

Effect of tillage and cultivars on growth and growth indices of rice (*Oryza sativa* L.)

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ABSTRACT

A field experiment was undertaken at the Experimental Farm of Department of Agronomy of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (H.P.) during *kharif* 2019 to study the effect of different tillage system and varieties on yield of rice. The treatments consisted of three rice varieties (viz., HPR 1156, HPR 2656 and HPR 2795) which were tested under three tillage systems viz., conventional tillage, and minimum tillage without residue and minimum tillage with residue treatment. The trial was laid out in split plot design with tillage system in main plot and rice varieties in sub plot and was replicated thrice. Conventional tillage recorded taller plants (124.50 cm) and higher dry matter accumulation (858.49 g/m²) which was followed by minimum tillage without residue. Among the varieties tested HPR 2795 recorded taller plants (128.31 cm) and higher dry matter accumulation (891.33 g/m²) which was followed by HPR 2656. Higher value of AGR, CGR and RGR was recorded in conventional tillage and among the varieties; HPR 2795 resulted in higher growth indices.

Introduction

Rice (*Oryza sativa* L.) is the most widely consumed cereal for a large portion of the world's population. Approximately 90% of the world's rice is cultivated and consumed in Asia (Rana, 2018). Rice farming is well-suited to nations and locations with cheap labour costs and abundant rainfall, as it is labor-intensive and water-intensive. Rice, on the other hand, can be grown almost anywhere, including on a steep hill or mountain with the use of water-controlling terrace systems. As a rainfed crop, it also find place in the slopy lands of hills (Angiras *et al.*, 2009). Rice is a photo periodically short-day plant that thrives in a hot, humid environment. It is best suited to areas with high humidity and a

reliable water supply. It will be adequate for a profitable rice harvest if an area receives roughly 1500-1800 mm of well-distributed rainfall each year throughout the crop growing season. In India, this crop ranks first in area and production (Rana, 2018). In India rice is cultivated on an area of 43.78 million hectare with the total production of 118.43 million tonnes with the average productivity of 27.05 q/ha (Anonymous, 2020). Even in the state of Himachal Pradesh rice is the most important *Kharif* crop (second only to maize) which was cultivated on an area about 71 thousand hectare with the production of 114.8 thousand tonnes and productivity of about 16 q/ha (Anonymous,

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2018). Traditional tillage methods are simple to implement and create a clean cultivating environment. However, because it totally inverts the soil and buries rice crop residue / waste, exposing the land to the erosive forces of nature like wind and water. Erosion affects land productivity in the long run. Conservation tillage offers an alternative to all of these issues (Mathew *et al.*, 2012). Conservation agriculture approaches have gained popularity in recent years as farmers have sought to decrease variable cultivation costs, as a large part of energy (25–30%) is used for field preparation and crop establishment.

The intensity of tillage operations can be reduced to reduce this. When compared to traditional sowing procedures, the zero tillage method is more cost effective, energy efficient, and environmentally friendly (Filipovic *et al.*, 2006). Minimum and zero tillage systems can help with timely planting and healthy germination by using leftover moisture in the soil. It can also lower the cost of production. However the performance of rice genotypes can vary depending on a variety of factors including tillage patterns used and the effect of changes in microclimate owing to the adoption of conservation agriculture technologies. Specific genotypes like HD 2967 is recommended in wheat and lalat in rice that are also recommended for no till farming around the world. Thus it is important to test this new concept in one of the most important cereal crop besides wheat, soyabean, mustard etc. grown in the state. Keeping the above facts in view, the present study is being proposed.

Material and Methods

The present investigation was carried out during *kharif* 2019 at the Experimental Farm of Department of Agronomy, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur (32°09' N latitude, 76°54' E longitude and at an altitude of 1290 m above mean sea level).

The area represents the mid hills sub humid zone of Himachal Pradesh and is characterized by mild summers and cool winters (Figure 1). The area receives a high rainfall that ranges between 2000–2500 mm per annum, of which 80 per cent is received during monsoon months from June to September. Each treatment was located randomly in

plots by using random number table and replicated thrice. The soil of the experimental site was silty

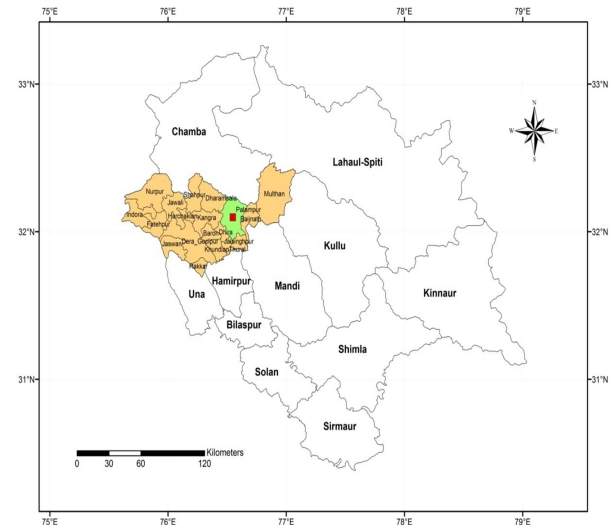


Figure 1: Sampling locations (32°09' N, 76°54' E).

clay loam in texture, acidic in reaction. The soil was medium in available nitrogen, phosphorus and potassium. The meteorological data during the crop season revealed that the weekly maximum and minimum temperature ranged from 23.57 to 31.64 °C and 10.14 to 20.39 °C respectively. The mean relative humidity ranged from 51.79 to 91.57 % and total rainfall was 197.80 mm. The total sunshine at experimental location was found to be 94.16 hours (Anonymous 2021, Crop weather outlook).

The experiment consisted of nine treatment combinations which included three tillage practices viz conventional tillage, minimum tillage without residue and minimum tillage with residue and three varieties which included HPR 1156, HPR 2656 and HPR 2795. The experiment was laid out in split plot design, replicated thrice, with tillage practices in main plot and varieties in sub plot. The crop was

sown on 13th June 2019. Urea (46 % N), single super phosphate (16% P₂O₅) and muriate of potash (60% K₂O) were used to supply the desired quantities of nitrogen, phosphorus and potassium, respectively in relevant treatment. Recommended dose of fertilizers (60:30:30) (Package of practices, kharif, 2019 HP) in the state was applied. The entire dose of phosphorus and potassium was applied at the time of sowing while basal dose of nitrogen was added at the time of sowing and split doses after three week intervals. Mustard straw @ 3t/ha was used as mulch material and applied as per treatment.

For measuring the plant height, ten plants were selected at random from each net plot and tagged. The height was measured at 30 days interval (30, 60, 90 DAS and at harvest) and at harvest from the ground level up to top most leaf tip before the panicle emergence and up to top of the panicle thereafter. The average of these ten plants was taken as mean plant height in centimeter. The progressive tiller count was recorded at 30 days interval and at harvest from two observational units of one m⁻², earmarked randomly in each net plot of experiment. The data so recorded were averaged and multiplied by factor 5 to get number of tillers m⁻². The second row from both sides of each plot was demarcated as sampling row. The plant samples were harvested from ground surface by using sickle at monthly interval. These samples were dried in an oven at 70°C till the constant weight was achieved. The dry weight was expressed as gram per square meter (g m⁻²). The data on plant height and dry matter accumulation was recorded at periodic interval (30, 60 and 90 days after sowing, DAS) and at harvest.

The following formulae were used to determine various growth indices:

Absolute growth rate was determined by using the formula given by (Radford, 1967).

$$AGR (cm/day) = \frac{h_2 - h_1}{t_2 - t_1}$$

Crop growth rate was determined by using the formula given by (Watson, 1956).

$$GR (g/m^2/day) = \frac{w_2 - w_1}{P \times (t_2 - t_1)}$$

Relative growth rate was determined by using the formula given by (Blackman, 1919).

$$RGR (mg/g/day) = \frac{(\log w_2 - \log w_1)}{t_2 - t_1} \times 1000$$

Where

H₁& H₂: Plant height (cm) of plant at time t₁ and t₂, respectively

W₁& W₂: Whole plant dry weight at time t₁ and t₂, respectively

P is the ground area on which W₁& W₂ are recorded. The data obtained was statistically analysed using (plant height, dry matter accumulation, number of tillers, AGR, CGR and RGR) the Gomez and Gomez technique (1984). The critical difference (CD) was estimated for parameters with significant impacts at the 5% probability level.

Results and Discussion

Data pertaining to growth and growth indices has been presented in table 1 and table 2. A perusal of data revealed that tillage practices had no significant effect on plant height at all stages of observation. The tallest plant at 30 DAS (Days after sowing) were observed in conventional tillage and smallest plant at 30 DAS is observed in minimum tillage with residue. Similar results were observed at 60 DAS. At 90 DAS as well as at harvest conventional tillage produced taller plants as compared to minimum tillage without residue. Minimum tillage with residue produced shorter plants even at these stages also. Higher plant height in case of conventional tillage might be due to more vigorous and healthy seedling at initial growth period of crop. Hazarika and Sarmah (2017) reported that conventional tillage enhance the physical state of the soil by manipulating and pulverising it, which not only offers a good environment for germinating seeds and emerging seedlings, but also delivers free oxygen, increased soil moisture, and critical nutrients to the plants and ultimately improve the growth of plant. Similar results are reported by (Seth, 2019 and Pandey and Tanka, 2020). Among the varieties tested, varieties showed significantly differences in plant height at all the stages of observation. At 30 DAS HPR 2795 recorded significantly higher plant height, which was fb (followed by) by HPR 2656 and in turn was

Table 1: Effect of tillage practices and varieties on plant height, dry matter accumulation and number of tillers of rice

Treatment	Plant Height (cm)				Dry matter accumulation (g/m ²)				Tillers (No./m ²)			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Tillage Practices												
Conventional tillage	40.88	103.68	124.03	124.50	84.54	524.06	738.41	858.49	174.8	260.2	250.3	238.1
Minimum tillage without residue	39.16	100.14	120.36	120.78	83.42	515.16	718.24	835.61	179.2	265.1	254.1	242.7
Minimum tillage with residue	38.72	98.74	118.12	118.99	81.31	506.32	692.62	796.44	168.1	248.3	240.9	230.6
SEM ±	2.31	3.37	5.56	5.91	0.61	4.16	5.71	8.38	2.4	3.1	2.7	2.5
CD (P = 0.05)	NS	NS	NS	NS	2.39	16.32	22.40	32.90	9.4	12.2	10.6	9.8
Varieties												
HPR 1156	36.38	95.40	116.83	117.17	81.88	490.87	660.32	750.41	176.0	264.6	253.8	246.5
HPR 2656	38.72	99.69	117.82	118.79	83.08	519.83	726.31	848.33	178.1	268.3	258.8	248.7
HPR 2795	43.66	107.48	127.86	128.31	84.32	534.84	762.64	891.33	167.5	240.7	232.7	216.2
SEM±	1.21	2.20	2.46	2.42	0.86	6.06	13.08	17.03	3.2	5.8	5.7	5.6
CD (P = 0.05)	3.76	6.78	7.61	7.45	NS	18.67	40.32	52.48	NS	17.9	17.6	17.3

*SEM ± - Standard error mean *CD – Critical difference *NS- Non significant

Table 2: Effect of tillage practices and varieties on absolute growth rate, crop growth rate and relative growth rate of rice.

Treatment	Absolute growth rate (cm/day)			Crop growth rate (g/m ² /day)			Relative growth rate (mg/g ¹ /day)		
	0-30 DAS	30-60 DAS	60-90 DAS	0-30 DAS	30-60 DAS	60-90 DAS	0-30 DAS	30-60 DAS	60-90 DAS
Tillage Practices									
Conventional tillage	1.36	2.09	0.68	2.82	14.65	7.15	147.91	60.81	11.43
Minimum tillage without residue	1.31	2.03	0.67	2.78	14.39	6.77	147.46	60.69	11.08
Minimum tillage with residue	1.29	2.00	0.65	2.71	14.17	6.21	146.61	60.96	10.44
SEM ±	0.04	0.05	0.02	0.02	0.01	0.05	0.42	0.34	0.22
CD (P = 0.05)	NS	NS	NS	0.08	0.04	0.19	NS	NS	0.86
Varieties									
HPR 1156	1.21	1.97	0.71	2.73	13.63	5.65	146.84	59.70	9.88
HPR 2656	1.29	2.03	0.60	2.77	14.56	6.88	147.33	61.12	11.15
HPR 2795	1.46	2.13	0.68	2.81	15.02	7.59	147.82	61.58	11.83
SEM±	0.03	0.03	0.02	0.04	0.18	0.25	0.68	0.50	0.28
CD (P = 0.05)	0.10	0.08	0.05	NS	0.54	0.76	NS	1.54	0.86

*SEM ± - Standard error mean *CD – Critical difference *NS- Non significant

at par with HPR 1156. HPR 1156 recorded significantly lowest height due to genetic makeup of plant. Similar trend was followed at all the stages of observation. HPR 2795 produced significantly taller plant which was at par with HPR 2656 and in turn was at par with HPR 1156. HPR 1156 produced significantly shorter plants.

The data pertaining to the effects of tillage practices and varieties on dry matter accumulation by rice recorded at different stages. A perusal of data revealed significant effect of tillage practices and varieties on dry matter accumulation by the rice crop at all stages of observation except at 30 DAS in case of varieties. Among the tillage practices significantly higher dry matter accumulation at 30 DAS was recorded in conventional tillage, though this treatment was at par with minimum tillage with residue which was in turn at par with minimum tillage with residue. The dry matter accumulation at 60 DAS also followed similar trend. At 90 DAS and harvest, conventional tillage reported the maximum dry matter accumulation, which is comparable to minimum tillage without residue. Significantly lowest dry matter accumulation was recorded in minimum tillage with residue. Higher dry matter under conventional tillage may be due to more plant population. Similar results are reported by Seth (2019). According to Seth *et al.*, 2019 data revealed that tillage practices have significant effect at all the stages of observation in rice crop. Varieties also behaved differently with respect to dry matter accumulation at different stages of observation. At 30 DAS dry matter accumulation was not significantly influenced by varieties. Higher dry matter accumulation at 30 DAS was recorded in HPR 2795 and lowest was recorded in case of HPR 1156. At 60 DAS significantly highest dry matter accumulation was in HPR 2656. While significantly lowest value was recorded in HPR 1156. Similar trend was followed at 90 DAS and at harvest. HPR 2795 produced higher dry matter which was at par with HPR 2656 and lowest dry matter accumulation was recorded in HPR 1156.

Tillage techniques, as well as rice types, had a substantial impact on the number of tillers per square metre reported at monthly intervals and at harvest. A perusal of data revealed that significantly higher number of tillers per square meter at 30 DAS was recorded in minimum tillage without residue, which was at par with

conventional tillage and in turn at par with minimum tillage with residue. Minimum tillage with residue produced significantly lowest number of tillers per meter square. Similar results were recorded at all stages of observation (60, 90 DAS and at harvest). The results so obtained can be explained by the fact that the tillers buds are formed at each node of the rice stem irrespective of varieties (Kakizaki, 1987). Similar results are reported by (Pandey and Kandel, 2020). According to Pandey and Kandel 2020 conventional tillage resulted in higher grain yield, plant height and effective tillers per meter square as compared to zero tillage. Varieties had a substantial impact on the quantity of tillers per square metre except at 30 DAS. At 30 DAS, HPR 2656 produced the most tillers per square metre, while HPR 2795 produced the least. HPR 2656 produces a much larger number of tillers per square metre than HPR 1156 at 60 DAS. HPR 2795 has the lowest number of tillers per square metre at 60 DAS. At 90 DAS and at harvest, a similar trend was seen.

Absolute growth rate (AGR): A perusal of data revealed that the trend of absolute growth rate could not reach level of significance at all stages of observation in case of tillage practices. At 0-30 DAS higher value of AGR was observed in conventional tillage and lowest was in case of minimum tillage with residue. In general higher value of AGR was recorded between 30-60 DAS as compared to 60-90 DAS as the height of rice usually increases till the initiation of flowering after which there is a slight increase in height. The highest AGR value was found in conventional tillage at 30-60 DAS, which might be due to better crop growth under improved soil physical and chemical properties like lower bulk density, higher macro and micro nutrient availability easily due to faster decomposition of crop residue throughout the crop growth stages. According to Karunakaran and Behera (2015) agricultural residues which are retained on or near the soil surface reduce soil erosion, runoff of surface water, summer time soil temperatures and enhance water retention. All these factors help to increase plant height of plant which in turns enhances the absolute growth rate. Similar trend was followed at 60-90 DAS. Amongst the Varieties, they have significant effect on AGR. HPR 2795 recorded significantly higher value of AGR between 0-30 DAS which was at par with HPR 2656

and in turn at par with HPR 1156. HPR 1156 had a much higher AGR value between 60 and 90 DAS, which was comparable to HPR 2795. Lowest value of AGR was recorded in case of HPR 2656.

Crop growth rate (CGR): CGR is the rate of daily increment in accumulation of dry matter by the crop of a particular area. The perusal of data reveals that CGR was significantly influenced by tillage practices as well as rice varieties. At 0-30 DAS significantly higher value was recorded in conventional tillage which was at par with minimum tillage without residue and in turn at par with minimum tillage with residue. At 30-60 DAS, conventional tillage, which was followed by minimum tillage without residue, had a considerably higher CGR value. Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light interception. At 30-60 DAS lower value of CGR was in minimum tillage with residue. Similar results were observed at 60-90 DAS. Among the varieties tested, at 0-30 DAS higher value of CGR was recorded in HPR 2795 and lowest was in case of HPR 1156. At 30-60 DAS, the highest CGR value was found in HPR 2795, which was near HPR 2656, while the lowest CGR value was found in HPR 1156. At 60-90 DAS, HPR 2795 had a much higher CGR value than HPR 2656, which was in turn comparable to HPR 1156.

Relative growth rate (RGR): Different tillage practices did not effect RGR at 0-30 DAS and 30-60 DAS, according to a detailed examination of the

data. At 60-90 DAS higher RGR value was recorded in case of conventional tillage which was comparable to minimum tillage without residue and in turn at par with minimum tillage with residue. Among different varieties tested HPR 2795 recorded higher RGR value which was fb HPR 2656 at 30 DAS. At 30-60 DAS, HPR 2795 recorded higher value of RGR which was at par with HPR 2656 and in turn at par with HPR 1156. At 60-90 DAS, HPR 2795 recorded higher RGR value which was at par with HPR 2656. At 60-90 DAS lower RGR value was recorded in HPR 1156.

Conclusion

From the present study it can be concluded the research on conservation agriculture is the need of hour. Farmers generally prefer clean cultivation and thus go for traditional agricultural practices. Conservation agriculture is a sustainable way alternative for maintaining soil resource base. From the present study it may be concluded that conventional tillage resulted in higher growth and growth indices as compared to minimum tillage with residue. Also amongst different varieties HPR 2795, a new red rice variety, gave better results under direct seeding.

Conflict of interest

The authors declare that they have no conflict of interest.

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