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Influence of Tillage Practices on Growth and Growth indices of Rice (*Oryza sativa* L.) varieties under Mid Hills of Himachal Pradesh

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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 lack of information about of the influence of cultivation practices on the performance of different rice varieties raised under direct seeded conditions. Additionally, little research has been done on the effect of residue incorporation on the growth and growth indices of direct seeded rice. Therefore the present investigation "Influence of tillage practices on growth and growth indices of rice (*Oryza sativa* L.) varieties under mid hills of Himachal Pradesh was conducted during *kharif* seasons 2020 and 2021 at two locations, at the Experimental Farms of the Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur and Rice and Wheat Research center, Malan (H.P.). Treatments comprised of four tillage practices *viz*., reduced tillage, zero tillage, conventional tillage and natural farming treatment which were tested with three rice varieties *viz*., *Sukara Dhan* 1 (HPR 1156), *Him Palam Dhan* 1 (HPR 2656) and *Him Palam Lal Dhan* 1 (HPR 2795). The study was conducted in split plot design and was replicated three times. The texture of the soil at both the locations was silty clay loam. Results revealed that conventional tillage recorded significantly taller plants and higher dry matter accumulation at both the locations (Palampur and Malan) which was followed by reduced tillage while significantly lower plant height and dry matter accumulation was recorded in natural farming. Among the varieties tested *Him Palam Lal Dhan* 1 (HPR 2795) produced significantly taller plants and recorded significantly higher dry matter accumulation which was followed by *Sukara Dhan* 1 (HPR 1156). Higher value of AGR, CGR and RGR were recorded in conventional tillage and among the varieties, *Him Palam Lal Dhan* 1 (HPR 2795) resulted in higher values of different growth indices at both the locations (Palampur and Malan).

Keywords: Growth, Natural farming, Residue, Rice, Tillage and Varieties.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of our country and its cultivation is the primary economic activity and main source of income for many Indians rural households involved is rice farming. In order to meet the requirement of burgeoning population the demand for rice is expected to grow by 25% between 2001 and 2025. Due to the scarcity of suitable varieties and means for applying fertilizer in rainfed environments, the acreage of upland rice is decreasing. To meet the increasing demands for rice with the limited resources available, it is vital to enhance yield per unit area while using less water. Due to competition among agricultural, industrial, and domestic uses, a water crisis is on the horizon. In Asia, rice consumes almost half of the water used in agriculture sector (Gohain 2014).Upland rice, where the crop is not flooded at all during the complete life cycle, is an effective way to save water and to reduce the methane emissions produced by flooded rice (Tung *et al.,* 2005). In India, this crop ranks first in both area and production where it 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, 2020a) Also in the state of Himachal Pradesh rice is one of the most important *Kharif* crop (second only to maize) which was cultivated on an area about 71.81 thousand hectares with the production of 114.9 thousand tonnes and productivity of about 16.0 q/ha (Anonymous, 2020b).

Traditional tillage methods are easy to use and maintain a clean cropping environment. They have been used to produce a variety of crops, including rice for long time although they are considered to be labour and fuel intensive. Erosion is a major hazard in conventional tillage where it completely inverts the soil and buries crop residue/waste, exposing the land to erosive natural factors such as wind and water. In the long run, erosion has an impact on land production. Conservation agriculture methods provide a solution to all of these problems (Mathew *et al.,* 2012).

Farmers have tried to reduce the variable component of total cost of cultivation in which a large portion of energy (25–30%) is consumed for field preparation and crop establishment; therefore, conservation agriculture practices have gained popularity in recent years. In some cases the tillage operations cannot be completely avoided and under such conditions the intensity of tillage operations is lowered by only doing primary tillage and avoiding secondary tillage operations. The zero-tillage approach is more cost effective, energy efficient, and ecologically beneficial than traditional sowing methods/ transplanting (Filipovic *et al.,* 2006). By using residual moisture in the soil, minimum and zero tillage techniques can aid in timely planting and successful germination. However there are conflicting reports about the success of this tillage option, thereby indicating the need to conduct research on this aspect.

Also 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 practices. Specific genotypes are also recommended for no till farming around the world. However there has been very little work done in India to identify rice varieties for conservation agriculture. Thus, it is important to test this concept in one of the most important cereal crop grown in the state. Keeping the above facts in view, the present study was carried out to study the performance of rice varieties under different tillage practices.

MATERIAL AND METHODS

A two years field experiment was conducted at two location’s representing the mid hill sub humid zone of Himachal Pradesh (Palampur and Malan), at the Experimental Farms of Department of Agronomy, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur and Rice and Wheat Research Centre (RWRC), Malan during *kharif* seasons of 2020 and 2021.

Experimental site (Palampur). The Experimental Farm of Department of Agronomy is located at 32°09' N latitude, 76°54'E longitude, at an altitude of 1290 m above mean sea level. The farm is located in the mid-hills sub-humid zone of Himachal Pradesh which is characterized by mild summers and cold winters. The region receives a lot of rain, ranging from 2000 to 2500 mm per year, with 80 percent of it falling between June and September, when the monsoon season is in full swing. The soil at the test site a silty clay loam texture, was acidic in reaction, and contained a medium quantity of available nitrogen, phosphorus, and potassium.

During the rice growing season (June to October, *kharif*), the mean weekly maximum temperature ranged between 24.3 to 30.5°C and 22.1 to 31.1°C during 2020 and 2021, respectively while mean weekly minimum temperature fluctuated between 8.9 to 20.1°C and 9.3 to 20.8°C during 2020 and 2021, respectively. The crop experienced well distributed rainfall of 226.8 and 559.0 mm in the first and second season, respectively. The average relative humidity during the cropping seasons of first and second season was between 51.8 to 92.0 per cent and 59.7 to 94.3 per cent. (Anonymous, 2021, Crop weather outlook).

Experimental site (Malan). The Experimental Farm of RWRC, Malan is located at 32^{o}07' N latitude, 76°23′ E longitude, 950 m above mean sea level and also falls under sub-humid mid hill zone of Himachal Pradesh. The soil at the test site had a silty clay loam texture, was acidic in reaction, and was rated a medium in available nitrogen, phosphorus, and potassium.

During the rice growing season (June to October, *Kharif*), the mean weekly maximum temperature as recorded in the Meteorological Observatory of RWRC, Malan ranged between 28.8 to 33.9°C and 28.5 to 33.2°C during 2019-20 and 2020-21, respectively. While mean weekly minimum temperature fluctuated between 10.1 to 18.1°C and 12.7 to 18.1°C during 2020 and 2021, respectively. The crop experienced well distributed rainfall of 300.2 and 249.8 mm in the first and second year, respectively. The average relative humidity during the cropping seasons of first and second year was between 65.0to 79.5 per cent and 73.8 to 79.1 per cent. (Anonymous, 2021, Crop weather outlook).

The field Experiment comprised of four cultivation practices in the main plot(reduced tillage with residue, zero tillage, conventional tillage and natural farming) and three varieties rice (*Sukara Dhan* 1 (HPR 1156), *Him Palam Dhan* 1 (HPR 2656) and *Him Palam Lal Dhan* 1(HPR 2795)) in sub plot. With the experiment being laid out in split plot design with three replications.

The crop of rice at both the locations was planted on normal dates of sowing. The recommended dose of fertilizers for rice (60 kg N, 30 kg P and 30 kg K ha^{-1})was applied using urea (46 % N), single super phosphate (16 % P_2O5), and muriate of potash (60 % K_2O) (Package of practices, *kharif*, 2020 HP). The entire quantity of phosphorus and potassium was applied at the time of planting, whereas nitrogen was applied in two equal splits at the time of sowing and at three-week later. Wheat straw @ 3t/ha was applied on the reduced tillage treatment. All the practices of natural farming were also adopted to raise the rice crop.

Data was recorded on plant height and dry matter accumulation at periodic interval and was used to estimate different growth indices at both the location.

The following formulae were used to determine various growth indices:

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

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

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

$$\text{CGR (g/m2/day)} = \frac{w_2 - w_1}{\text{P} \times (t_2 - t_1)}$$

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

$$\text{RGR (mg/g/day)} = \frac{(\text{loge}_{\text{w2}} - \text{loge}_{\text{w1}})}{t_2 - t_1} \times 1000$$

Where

H_1& H_2: Plant height (cm) of plant at time t_1 and t_2, respectively

W_1& W_2: Whole plant dry weight at time t_1 and t_2, respectively

P is the ground area on which W_1& W_2 are recorded

The data obtained was statistically analyzed using the analysis of variance technique as outlined by Gomez and Gomez (1984). The critical difference (CD) was estimated for parameters with significant impacts at the 5% probability level.

RESULTS AND DISCUSSION

Plant height: The data on plant height of rice recorded at periodic intervals and at harvest, at both the locations has been given in Table 1. A perusal of data revealed that the plant height was significantly influenced at all the stages of observation by cultivation practices. Irrespective of treatments, consistent increase in plant height with advancement in crop age was recorded in both the years. At 30 DAS significantly taller plants were recorded in conventional tillage which was at par with reduced tillage which in turn was at par with zero tillage while significantly shorter plants were recorded in natural farming at both the locations though this treatment was also at par with the zero tillage. Similar results were recorded at 60 DAS, 90 DAS and at harvest where significantly higher plant height was recorded with conventional tillage though this treatment was at par with reduced tillage which in turn was at par with zero tillage. Only difference between plant height at 30 DAS and remaining stages was that the difference between zero tillage and natural farming was not significant at 30 DAS while it was significant at all the later stages. Higher plant height in case of conventional tillage might be due to more vigorous and healthy seedlings at initial growth period of crop. Hazarika and Sarmah (2017) have also reported that conventional tillage improves the physical condition by manipulating and pulverizing the soil which not only provides suitable environment to the germinating seed and emerging seedlings but also supplies free oxygen, ensures availability of higher moisture and essential nutrients to plants and ultimately improves the growth of plant. Significantly shorter plants were recorded in natural farming treatment. This could be attributed to the inadequate supply of nutrients to the rice crop, particularly during initial stage of plant growth which resulted in poor growth of the crop. Also, the practices of natural farming adopted during the life cycle of rice crop was not able to meet the nutritional requirement of rice resulting in poor and reduced plant height. Similar results have also been reported by Seth *et al.* (2019); Pandey and Tanka (2020); Ankit *et al*. (2022).

Table 1: Effect of tillage practices on plant height (cm) of different rice varieties at Palampur and Malan (Pooled over two years).

Treatments	Plant height (cm)							
	Palampur				Malan			
	30DAS	60DAS	90DAS	Harvest	30DAS	60DAS	90DAS	Harvest
Cultivation practices								
Reduced Tillage	33.9	72.1	91.1	99.5	36.5	76.2	94.4	101.7
Zero Tillage	31.9	69.6	88.2	96.4	34.7	72.5	89.4	97.4
Conventional Tillage	36.1	75.9	95.0	104.5	39.0	78.3	97.8	106.2
Natural farming	29.5	63.2	79.0	86.1	32.4	67.7	81.4	90.3
SEm ±	1.2	1.5	1.5	1.7	1.1	1.3	1.3	1.4
CD (P = 0.05)	3.5	4.6	4.6	5.1	3.3	3.9	4.0	4.2
Varieties								
Sukara Dhan 1 (HPR 1156)	32.7	68.3	83.7	91.9	34.4	71.2	87.2	94.8
Him Palam Dhan 1 (HPR 2656)	32.4	68.1	83.7	94.7	35.5	72.9	89.5	97.9
Him Palam Lal Dhan 1(HPR 2795)	33.5	74.3	94.6	103.3	36.9	76.8	95.5	104.0
SEm ±	0.8	1.5	1.6	1.7	0.9	1.1	1.3	1.2
CD (P = 0.05)	NS	4.2	4.7	4.9	NS	3.2	3.7	3.7

The rice varieties exhibited significant differences in plant height at all the stages except at 30 DAS at Palampur. At 60 DAS, 90 DAS and at harvest significantly taller plants were recorded from *Him Palam Lal Dhan* 1 (HPR 2795) while the other two varieties were at par with each other. The differences in plant height amongst the varieties could be attributed to the genetic make up of these varieties. Similar trend was also observed in the trial conducted at RWRC, Malan at all the stages of observation.

The interaction between the cultivation practices and varieties was found to be non-significant for plant height at both the locations.

Dry matter accumulation: The data pertaining to the effect of cultivation practices and varieties on dry matter accumulation of rice crop at periodic intervals at both the locations has been presented in Table 2. At Palampur significantly higher dry matter accumulation at all the stages of observation was recorded in the conventional tillage practice followed by reduced tillage and zero tillage practices which were at par with each other while significantly lower dry matter accumulation was recorded in natural farming treatment. Almost similar result was observed at Malan also though the dry matter accumulation in conventional tillage at 30 DAS was at par with the reduced tillage treatment. Higher dry matter accumulation recorded in conventional tillage at all the stages of observation was due to better physical condition of soil owing to primary tillage, better root penetration and better nutrient availability to crop which resulted in better root growth and penetration allowing roots to extract nutrients from a wider soil profile which improved the photosynthetic efficiency and hence higher dry matter accumulation. In reduced tillage also the land is exposed to primary tillage which improves the physical condition of the soil. The use of residue also results in a better moisture regime resulting in better root growth and higher dry matter accumulation. Further significantly lowest dry matter accumulation in natural farming was due to the inadequate supply of all the primary elements to the crop which could have resulted in poor root and shoot growth and ultimately resulted in poor dry matter accumulation. Similar results have also been reported by Seth *et al.* (2019); Ankit *et al.* (2022).

Table 2: Effect of tillage practices on dry matter accumulation (g m^{-2}) of different rice varieties at Palampur and Malan (Pooled over 2 years).

Treatments	Dry matter accumulation (g m^{-2})							
	Palampur				Malan			
	30DAS	60DAS	90DAS	Harvest	30DAS	60DAS	90DAS	Harvest
Cultivation practices								
Reduced Tillage	55.7	423.5	656.9	834.8	64.1	482.0	701.3	848.9
Zero Tillage	54.0	410.1	638.5	806.3	61.0	462.7	672.9	803.9
Conventional Tillage	59.4	450.8	716.7	923.5	67.8	528.6	757.2	930.1
Natural farming	48.5	356.6	497.2	606.9	56.7	425.4	585.8	683.8
SEm ±	1.1	8.3	14.3	18.8	1.3	9.7	14.1	19.0
CD (P = 0.05)	3.2	25.2	43.4	57.0	4.0	29.5	42.8	57.7
Varieties								
Sukara Dhan 1 (HPR 1156)	53.5	403.0	619.0	781.3	62.7	471.5	673.3	808.2
Him Palam Dhan 1 (HPR 2656)	52.6	398.5	609.6	768.5	60.7	459.4	657.6	783.5
Him Palam Lal Dhan 1 (HPR 2795)	57.1	429.2	653.3	828.8	63.8	493.2	707.1	858.3
SEm ±	0.9	7.6	10.5	12.6	0.8	7.4	10.2	14.6
CD (P = 0.05)	2.5	22.0	30.3	36.3	2.3	21.2	29.3	42.1

Significant differences were also observed between different varieties for dry matter accumulation at periodic intervals at Palampur with *Him Palam Lal Dhan* 1(HPR 2795) accumulating significantly higher dry matter at all the stages of observation (30, 60, 90 DAS and at harvest) while the other two varieties namely *Sukara Dhan* 1 (HPR 1156) *and Him Palam Dhan* 1 (HPR 2656) were at par with each other. Similar trend was observed for this parameter at Malan with the exception that the difference between *Him Palam Lal Dhan* 1 (HPR 2795) and *Sukara Dhan* 1 (HPR 1156) for dry matter accumulation at 30 DAS was not significant. The higher dry matter accumulation recorded in *Him Palam Lal Dhan* 1 may be due to rapid initial growth (as indicated by plant height), more tillering, higher leaf area which resulted in higher photosynthetic efficiency leading to higher dry matter accumulation. Similar trend was also followed at RWRC, Malan at all the stages of observation.

The interaction between the cultivation practices and varieties was found to be non-significant for dry matter accumulation at both the locations.

Absolute Growth Rate: Absolute Growth Rate (AGR) showed significant differences with respect to cultivation practices and varieties (Table 3 & 4) At Palampur significantly higher Absolute Growth Rate between 30-60 DAS was recorded in conventional tillage which was at par with reduced tillage and latter in turn was at par with zero tillage while significantly lower value of AGR between 30-60 DAS was recorded in natural farming treatment. Between at 60-90 DAS significantly higher value of AGR at Palampur was recorded in conventional tillage which was at par with both reduced tillage and zero tillage while significantly lower value of AGR between 60-90 DAS was recorded in natural farming treatment.

The better physical condition of soil achieved as a result of conventional tillage resulted in more robust and taller plants which was reflected in the higher value of this parameter at all the stages. Also, higher value of AGR recorded between 30-60 DAS as compared to 60-90 DAS may be due to the reason that height of rice usually increases till the initiation of flowering after which there is only slight increase in height. Similar trend was also observed for Absolute Growth rate at periodic stages at Malan also with conventional and reduced tillage recording higher AGR between 30-60 DAS and 60-90 DAS while significantly lower values were recorded in natural farming treatment.

Significant differences were observed among varieties for Absolute Growth Rate between 30-60 DAS and 60-90 DAS at both the locations. Significantly higher value of AGR between 30-60 DAS was recorded in *Him Palam Lal Dhan* 1 while the other two varieties *Sukara Dhan* 1 and *Him Palam Dhan* 1 were at par with each other at both Palampur and Malan. The Absolute Growth Rate between 60-90 DAS also followed the similar trend with HPLD 1 recording significantly higher value at both Palampur and Malan. Similar results, have also been reported by Ankit *et al*. (2022).

Crop growth Rate: Crop Growth Rate **(**CGR) is the rate of daily increment in dry matter accumulation by the particular crop. A perusal of data revealed that CGR at both the stages was significantly influenced by cultivation practices as well as by rice varieties at both the locations. At 30-60 DAS conventional tillage had considerably higher value of CGR at both the locations followed by reduced tillage and zero tillage in that order, both the latter treatments being at par with each other while the natural farming recorded significantly lowest CGR between at 30-60 DAS. Similar trend w.r.t. the CGR between 60-90 DAS was observed at both Palampur and Malan with conventional tillage logging higher CGR while significantly lowest value recorded in natural farming Higher CGR value may be due to higher production of dry matter owing to greater LAI and higher light interception.

Among the varieties tested, at both 30-60 DAS and 60-90 DAS significantly higher value of CGR was recorded in *Him Palam Lal Dhan* 1 (HPR 2795) at Palampur which was followed by variety *Sukara Dhan* 1 (HPR 1156) while lowest value of CGR was recorded in case of *Him Palam Dhan* 1 (HPR 2656) differences between the latter two varieties could not breach the level of significance. Similar results were also obtained for this parameter at Malan.

Relative Growth Rate: Relative Growth Rate is the rate of accumulation of new dry mass per unit of existing dry mass and plays an important role in determining the plant competitiveness for various resources. The data on RGR, as influenced by tillage practices and varieties, recorded between different stages (30-60 DAS and 60-90 DAS) at Palampur and Malan (Table 3 and 4) revealed that this parameter was not significantly impacted by rice varieties while the effect of tillage was significant only between 60-90 DAS. Significantly higher RGR between 60-90 DAS was recorded from conventional tillage though this treatment was at par with reduced tillage as well as zero tillage while significantly lower value of RGR at this stage was recorded in natural farming treatment.

Table 3: Effect of tillage practices on Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate of different rice varieties at Palampur (Pooled over two years).

	Absolute growth rate (cm day^{-1})		Crop growth rate (g m^{-2} day^{-1})		Relative growth rate (mg g^{-1} day^{-1})	
Treatments	**30-60 DAS**	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**
Cultivation practices						
Reduced Tillage	1.28	0.63	12.26	7.78	67.63	14.63
Zero Tillage	1.26	0.62	11.87	7.61	67.50	14.76
Conventional Tillage	1.33	0.64	13.05	8.86	67.59	15.45
Natural farming	1.12	0.53	10.27	4.69	66.51	10.95
SEm ±	0.02	0.01	0.18	0.13	0.67	0.39
CD (P = 0.05)	0.05	0.04	0.55	0.39	NS	1.18
Varieties						
Sukara dhan 1	1.19	0.52	11.65	7.20	67.35	14.30
Him palam dhan 1	1.19	0.52	11.53	7.04	67.51	14.17
Him palam lal dhan 1	1.36	0.68	12.41	7.47	67.24	14.00
SEm ±	0.03	0.02	0.11	0.08	0.36	0.20
CD (P = 0.05)	0.08	0.06	0.32	0.23	NS	NS

Table 4: Effect of cultivation practices on Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate of different rice varieties at Malan (Pooled over two years).

	Absolute growth rate (cm day^{-1})		Crop growth rate (g m^{-2} day^{-1})		Relative growth rate (mg g^{-1} day^{-1})	
Treatments	**30-60 DAS**	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**
Cultivation practices						
Reduced Tillage	1.32	0.61	13.93	7.31	67.26	12.50
Zero Tillage	1.26	0.56	13.39	7.01	67.57	12.49
Conventional Tillage	1.31	0.65	15.36	7.62	68.48	11.98
Natural farming	1.18	0.46	12.29	5.35	67.15	10.66
SEm ±	0.02	0.02	0.22	0.14	0.72	0.43
CD (P = 0.05)	0.07	0.06	0.67	0.42	NS	1.30
Varieties						
Sukara Dhan 1 (HPR 1156)	1.23	0.53	13.63	6.73	67.25	11.88
Him Palam Dhan 1 (HPR 2656)	1.25	0.55	13.29	6.61	67.51	11.95
Him Palam Lal Dhan 1 (HPR 2795)	1.33	0.62	14.31	7.13	68.16	12.02
SEm ±	0.02	0.02	0.15	0.10	0.42	0.24
CD (P = 0.05)	0.06	0.05	0.42	0.29	NS	NS

CONCLUSION

From the present study it can be concluded that conventional tillage resulted in higher growth and growth indices of rice as compared to other tillage practices and natural farming. Among different rice varieties *Him Palam Lal Dhan*1, a new red rice variety, gave better results under direct seeded upland conditions.

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Conflict of Interest. None.

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