tilled field was markedly more due to management of previous stubble management which increased the soil water holding capacity, soil practical aggregation, microbial activity; soil porosity reduced the soil water erosion and soil wind erosion (Felton et al., 1992). Thermal conductivity, bulk density and compaction of soil are increased due to heavy agricultural machinery movement on the soil for conventional tillage practices which reduced infiltration rate, soil porosity and plant growth (Flower et al., 1998; Sarkar and Singh, 2007; Miransari et al., 2007).

The minimum tillage and direct drilling systems were significant in saving energy, production cost and environmentally friendly reducing the soil pollution as compared to conventional and sequential tillage practices (Hernanz et al., 1994; Sharma et al., 1995). Lopez-Garredo et al., 2009 reported comparatively little amount of plants residue changing into microbial mass in case of conventional tillage, because higher microbial increased the CO_2 emission from soil which badly disturb and slow down the microbial activity. Seed placement is an important phenomenon for its proper germination and nutrients uptake. Most of the seeds of crop remain dormant due to very deep placement where availability of oxygen and sunlight in not possible, ultimately number of plant population is less than the recommended and yield is drastically reduced. In the zero-tilled field the seed placement is ensured at proper depth by zero-tillage drill which give its response in term of good crop harvest (Campbell et al., 1993) In conventional tillage, the soil organic matter was exposed to the direct sunlight which caused increased the mineralization rate while zero-tillage provide a cover to the soil organic matter which caused slow degradation of organic matter and provided the nutrients to the plants (Balesdent et al., 2000). As the microbial activity is directly correlated to the soil moisture, pH and temperature (Torabi et al., 2008) in the soil, these factors can be ensured in the zero-tilled field. The different cultivars showed significant response to the different tillage practices while all the other inputs such as seed rate, fertilizers and irrigation were the same for all cultivars. The results of the experiment are in close agreement with many researchers who stated that the wheat produced better grain yield with energy, cost and resource saving in the zero-tillage than conventional tillage (Pan et al., 1986; Hernanz et al., 1994; Hammel, 1995; Lopez-Bellido et al., 1996; Anken et al., 1999; Iqbal et al., 2002). Among the cultivars under study, V_1 (Inqlab-91) performed better throughout the experiment and produced the significantly more grain yield (4.78 tha^{-1}) than the other cultivars. Although the spike length and number of grains per spike was less in V_1, the 1000 - grain weight is more because the V_1 cultivars produced bold seed and ensured better utilization of available resources as compared to the other cultivars in the zero-tillage system over the conventional tillage sys-tem (Majid et al., 1986; Aslam, 1995; Zamir, 2006). Due to moisture conservation and their prolonged effective use, the plant height was more in V1 and it was statistically at par with V4 (Iqbal-2002) than the rest of the cultivars. These results are in accordance with Maqsood (1998) and Zamir (2006) who stated wheat cultivars attained more height in zero-tillage than conventional tillage. The number of fertile tiller per plant was also more in the zero-tillage than the conventional tillage might be due to the sowing of the wheat crop at optimum time as conventional tillage where sowing of crop was late due to more time is consumed towards the land preparation (Maqssood, 1998). Low harvest index was in V_1 than other cultivars, this was due to more biomass was produced by V_1 than the other cultivars. This indicates that the V_1 physiologically more efficient in the convention of the photosynthates into grain yield. Harvest index mainly depends on the genetic potential of a cultivar and is affected by different agrono-mic practices under which these were grown. Our result are in close agreement with those of Ahmad (1991) and Rasheed (1992) who recorded more harvest index in the wheat cultivars grown in the zero-tillage system.

Conclusion

The result obtained confirmed the validity of innovative tillage system, zero tillage which had been proposed both for energy conservation in broad sense (reduction of work time, fuel consumption and trampling surface) with the assurance of satisfactory yield production in rice-wheat cropping system. As far as varieties are concerned, Inqlab-91 should be adopted because it has higher number of tillers m^{-2}, more 1000-grain yield and hence higher grain yield at the end and adaptive to vast range of climates. Our resources are depleting day by day, so a dire need is to protect them from wasting for sustainable food production to feed the increasing the world population. Therefore, the zero-tillage is a positive approach, which increased the crop yield by conserving our resources such as soil, water, environment and energy as compared with conven-tional tillage. However, further research should be conducted to substantiate the findings in the particularly rice-wheat cropping system of Pakistan and thought out the world in general.

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