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RESEARCH ARTICLE

Cost Analysis on Wheat with Operational Time and Fuel Ingestion of Different Tillage Practices in Rice-Wheat Cropping System of Punjab, Pakistan

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ABSTRACT

The districts of Punjab province having rice-wheat cropping system are the food basket in Pakistan. Tillage operations vary depending upon the soil types. In fine textured soils, 6-8 ploughing and planking operations are quite common that resulted in higher energy utilization and delay in wheat sowing. Wheat (*Triticum aestivum* L.) is the most important crop of the rice-wheat system. This research study presents economic finding of the working time, fuel consumption, and cost estimation of conventional and zero tillage on wheat at Post Graduate Agricultural Research Station, University of Agriculture, Faisalabad, Pakistan during cropping years 2007-08 and 2008-09. In conventional tillage (CT_1) system, deep ploughing with a chisel plough, disc cultivation, planking and conventional sowing with broadcast method were performed; in CT_2 , deep ploughing with a chisel plough, disc cultivation, planking and conventional sowing with rabi drill; zero tillage (ZT_1) direct sowing with happy seeder after manual harvesting of rice ; in ZT_2direct sowing with zone disc tiller after manual harvesting of rice ; in ZT_3 direct sowing of with zone disc tiller after combine harvesting of rice ; ZT_4zero tillage (direct sowing) with happy seeder after combine harvesting of rice field. Cost assessment analysis of different tillage techniques, it was recognized that the maximum consumption of working time is in the case of treatments with conventional tillage and sowing systems (CT_1 and CT_2). In the case of application of zero tillage technology (ZT_1, ZT_2, ZT_3 and ZT_4), 5 to 7 hours ha^{-1} of the working time compared to conventional systems can be saved. In conventional tillage and sowing methods, the fuel consumption is more than 5 times higher compared to zero tillage systems. If the farm dimension is increased to 20 ha, the costs in different tillage systems decrease by 30 to 40 % ha^{-1}. Results revealed that zero tillage system found better in rice-wheat cropping areas of Punjab, Pakistan.

INTRODUCTION

Rice-wheat cropping scheme occupies 27.44 million hectares of developed soil in the Asian subtropics (Dawe et al., 2009). The area of rice-wheat systems in India, Pakistan, Bangladesh and Nepal is 10.0, 2.2, 0.8, and 0.5 million hectares, respectively, representing 32 percent of total rice area and 42 percent of the wheat area in these countries. (Ladha et al., 2000; Lee et al., 2003; Laxmi et al., 2007; Marabet et al., 2009). In Pakistan, under a rice-wheat cropping system, farmers cultivate rice in Kharif season followed by wheat in *Rabi* season. The entire area under rice in Pakistan is about 2.2 million ha, out of which 62 percent is in the Punjab (GOP, 2007). Out of the total rice area in the country, 50 percent is under fine rice varieties (Basmati). Punjab, the largest rice-growing province in the country has 78 percent of its area under fine varieties (Economic Survey of Pakistan, 2006-07). Farmers have a preference to grow fine rice in spite of low production and the longer time period due to its high gross margins. Punjab province contributes about 96 percent of the total rice production of Pakistan (Khan et al., 2007). A diverse range of tillage systems are being practiced throughout the world (Gupta et al., 2002). This affects the distribution and location of crop residues left behind after harvest. Conventional, minimum and zero tillage techniques are the most common practiced by farmers. Proper selection of the tillage system is highly dependent on the climatic conditions, properties of soil, available fleet of the tillage machinery, plant species, and other factors. Each tillage system has its own advantages and disadvantages. In case of conventional tillage system, there is a probability of obtaining higher crop yield thereof; however, because of low working capacity of the tillage machinery and need for high-capacity tractors, costs of such tillage system will be the highest (Erenstein et al., 2007; Erenstein et al., 2008). In case of zero tillage system, the costs for tillage will be lower and the impact on the environment, soil, and biodiversity will be more positive. The main purposes of reduced tillage are to conserve environment and soil, protect soil against wind and water erosion, reduce eradication of the fertile soil layer, fertilizers, and pesticides into water reservoirs, increase biodiversity, reduce fuel consumption, save working time, reduce the self-cost of the cultivated agricultural products (Fischer, 1994; Hobbs and Gupta, 2003). Another very important factor is that decreasing of tillage intensity can allow reducing the number of tillage operations and thus the number of tractor and tillage implement trips over soil. When performing several technological operations, up to 80 % of the whole soil surface is run over, while at the end of a field, at the turning point, one place is crossed several times. This causes densification of deeper-lying soil layers, and it becomes more difficult for moisture to reach the roots of plants. Rusu et al. (2010) claims that in the case of application of the reduced tillage system, the amount of water conserved in the layer at a soil depth of 0-50 cm is by 1 to 32 m^2ha^{-1} greater than that in the soil treated by the conventional tillage method. This is especially relevant in dry years, when the amount of precipitation is small and lack of moisture occurs. Backer and Griffis (2005) concluded that if tillage is reduced or zero, up to 80 % of the costs for fuel and 60 % of the working time spent for machinery repair and maintenance can be saved. So, this study has been planned to achieve the major objectives, develop the most economical method for sowing wheat in a rice-wheat cropping system and compare economics and energy use of implements used for sowing wheat for a rice-wheat cropping system.

MATERIALS AND METHODS

The proposed study was conducted at Post Graduate Agricultural Research Station (PARS), University of Agriculture Faisalabad during 2007-08 and 2008-09. The rice crop was harvested keeping in regard

Table A: Detail of input and output cost of Wheat (Rs. ha^{-1}) during 2007-08 and 2008-09
Fixed cost

Operation/ Input	No./Amount/ Quantity	Rate/Unit (Rs.)	Cost/ ha (Rs.)
2) seed and sowing operations			
➢ seed	125 kg/ha	16	2000
➢ seed treatment	1	200	200
➢ bund making (man days)	½	200/day	100
Total			2300
3) Fertilizer			
➢ DAP	5 bags	3200	16000
➢ Urea	8.5 bags	900	7650
➢ Transportation charges	13.5 bags	20	270
➢ Application charges	2 man day	200	400
Total			24320
4) Irrigation			
➢ Water rates	2	750	1400
➢ Tube well irrigations	2	2250	4500
➢ Water course cleaning	2 man days	200	400
➢ Application charges	4	200	800
Total			7100
Total charges from 1-4 excluding water rates			26620
Mark up on investment from 1-4 Rs=26620 @9 % per annum	6 months	199.65/month	1197.9
Management charges for six months of manager @ 15000 PM for 100 Acres	6 months	375/month	2250
Land rent for six months @ 60000 /hectare	6 months	5000/month	30000
Harvesting charges @ 7.5 monds per hectare	1	7.5	7125
Artisan charges	-	500	500
Total			41072
Total permanent cost		74793	

Govt. of Punjab

Table B: Variable cost for conventional tillage

Operation/ Input	No./ Amount/ Quantity	Rate/ Unit (Rs.)	Cost/ ha (Rs.)
1) land preparation			
➢ deep ploughing	3	2500/ha	7500
➢ rotavator	1	2500/ha	2500
➢ planking	2	500/ha	1000
➢ leveling	1	1250/ha	1250
Total			12250
2) seed and sowing operations			
➢ cultivation	3	1250/ha	3750
➢ planking	1	500/ha	500
➢ sowing charges (drill)	1	1200/ha	1200
Total			17700

Variable cost for minimum tillage

Operation/ Input	No./ Amount/ Quantity	Rate/ Unit (Rs.)	Cost/ ha (Rs.)
1) land preparation			
➢ cultivation	2	1250/ha	2500
➢ planking	1	500/ha	500
Total			3050
2) seed and sowing operations			
➢ cultivation	1	1250/ha	1250
➢ planking	1	500/ha	500
➢ sowing charges (drill)	1	1200/ha	1200
Total			6000

Variable cost for Zero tillage

Operation/ Input	No./ Amount/ Quantity	Rate/ Unit (Rs.)	Cost/ ha (Rs.)
1) land preparation			
➢ cultivation	----------	--------	------
➢ planking	---------	--------	-----
Total			00000
2) seed and sowing operations			
➢ cultivation	-------	--------	------
➢ planking	-------	--------	------
➢ Sowing charges (Happy seeder)	1	5000/ha	5000
Total			5000

treatments for rice residue management and wheat sowing**.** Conventional sowing of wheat was done by broad cast method and rabi drill after combine harvesting of rice. Happy seeder and Zone Disc tiller were used for sowing of wheat after manual and combine harvesting of rice. Experiments were laid out in a randomized complete block design and replicated four times with a net plot size of 10 m x 20 m. Wheat variety 'SH-2002' was sown during mid of November using a seed rate of 100 kg ha^{-1}. Nitrogen and phosphorus were applied at the rate of 120 kg ha^{-1} and 85 kg per ha respectively, in the form of urea and diammonium phosphate (DAP). Half of the N and whole of P_2O_5 was applied at the time of sowing and the remaining half N was applied at 1^{st} irrigation by broadcast method. Wheat was sown after harvesting of rice by using combine harvester machine and manual harvesting. In conventional methods, all conventional techniques i.e. 3 ploughing, 1 chiseling, 1plough with disc harrows and 2 planking with leveling were done, while, zone disc tiller and happy seeder, were used as zero tillage for wheat sowing after harvesting with combine harvester machine and manual harvesting of rice. Economic and energy analysis of tillage and sowing systems were performed for two conventional systems (CT_1 and CT_2) and four zero tillage techniques (ZT_1, ZT_2, ZT_3 and ZT_4). In conventional tillage systems, ploughing with chisel plough, disc plough, and three planking were performed. While in zero tillage systems, two different options were chosen. In the ZT_1 system, wheat was sown by happy seeder machine after manual harvesting of rice, in ZT_2wheat was sown by zone disc tiller after manual harvesting of rice, in ZT_3 wheat was sown by zone disc tiller but after harvesting with combine harvester machine and in ZT_4 wheat was again sown by happy seeder machine but after harvesting with combine harvester machine with direct sowing methods. In zero tillage techniques, where happy seeder was used after harvesting of rice with combine harvester, plant residues were remained on the soil surface due to chopping technology by happy seeder machine, this is why the mulch sowing system was also used. In order to calculate the working time, fuel consumption, and costs in the tillage and sowing systems, the working widths of the tillage and sowing machinery broadly used in experiment and power of tractors were chosen first of all. The direct and indirect costs were evaluated for the calculation of the costs of technological operations. The direct costs include the costs for upgrading, repair, and technical maintenance of the machinery, fuel and lubricants, labour compensation and inputs. The costs of diesel fuel were calculated with application of the complex price, i.e., 70 PKR L^{-1}. When calculating the indirect costs, operational costs related to the management of the agricultural service company and maintenance of the premises and equipment are assessed. The working capacity of the tillage and sowing machinery, fuel consumption, and technological operation costs for farm area of one hectare are presented in the table 1 given below at results and discussion. Before economics analysis of wheat during 2007-08 and 2008-09, inputs and outputs cost were calculated under fixed prices by Govt. of Punjab, Pakistan. All details of inputs/outputs and fixed costs are given in table A. Similarly, variable and energy costs for conventional tillage, minimum tillage and zero tillage are also given in table B. After analyzing these cost net return, net benefit and benefit cost ratio were calculated by the following methods. Net return was determined by subtracting the total cost of production from the gross income of each treatment (CIMMYT, 1988). Net

Table 1: Economics of wheat sowing technology with energy consumption in rice–wheat cropping system of Punjab, Pakistan

Tillage System/ Sowing Techniques	Working Time Hours (ha^{-1})	Fuel Consumption (L/ha^{-1}) (Including all operations)	Fuel Cost PKR (ha^{-1})	Operations Costs, PKR (ha^{-1})
CT_1 : Broad cost Sowing	12	37	2590	17700
CT_2 : Rabi Drill sowing	9	32	2240	17000
ZT_1 : Happy seeder (MHR)	6	12	840	5000
ZT_2 : Zone Disc tiller (MHR)	8	16	1120	6000
ZT_3 : Zone Disc tiller (CHR)	9	19	1330	6000
ZT_4 : Happy seeder (CHR)	8	16	1120	5000

Note * Per liter cost of diesel @ Rs: 70, H* working hours, L* Liter, *1US$= 100 PKR

Income = Gross income – Cost of production. Net field benefits were determined by subtracting the total variable cost from the gross benefits of each treatment combination (CIMMYT, 1988). Input and output cost of each treatment combination was converted to Rs. ha^{-1}. Fixed and Variable costs tables are also given at result and discussion chapter.

RESULTS AND DISCUSSION

On the basis of the analysis of the tillage systems, it was established that conventional ploughing is the least productive tillage technological operation. A plough with a working width of 1.75 m allows ploughing of land with an area of approximately 10 m x 20 m within one 1.5 hour. A tractor with the same power can be used for other tillage operations, i.e., deep chiseling and stubble disc cultivation. When tilling bigger land areas, this difference increases further. By assessing the consumption of the working time in different tillage and sowing systems, it was established that when sowing of wheat crop directly into soil (ZT) with an area of 10 m x 20 m, around 0.45 ha^{-1} was spent.

The biggest consumption of the working time in conventional tillage and sowing systems was in the case of deep chiseling (CT_1). By comparison of all tillage and sowing systems, it was established that conventional technologies, irrespective of the size of the farm area, require most working time. In the case of ploughing with reversible ploughs (CT_2), the consumption of the working time was by approximately 1-3 hha^{-1} lower than in the case of ploughing with non-reversible ploughs (CT_1).The data of the working time analysis show that working time can be saved by abandoning conventional tillage and substituting to zero tillage and sowing systems. It is especially important when the working time frames of separate technological operations in the plant cultivation technological chain are very tight. Abandonment of one or several tillage technological operations or their replacement with a more productive operation gives more space for planning of other agricultural technological operations and use of agricultural machinery. Besides, the saved time of farmers can be used for performing other important agricultural works.

By energy assessment calculations, it was established that in the case of sowing wheat directly into non-tilled

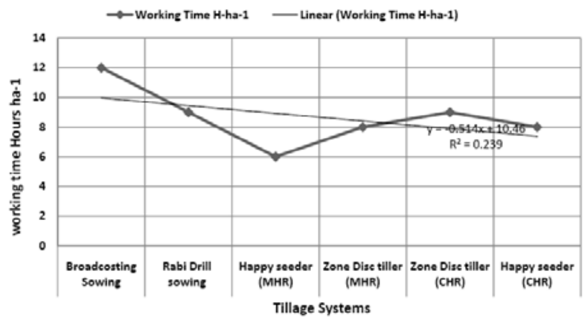

Fig. 2: Working time by different tillage and sowing systems on wheat in rice-wheat system.

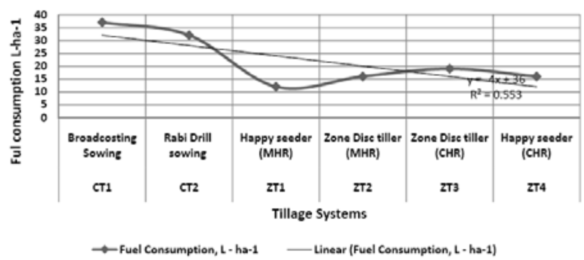

Fig. 3: Fuel consumption of different tillage and sowing systems for different farm size

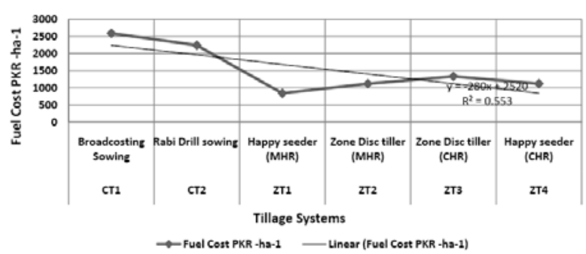

Fig. 4: Fuel costs of different tillage and sowing systems

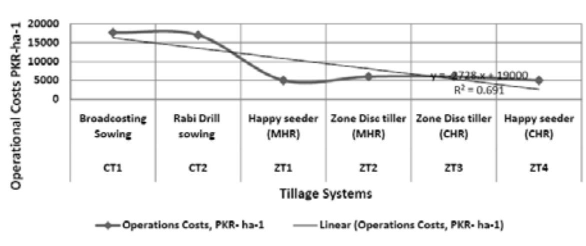

Fig. 5: Operational costs of different tillage and sowing systems

soil (ZT), the fuel consumption per hectare amounts to 16-17 Lha^{-1} (Fig. 3). The fuel consumption increases rapidly as the intensity of tillage grows and low-capacity tillage machinery was used. In the case of sowing into deep (22 – 24 cm) ploughed and cultivated soil (CT_1 and CT_2), the fuel consumption was by more than 3 times, and in the case of soil tilled by the reduced method , it was by around 2 times higher than in the case of application of the direct sowing system (ZT). In tillage and sowing systems with the application of ploughing, the fuel consumed for ploughing accounts for approximately 75 % of the total fuel consumption. In reduced tillage and sowing systems, when soil is tilled for sowing without using ploughs, only with deep or shallow soil tillage machinery, the fuel consumption was by 10 % to 2 times lower compared to the conventional tillage and sowing system.

Ploughing with all operations and sowing of wheat in one hectare with the conventional sowing system (CT_1 and CT_2) costs around PKR= 2600 (Fig. 4). Minor fuel consumption was the biggest contributor to this reduction. In the case of application of direct sowing, the savings can be 20.0 to 25.0 L ha^{-1}. Operational costs were also minimum in case of ZT.

Similar findings were observed by Grey et al. (1996) who found an increase in the yield with zero tillage rather than conventional tillage and the saving made through less fuel and implements usage. Economically zero tillage is superior over the conventional method of planting as more net returns were calculated on zero tillage farms than conventional tilled field in addition to its superiorly for environment friendly practices (Nagarajan et al., 2002). Whereas Erenstein and Laxmi (2008 a) revealed that zero-tillage wheat after rice generates substantial benefits at the farm level by enhancing farm income from wheat cultivation (US$97 per hectare) through the combined result of a yield increase and a cost-saving effect. The cost-saving effect (US$52 per hectare) primarily reflects the drastic reduction in tractor time and fuel for land preparation and wheat establishment (Erenstein and Laxmi, 2008b).

Conclusions

Shrinking of the amount of tillage preserves environment and topsoil, safeguards plant stubbles, keep the soil safe against storm and water destruction, decreases losses of the fertile soil layer, fertilizers and insecticides into water reservoirs, proliferations biodiversity, cuts the fuel consumption, saves the operational time, decreases the self-cost of cultivated, and expands the economical ability of farmers.Net income return was calculated on average data of 2007-08 and 2008-09. Data revealed that zero tillage technique with different sowing machines and straw management gave maximum output Rs. 52777.4, 52707.00 (2007-08) and Rs. 51317.00, 52737.00 (2008-09), respectively. With regard to conventional tillage and minimum tillage, net return was minimum. Cost of production was observed maximum in conventional tillage. Fuel consumption was found lowest in zero tillage followed by minimum tillage and maximum was observed in conventional tillage during both years 2007-08 and 2008-09, respectively.

Happy seeder proved to be better as compared to the other treatments and more yield was observed and Zero tillage techniques gave the highest net income (52777.4) as compared to conventional tillage techniques.

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