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Growth, yield and yield components of rice (*Oryza sativa*) as influenced by tillage methods and cultivars

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ABSTRACT

Different tillage methods i.e. zero tillage, natural farming, reduced tillage and conventional tillage in combination with 3 rice varieties, viz. Sukara Dhan 1 (HPR 1156), Him Palam Dhan 1 (HPR 2656) and Him Palam Lal Dhan 1 (HPR 2795) were evaluated in terms of growth, yield attributes and yield of direct seeded rice at research farm of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh during rainy (*kharif)* season of 2020 and 2021. The experiment, was laid out in split plot design with tillage options in main plot and cultivars in subplot and replicated thrice. Findings exhibits that the, conventional tillage recorded significantly higher grain, straw and biological yield followed by reduced tillage and zero tillage while significantly lower values of all these traits were observed in natural farming during both the years of experimentation. Significantly greater and lower yields recorded in conventional tillage and natural farming treatments were due to the significantly higher and lower values of different yield attributes including number of panicles/m^2, number of grains/panicle, grain weight/panicle and 1000-grain weight, observed in the respective treatments. From the present investigation it can be concluded that conventional tillage resulted in higher yield attributes and yield as compared to natural farming while lower values of yield attributes and yield were recorded under natural farming. Among different rice cultivars Him Palam Lal Dhan 1 was found superior than Sukara Dhan 1 and Him Palam Dhan 1.

Keywords: Cultivars, Grains, Rice, Straw, Tillage, Yield

Rice (*Oryza sativa* L.) is the staple food for the world's poorest and malnourished populations (Prabhu *et al.* 2021). Asia, contributes to more than 90% of the entire production and consumption of this crop (Bandumula 2018). In India rice is grown on 43.75 million hectares (M ha) area with the total harvest of 118.43 million tonnes (Mt) and the average productivity of 27.0 q/ha (Anonymous 2020). It occupies a prominent position among the major cereal crops due to its wider adaptability to climatic, cultural and edaphic conditions.

Intensive tillage and crop establishment techniques need a lot of water and labour, which raises the cost of farming. Reduced availability of labour as well as water has become a key area of concern for the productivity and long-term sustainability of rice (Pathak *et al.* 2010, Saharawat *et al.* 2010). Due to rising labour costs and their non-availability at crucial times, the situation is further anticipated to worsen in the upcoming years. The leftover residue of rice was traditionally taken out of the fields for animal feed and other uses. However, due to an increase in mechanized harvesting, considerable amounts of residue are left in the fields which are burned by the farmers to ensure timely sowing of succeeding crops. These residues could be used for an enhanced supply of nutrients and maintaining soil organic matter besides ensuring environmental safety All of these issues can be resolved through conservation practices (Mathew *et al.* 2012).

Increasingly, farmers are using conservation agriculture practices to reduce variable costs and energy input (25–30%) necessary for field preparation and crop establishment. Reduced tillage and zero tillage methods are more efficient, cost-effective and environmentally friendly than conventional tillage methods (Saini *et al.* 2022) that can assist in timely planting and successful germination by utilizing the remaining moisture in the soil. A large number of rice cultivars have been developed by the breeders with eye on specific growing conditions. However very little work has been carried out to identify cultivars suitable under different types of tillage. Keeping these points in consideration the present investigation was initiated with

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the objective of identifying cultivars of rice suited for conservation agriculture.

MATERIALS AND METHODS

The present study was carried out at research farm of the Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh during rainy (*kharif)* season of 2020 and 2021 growing seasons. The region reflects Himachal Pradesh's mid hills sub-humid zone, which has moderate summers and chilly winters. The site of current study was silty clay loam in texture and acidic in reaction and rated as medium in available nitrogen (373.6 kg/ha), phosphorus (16.4 kg/ha) and potassium (276.4 kg/ha). Split plot design with 3 replications was used during the current investigation. In the main plot, 4 methods of tillage, viz. reduced tillage, zero tillage, conventional tillage and natural farming while 3 different cultivars of rice were planted in the sub-plots of the main plots. The direct seeded rice crop was sown at 20 cm spacing on the regular sowing dates, and raised using the recommended package and practices. The inorganic fertilizers urea, Single Super Phosphate (SSP) and MOP Muriate of Potash (MOP) were used to apply the recommended doses of nutrients (60:30:30) in all treatments except natural farming where the practices as enshrined by Palekar (2011) were applied. Phosphorus and potassium were administered in full at sowing, whereas nitrogen was supplied in two equal splits during the planting and tillering stages. Wheat straw @3 t/ha was applied in the reduced tillage and natural farming treatment. Prior to planting, glyphosate was applied on plots with zero tillage. In rice weeds were controlled using butachlor @1.5 kg/ha throughout all treatments except natural farming treatment, where weeds were eradicated by hand. In natural farming treatment, all the recommendations made for such type of cultivation were adopted. The data on different growth, yield and yield attributes, viz. number of panicles/m^2, number of grains/panicle, grain weight/panicle and 1000-grain weight as well as grain, straw and biological yield were recorded using standardized procedures. The data so recorded in both trials were subjected to analysis of variance (ANOVA) using the method described by Gomez and Gomez (1984.)

RESULTS AND DISCUSSION

Tillering ability is one of the most important yield deciding characters in rice which helps to achieve higher yield (Hanada 1993). Data showed significant differences amongst treatments for the number of tillers at all stages of observation (Table 1). Significantly higher number of tillers/m^2 at 30 DAS during both years (2020 and 2021) was recorded in conventional tillage though this treatment was at par with reduced tillage during both the years of study while significantly lowest number of tillers/m^2 were recorded in natural farming. The trend w.r.t. number of tillers/m^2 for 60 DAS, 90 DAS and at harvest was similar as that of 30 DAS as the conventional tillage, remaining at par with reduced tillage, producing significantly higher number of tillers/m^2. Natural farming produced significantly lower number of tillers/m^2 during both years the reason of this could be attributed to the inability of the practices of natural farming to meet the nutritional requirement of rice crop which resulted in poor initial growth leading to lower number of tillers/m^2 at all stages of observation. As discussed earlier the better physical condition of the soil achieved in conventional tillage resulted in the development of deep and extensive root system leading to better initial growth and higher tiller number per unit area.

Among the cultivars tested Him Palam Lal Dhan 1, remaining at par with Sukara Dhan 1 reported significantly

Table 1 Effect of tillage methods on number of tillers (No./m^2) of rice cultivars

Treatment	30 DAS		60 DAS		90 DAS		At harvest	
	2020	2021	2020	2021	2020	2021	2020	2021
Tillage methods								
Reduced tillage	144.7	139.5	261.7	246.9	320.6	323.3	308.9	305.9
Zero tillage	138.2	135.2	250.2	237.2	304.4	312.1	293.3	292.3
Conventional tillage	152.1	142.7	273.6	254.1	330.8	334.6	320.0	318.0
Natural farming	130.2	128.4	218.9	200.4	261.3	236.9	249.0	221.8
SEm ±	3.5	2.6	6.0	4.4	7.0	5.0	6.6	4.5
CD (P = 0.05)	12.0	9.0	20.8	15.1	24.2	17.4	22.9	15.7
Cultivars								
Sukara Dhan 1 (HPR 1156)	140.7	135.8	249.3	233.8	301.6	301.5	290.7	283.9
Him Palam Dhan 1 (HPR 2656)	137.5	131.9	239.6	225.9	289.1	287.8	279.8	272.9
Him Palam Lal Dhan 1 (HPR 2795)	145.7	141.7	264.4	244.2	322.1	315.9	307.9	296.7
SEm ±	2.4	2.8	4.7	4.9	5.5	5.6	5.2	5.3
CD (P = 0.05)	7.3	8.4	14.2	14.7	16.6	16.7	15.6	15.8

DAS, days after sowing.

higher number of tillers/m^2 at 30 DAS during both years though the latter cultivar was also at par with Him Palam Lal Dhan 1. However, at remaining stages of observation the trend was different during both years with significantly higher number of tillers/m^2 recorded in Him Palam Lal Dhan 1 while the other two cultivars were at par with each other. The tillering ability of a cultivar is controlled by the genetic makeup of the cultivar as well as by the agronomic practices adopted to raise this cultivar. Him Palam Lal Dhan 1 has a higher tillering ability and was able to produce significantly higher number of tillers per unit area.

Data revealed that the significantly lower yield attributes of rice (number of panicles/m^2, number of grains/panicle, grain weight/panicle and 1000-grain weight) were observed in natural farming treatment during both years which can be attributed to the inadequate supply of the nutrients to the crop which could not meet the nutritional requirement of rice crop and resulted in poor growth of crop and hence lower yield attributes (Table 2). Among the tillage methods significantly higher higher yield attributes were observed in conventional tillage which was considerably equal to reduced tillage. The higher values of yield attributes found in conventional tillage might be ascribed to tillage's influence in loosening the soil, increasing porosity and allowing for adequate air exchange and root development. It improved root development enables the plant to access nutrients and water from a wider soil profile, resulting in greater crop establishment and a larger yield attributes value. These findings are consistent with Gupta and Seth (2007) and Seth *et al.* (2019).

Among the rice cultivars tested significantly higher values of yield attributes of rice (number of panicles/m^2, number of grains/panicle, grain weight/panicle and 1000-grain weight) was observed in the cultivar Him Palam Lal Dhan 1 which was followed by Sukara Dhan 1 and Him Palam Dhan 1. The difference among the cultivars w.r.t. this parameter can be attributed to the genetic composition of the cultivars. The findings are in agreement with Ankit *et al.* (2022a).

Tillage methods and cultivars treatments brought significant variation in the yield of rice during both the years of experimentation. For both years, conventional tillage resulted in significantly higher grain output, which was followed by reduced tillage, and in turn at par with zero tillage (Table 3). Significantly lower grain yield of rice was recorded in natural farming during both years of experimentation. Higher values of contributing characteristics or yield attributes may result in higher grain yield under conventional tillage. In conventional tillage, soil become soft during field preparation. Under soft soil, the roots of the crop grow better as compared to reduced and zero tillage. Better root growth helps to extract more nutrients from the soil which resulted in better growth and yield in this treatment. In reduced tillage residues on the soil surface can reduce growth initially due to greater nitrogen immobilization which can reduce the final yield. The similar findings have been reported by several researchers (Seth *et al.* 2019, Seth *et al.* 2020, Ankit *et al.* 2022b, Ankit *et al.* 2022c, Seth and Manuja (2022) and Saini *et al.* 2022).

Among the cultivars investigated, Him Palam Lal Dhan 1 had a considerably higher grain yield of rice while significantly lower yield was observed in Him Palam Dhan 1. The highest yield reported in Him Palam Lal Dhan 1 was due to a greater number of panicles/m^2, number of grains/panicle and test weight in this cultivar, all of which contributed to a higher yield. Lower values for all of these attributes in Him Palam Dhan 1 resulted in a lower yield of this cultivar.

Table 2 Effect of tillage methods on yield attributes of rice cultivars

Treatment	No. of panicle/m^2		No. of grains/panicle		Grain weight/panicle		1000-grain weight (g)	
	2020	2021	2020	2021	2020	2021	2020	2021
Tillage methods								
Reduced tillage	275.3	281.7	72.8	70.7	1.82	1.87	23.18	23.68
Zero tillage	265.9	269.3	68.5	67.8	1.68	1.78	22.86	23.48
Conventional tillage	287.5	290.3	75.9	74.0	1.92	1.95	23.42	24.06
Natural farming	218.9	201.9	60.8	55.9	1.42	1.38	21.82	22.28
SEm ±	5.1	4.2	1.5	1.2	0.04	0.03	0.21	0.18
CD (P = 0.05)	17.7	14.6	5.2	4.2	0.15	0.11	0.74	0.63
Cultivars								
Sukara Dhan 1 (HPR 1156)	258.5	260.3	69.2	66.7	1.69	1.75	22.56	23.10
Him Palam Dhan 1 (HPR 2656)	250.3	251.2	65.7	64.5	1.62	1.68	22.30	22.76
Him Palam Lal Dhan 1 (HPR 2795)	276.9	270.9	73.6	70.1	1.82	1.81	23.60	24.26
SEm ±	4.6	5.1	1.4	1.2	0.04	0.03	0.18	0.24
CD (P = 0.05)	13.7	15.3	4.1	3.7	0.12	0.10	0.55	0.70

Table 3 Effect of tillage methods on yield (kg/ha) of rice cultivars

Treatment	Grain yield		Straw yield		Biological yield		Harvest index	
	2020	2021	2020	2021	2020	2021	2020	2021
Tillage methods								
Reduced tillage	3013	3068	5402	5444	8415	8512	35.79	36.03
Zero tillage	2876	2911	5326	5301	8202	8212	35.04	35.43
Conventional tillage	3388	3452	5973	6047	9361	9499	36.20	36.35
Natural farming	2359	1909	4519	3587	6879	5496	34.28	34.70
SEm ±	72	61	150	121	216	174	0.18	0.21
CD (P = 0.05)	251	214	519	420	748	601	0.62	0.73
Cultivars								
Sukara Dhan 1 (HPR 1156)	2892	2831	5183	4998	8075	7829	35.73	36.01
Him Palam Dhan 1 (HPR 2656)	2730	2680	5177	5039	7907	7714	34.46	34.63
Him Palam Lal Dhan 1 (HPR 2795)	3105	2994	5556	5247	8661	8241	35.80	36.24
SEm ±	60	64	70	71	124	130	0.12	0.16
CD (P = 0.05)	180	192	210	213	372	388	0.36	0.48

A review of the data on the influence of tillage methods and cultivars on straw yield of rice revealed significant influence of both the factors on this parameter during both the years of experimentation. Conventional tillage observed significantly higher straw yield which was at par with reduced tillage and zero tillage. Higher straw production in conventional tillage may be due to improved root growth, increased nutrient availability and absorption, and higher photosynthetic activity as compared to natural farming. Similar findings have been reported in previous studies by several researchers (Ankit *et al.* 2022b, Ankit *et al.* 2022c). Further perusal of the data indicates that natural farming treatment has much reduced straw yield of rice which was due to insufficient supply of nutrients in this treatment.

Among the cultivars investigated, during both years significantly higher straw yield of rice was observed in Him Palam Lal Dhan 1 while significantly lower straw yield of rice during first year was observed in Him Palam Dhan 1 while during second year it was observed in Sukara Dhan 1. A perusal of data (Table 3) indicates that conventional tillage resulted in significantly higher biological yield of rice while significantly lowest biological yield was resulted in natural farming treatment.

Among the cultivars investigated, highest biological yield was recorded in Him Palam Lal Dhan 1 during both years of experimentation which was followed by cultivar Sukara Dhan 1 and Him Palam Dhan 1, both of which were at par with each other. The findings are in agreement with the results of Ankit *et al.* (2022b) and Ankit *et al.* (2022c).

The harvest index values obtained under different tillage methods and cultivars were significantly affected during both years (Table 3). A significantly higher value of harvest index was noted in conventional tillage during both the years of study though this treatment was at par with reduced tillage. A significantly lower harvest index was recorded in natural farming treatment. Since the harvest index expresses the ratio of economic yield to the total biomass yield, this ratio is more controlled by genetic as well as environmental factors rather than agronomic practices, consequently, little variation in harvest index was observed. However, the differences among tillage practices could be attributed to the availability of primary nutrients, particularly nitrogen and phosphorus and the role played by them in the dry matter production and its remobilization to the grains. The higher availability of these nutrients in conventional tillage resulted in higher production and effective remobilization of photosynthates resulting in a higher harvest index.

The harvest index of rice cultivars also varied significantly with Him Palam Lal Dhan 1 showing a significantly higher harvest index though it was at par with Sukara Dhan 1 while Him Palam Dhan 1 showed significantly lower harvest index. The differences in harvest index of cultivars might be due to the genetic composition of these cultivars. Results are in accordance with the findings of Ankit *et al.* (2022b) and Ankit *et al.* (2022c).

For all the above mentioned parameters (growth, yield and yield attributes) of rice crop, it was found that there was no significant interaction between tillage methods and cultivars. From the present study, it may be concluded tat conventional tillage resulted in higher growth and yield of rice crop as compared to other practices investigated. Also amongst different cultivars Him Palam Lal Ohan 1, a new red rice variety, gave better results under direct seeding.

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