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Productivity and Profitability of Rice (*Oryza sativa* L.) as Influenced by different Tillage Systems and Cultivars

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ABSTRACT: Popularizing direct seeded rice technology is the need of the hour as the rice production under transplanted conditions have treated havoc in the water economy of the country. Conservation tillage practices also play an important role in ensuring higher productivity with minimal and verse impact in the environment. There is a paucity of information regarding the effect of different tillage techniques on the performance of rice cultivars raised under direct seeded upland conditions. Also little information is available on the impact of residue integration on yield and economics of direct seeded rice, particularly under the sub-tropical conditions of Himachal Pradesh. Hence the present investigation was carried out during *kharif* 2019 at the Experimental Farm of Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to generate information on the effect of different tillage practices, with or without residue retention, on the performance of different rice cultivars raised under direct seeded conditions. The treatments comprised of three tillage practices *viz*., conventional tillage, minimum tillage without residue retention and minimum tillage with residue retention in main plot and three rice cultivars (HPR 1156, HPR 2656 and HPR 2795) in sub plot, the trial being conducted in split plot design with three replications. The soil of the test site was silty clay loam in texture, acidic in reaction and was rated as medium in available nitrogen, phosphorus and potassium. The result so obtained indicated that the conventional tillage, remaining at par with minimum tillage without residue, recorded significantly higher grain yield, straw yield and biological yield while the lower values of the grain, straw and biological yield were recorded in treatments where the residue of the preceding crop was retained. Among the cultivars tested HPR 2795 and HPR 2656 recorded significantly higher yield and gave better economic returns as compared to the third variety HPR 1156. Higher value of gross return was recorded in conventional tillage while net return and B:C ratio was higher in minimum tillage without residue retention.

Keywords: Productivity, Profitability, Residue, Rice and Tillage.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops which play a dominant role in ensuring the nutritional and livelihood security of large proportion of the global population, particularly in the under developed and developing countries of Asia and Africa. It is an important staple crop and a source of food security for the rural people (Prabhu *et al.*, 2021). The importance of this crop in the global food security scenario can be judged from the fact that this crop supplies more than 50% of the world's staple food while also making up for 20 per cent of the world's dietary energy supply (Schatz *et al.*, 2014). This is the most important cereal crop of our country where it was cultivated on an area of 43.66 million hectare during 2019-20 with the total production of 118.87 million tonnes and average productivity of 27.22 q ha^{-1} Anonymous (2021). Rice is also the second most important food crop (after maize) grown during *kharif* season in Himachal Pradesh where it occupied an area of 72.62 thousand hectare during 2019-20 with the total production of 143.79 thousand tonnes and average productivity of 19.80 q/ha (Anonymous, 2021).

Rice is grown mainly as a transplanted crop, a method which uses excessive quantity of water to produce a unit of grain. With the reduced availability of this important input owing to rapid urbanization and increased demand from industry, it has become imperative to develop technologies that can reduce the water requirement of this crop. Direct seeded rice is one such technology in which this crop is sown directly in ploughed fields (conventional tillage) without going in for transplanting thereby reducing the quantity of water required for producing this crop. This conventional tillage method is easy to adopt and provide clean cultivation. However it leads to high erosion hazard as it completely inverts the soil and buries crop residues, making the land much more exposed to erosive forces of wind and water ultimately reducing the productivity of land (Mathew *et al.*, 2012). Conservation agriculture provides a good alternative to counter this problem. Recently, resource-conserving tillage (RCTs) and crop establishment (CE) methods have received increased attention to address soil health issues, reduce cost of land preparation and CE methods. Zero tillage and unpuddled transplanting, have been found to improve soil health, water consumption, crop production, and farmer income in RCTs. Conservation agriculture (CA) methods increase productivity and revenue while also addressing growing issues. CA is well-known for boosting soil fertility in terms of physical, chemical, and biological qualities, which increases overall soil health, water-use efficiency, crop production, system productivity, and farmer income (Pratibha *et al.*, 2021). However not all varieties can be successfully raised under conservation agriculture as this system requires varieties having a specific growth habits. Also specific genotypes have been recommended for conservation agriculture all over the world. However, very little work has been done in Himachal Pradesh for the identification of rice genotypes that can be successfully raised under conservation agriculture. Keeping the above facts in mind, the present investigation was carried out to study the suitability of raising rice crop under different tillage practices and to identify suitable rice cultivars for this method of cultivation.

MATERIALS AND METHOD

The present investigation was carried out during *kharif* 2019 at the Experimental Farm of the Department of Agronomy of CSK Himachal Pradesh Agricultural University, Palampur. The experimental site is located at 32°09′N latitude, 76°54′E longitude and at an altitude of 1290 m above mean sea level.

The soil of the experimental site was silty clay loam in texture, acidic in reaction and was rated as medium in available nitrogen, phosphorus and potassium. The field trial was laid out in split plot design with three tillage practices i.e., conventional tillage, minimum tillage without residue and minimum tillage with residue in main plot and three cultivars (HPR 1156, HPR 2656 and HPR 2795) in sub plot and was replicated thrice. The rice crop was sown on 13th June 2019 and was raised adopting recommended package of practices for the state. To meet the nutritional requirement the crop was provided with 60 kg N + 30 kg P +30 kg K ha^{-1} of which half of the recommended nitrogen along with complete dose of phosphorus and potassium was provided at the time of sowing while the remaining nitrogen was top-dressed in two equal splits at tillering and panicle initiation stages (Package of practices, *kharif*, 2019 HP). Mustard straw @ 3t/ha was used as residue material and applied as per treatment. The data was recorded on the biological yield, grain yield and straw yield using recommended procedures and were used to calculate harvest index. The economic indices viz., gross return, net return and benefit: cost ratio was calculated based on the prevailing market prices of different inputs as well as of grain and straw. The yield data so recorded was subjected to statistical analysis using analysis of variance technique as outlined by Gomez and Gomez (1984) and the treatments were compared by calculating critical difference at 5% probability level.

RESULTS AND DISSCUSSION

The data on the effect of different tillage practices on yield of different rice cultivars has been given in Table 1 which revealed the significant differences with respect to both the tillage practices and cultivars. Significantly higher grain yield was recorded in conventional tillage though this treatment was at par with minimum tillage without residue while significantly lower grain yield was recorded with minimum tillage with residue retention. The higher yield recorded with the conventional tillage may be attributed to the improved porosity as well as air circulation in the soil which resulted in better root growth allowing the plants to mine nutrients from the wider soil horizon resulting in better shoot growth and photosynthetic efficiency ultimately leading to higher yield. The treatment in which the crop residue was retained resulted in the immobilization of the nutrients thereby causing their deficiency to the crop, especially during the initial stages of crop growth resulting in poor initial growth and consequently poor tillering which ultimately resulted in lower yield. Similar results have also been reported by Edalat and Naderi (2016); Seth *et al.* (2019); Seth *et al.* (2020); Mitra and Patra (2019); Pandey and Kandel (2020). The biological yield as well as straw yield followed similar trend with conventional tillage, remaining at par with minimum tillage without residue, recording significantly higher values while minimum tillage with residue recorded lowest values for biological and straw yield, the reasons for the same has been discussed above. Further Harvest Index was not significantly impacted by the tillage options as this parameter is more of a genetic character and less impacted by the agronomic manipulations.

Table 1: Effect of tillage practices and varieties on yield of rice.

Treatments	Grain yield ($kgha^{-1}$)	Straw yield ($kgha^{-1}$)	Biological yield ($kgha^{-1}$)	Harvest Index
Tillage practices				
Conventional tillage	2853	5496	8349	0.342
Minimum tillage without residue	2805	5248	8053	0.348
Minimum tillage with residue	2628	4968	7596	0.346
SEM ±	**39**	**84**	**110**	**0.003**
CD (P= 0.05)	**152**	**328**	**432**	**NS**
Varieties				
HPR 1156	2404	4783	7187	0.335
HPR 2656	2853	5344	8197	0.348
HPR 2795	3029	5585	8614	0.352
SEM ±	**67**	**104**	**152**	**0.004**
CD (P= 0.05)	**208**	**320**	**468**	**0.012**

Among the cultivars tested significantly higher grain yield was recorded in cultivar HPR 2795 which was at par with HPR 2656 while significantly lower grain yield was recorded in HPR 1156. The higher yield in HPR 2795 was due to significantly longer panicle as well as higher number of grains $panicle^{-1}$ (data not given) and is more of the genetic potential. Similar results were obtained for the biological yield as well as straw yield with HPR 2795 recording significantly higher values and HPR 1156 producing significantly lower yields. The varieties also differed significantly in terms of Harvest Index (HI) with HPR 2656 had significantly higher HI while HPR 1156 recording significantly lower HI. The higher HI recorded in HPR 2795 was due to the higher translocation of photosynthates from the foliage to the economic part (grains) which is more of a varietal character.

The economic indices of different treatments (Table 2) calculated to evaluate their economic feasibility revealed that the gross return followed the trend similar to that of the grain yield with conventional tillage recording highest gross return (Rs. 73766 ha^{-1}) followed by minimum tillage without residue (Rs. 71903 ha^{-1}) and minimum tillage with residue (Rs. 67570 ha^{-1}) in that order, the last mentioned treatment recording lowest gross return. Contrary to this the net return was higher in minimum tillage without residue retention (Rs 40960 ha^{-1}) followed by conventional tillage (Rs 30623 ha^{-1}) while lowest net return was recorded from treatment in which minimum tillage was practices along with residue retention (Rs. 35252 ha^{-1}). The results so obtained can be attributed to the lower cost of cultivation in minimum tillage as the cost of tillage is reduced considerably. Though the gross return was higher with conventional tillage the higher cost of cultivation owing to higher tillage cost in this treatment resulted in lower net return. Similar results have also been reported by Seth (2018). The B:C ratio also followed the trend similar to that of net return with minimum tillage without residue recording higher value while minimum tillage with residue retention recording lower B:C ratio, the reason for which has been detailed above.

Among the cultivars evaluated HPR 2795 reported higher gross return followed by HPR 2656 and HPR 1156 in that order, the values depending on the grain and straw yield of respective varieties. Since the cost of cultivation was similar of all the three varieties the trend that was observed in case of gross return was also replicated for the net return and B:C ratio.

Table 2: Effect of tillage practices and varieties on economics of rice.

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Tillage practices				
Conventional tillage	34143	73766	39623	1.16
Minimum tillage without residue	30943	71903	40960	1.32
Minimum tillage with residue	32318	67570	35252	1.09
SEM ±	-	-	-	-
CD (P= 0.05)	-	-	-	-
Varieties				
HPR 1156	32468	62765	30297	0.93
HPR 2656	32468	73158	40690	1.25
HPR 2795	32468	77316	44848	1.38
SEM ±	-	-	-	-
CD (P= 0.05)	-	-	-	-

CONCLUSION

From the present study it can be concluded that conventional tillage gives better productivity of rice though it is almost similar to the yield obtained with minimum tillage without residue while retention of residue on the soil surface along with minimum tillage lowers the yield in the short run. Further among the varieties tested HPR 2795, a new red rice variety, give better results under direct seeding.

FUTURE SCOPE

Further among the varieties tested HPR 2795, a new red rice variety, give better results under direct seeding. However future research should be focused on studying the long term impact of different conservation agriculture practices on productivity and profitability of rice as well as their impact on the cropping system as a whole.

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Conflict of Interest. None.

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