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Influence of tillage practices on growth, growth indices and yield of wheat (*Triticum aestivum* L.) varieties under mid hills of Himachal Pradesh

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Abstract

The present studies on "Influence of tillage practices on growth, growth indices and yield of wheat (*Triticum aestivum* L.) varieties under mid hills of Himachal Pradesh" were conducted during the winter season of 2019-20 and 2020-21, at the experimental Farm of the Department of Agronomy and Rice and Wheat Research Centre, Malan of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (H.P.). The four cultivation practices viz., reduced tillage, zero tillage, conventional tillage and natural farming were kept as main plot treatments whereas three wheat varieties viz., HPW 349, HPW 368 and HS 562 were tested as sub-plot treatments in split plot design. The study was replicated three times. The texture of the soil at both the tested sites was silty clay loam. The results revealed that the conventional tillage recorded significantly taller plants and higher dry matter accumulation at both the locations (Palampur and Malan) which was followed by reduced tillage. Significantly lower plant height and dry matter accumulation was recorded in natural farming treatment. Among the varieties HPW 349 recorded significantly taller plants whereas HPW 368 recorded higher dry matter accumulation. The higher values of AGR (absolute growth rate), CGR (crop growth rate) and RGR (relative growth rate) were recorded in conventional tillage. Among the varieties, HPW 349 resulted in the higher AGR while HPW 368 provided higher values of CGR and RGR.

Key words: Growth, natural farming, tillage, varieties, wheat

Wheat (*Triticum aestivum* L.) is one of the major cereal crops of the world and plays an important role in food and nutritional security of large part of global population. In India, wheat is the second most important food crop after rice. It is considered an excellent health-building food containing approximately 78% carbohydrates, 12% protein, 2% fat and minerals, and a considerable amount of vitamins (Kumar *et al*. 2011). About 80 to 85% of wheat grains are ground into flour (atta) and consumed in the form of chapatis, bread, cake, biscuits, pastry and other bakery products. Moreover, wheat straw, which is nutritious, is mainly used as fodder for livestock. In India it is cultivated on an area of 31.45 million hectare with the total production of 107.59 million tonnes and average productivity of 34.2 q ha^{-1} (Anonymous, 2020a). Even in the state of Himachal Pradesh wheat is the most important *rabi* crop as well as food crop and was cultivated on an area about 319 thousand hectare with the production of 564.6 thousand tonnes and productivity of about 17.6 q/ha (Anonymous, 2020b).

Traditional tillage techniques are simple to implement and keep the cropping area clean. Despite being labor and fuel-intensive methods, they have been employed for a long time for crop cultivation. In traditional tillage, erosion poses a serious risk. The land is exposed to erosive natural forces like wind and water, fully inverting the soil and burying crop residue. Erosion affects the production of land over. All of these issues can be resolved through conservation practices. (Mathew *et al*. 2012).

In recent years farmers have tried to reduce through conservation agriculture, variable cultivation costs and a large amount of energy (25–30%) that is required for field preparation and crop establishment, therefore conservation agriculture methods have been gaining popularity. The intensity of tillage operations could be reduced to decrease this cost and energy use. As compared to conventional sowing techniques, the new tillage method is more economical, energy-efficient, and environmentally friendly (Filipovic *et al*. 2006 and Chaudhary *et al*. 2019). Minimal and zero tillage approaches can help in timely planting and effective germination by using the leftover moisture in the soil. Additionally, it can help in lowering the production costs.

The performance of wheat genotypes can differ based on a number of factors, including the tillage methods adopted and the effect of microclimate changes brought on by the use of conservation agriculture methods. Moreover, some genotypes are recommended for no-till farming globally (Ram *et al*. 2018 and Saini *et al*. 2022). Little research has been done in the state of Himachal Pradesh to identify wheat genotype for conservation agriculture. Thus, it is important to test this new concept in one of the most important cereal crop grown in the state. Keeping the above facts in view, the present study was conducted.

Materials and Methods

A two years field experiment was conducted at two locations 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 Vishvavidyalaya, Palampur and Rice and Wheat Research Centre (RWRC), Malan during winter seasons of 2019-20 and 2020-21.

Experimental site

Both the locations of Palampur and Malan are 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, with 80 per cent of it falling between June and September, when the south-west monsoon season is in full swing. 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. During the wheat growing season at Palampur (November to May), the mean weekly maximum temperature ranged between 13.1 to 26.2°C and 15.2 to 28.9°C during 2019-20 and 2020-21, respectively. Whereas mean weekly minimum temperature fluctuated between 1.6 to 14.6°C and 0.8 to 15.9°C during 2019-20 and 2020-21, respectively. The crop experienced well distributed rainfall of 749.5 and 691.6 mm in the first and second year, respectively. The average relative humidity was between 52.1 to 80.6 per cent and 39.7 to 71.2 per cent during the first and second year, respectively (Anonymous, 2021, Crop weather outlook).

The Experimental Farm of RWRC, Malan is located at 32°07' N latitude, 76°232 E longitude, 950 m above mean sea level. During the wheat growing season (November to May), the mean weekly maximum temperature at Malan ranged between 22.6 to 32.1°C and 22.8 to 31.5°C during 2019-20 and 2020-21, respectively. Whereas mean weekly minimum temperature fluctuated between 4.8 to 16.4°C and 5.6 to 15.2°C during 2019-20 and 2020-21, respectively. The crop experienced well distributed rainfall of 536.5 and 402.5 mm in the first and second year, respectively. The average relative humidity was between 70.1 to 78.6 per cent and 61.7 to 78.4 per cent during the first and second year, respectively (Anonymous, 2021, Crop weather outlook).

Before the experiment began, a composite soil sample was randomly collected at the depth of 0-15 cm from both the locations and analyzed for its physico-chemical characteristics. The soil at both the sites was silty clay loam in texture, acidic in reaction and was rated as medium in available nitrogen, phosphorus and potassium. 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 of wheat (HPW 349, HPW 368 and HS 562) in sub plot. The experiment was laid out in split plot design with three replications.

The crop of wheat at both the locations was planted on normal dates of sowing. The recommended dose of fertilizers for wheat (120 kg N, 60 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). The entire quantity of phosphorus and potassium was applied at the time of planting, whereas nitrogen was applied in three doses half at the time of sowing and in two equal splits at three-weeks interval. Rice straw @ 3t/ha was used as mulch material and applied on the reduced tillage treatment. All the recommended practices of natural farming were adopted to raise the wheat crop. The wheat crop in the natural farming treatment was raised with the practices that been enumerated below:

1. Application of 500 kg ha^{-1} *Ghanjeevamrit* after grinding before sowing.
2. Dipping of wheat seed in *Beejamrit* solution for 30 minutes before sowing.
3. Spray of *Jeevamrit* at one month after sowing by dissolving 25 litres of *Jeevamrit* in 500 litre water and using it in one ha area.
4. Second spray of *Jeevamrit* done after 3 weeks of first spray by dissolving 50 litres of *Jeevamrit* in 500 litre water and using it in one ha area.
5. Third spray of *Jeevamrit* done after 3 weeks of second spray by dissolving 50 litres of *Jeevamrit* in 500 litre water and using it in one ha area.
6. Spray of 25 litre butter milk dissolved in 500 litre water, 3 weeks after the last spray of *Jeevamrit* in one ha.

The data on plant height and dry matter accumulation was recorded at 30 days interval and was used for the calculations of various indices. The data on grain and straw yield was recorded at the time of harvest and has been presented here. 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).

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

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

$$\text{RGR (mg / g / day)} = \frac{(\log_e w_2 - \log_e w_1)}{t_2 - t_1}$$

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 were 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

Grain yield

Significantly higher grain yield of wheat was recorded in conventional tillage which was at par with reduced tillage at both the locations (Table 1). Significantly lower grain yield was recorded in natural farming treatment at both the locations. Higher grain yield recorded under conventional tillage was due to the higher values of all the yield attributes in this treatment including number of effective tillers m^{-2}, number of grains $spike^{-1}$ and 1000-grain weight while lower yield in natural farming treatment could be attributed to the lowest values of these attributes in this treatment (data not presented). The conventional tillage treatment includes both primary and secondary tillage operation. These operations improve the soil physical condition thereby promoting optimum root growth and development. This facilitates better uptake

Table 1. Effect of tillage practices on grain yield (kg ha^{-1}) of different wheat varieties at Palampur and Malan (Pooled over two years)

Treatments	Grain yield	
	Palampur	Malan
Cultivation practices		
Reduced Tillage	4269	4474
Zero Tillage	3994	4152
Conventional Tillage	4469	4664
Natural farming	1646	2072
SEm ±	68	67
CD (P = 0.05)	206	202
Varieties		
HPW 349	3448	3622
HPW 368	3714	4050
HS 562	3523	3849
SEm ±	38	60
CD (P = 0.05)	110	173

of nutrients from the soil especially, nitrogen and phosphorus. The enhanced uptake of the nutrients promotes good seed setting and tillering and other yield attributing characters. Similar result was also reported by Seth *et al*. (2019) and Seth *et al*. (2020).

Among the varieties tested HPW 368 recorded significantly higher grain yield while significantly lower grain yield was recorded in HPW 349. The higher yield recorded in HPW 368 and HS 562 was due to the higher values of all the yield attributes in this variety while the lower values of these attributes in HPW 349 resulted in significantly lower yield of this variety (data not presented here).

Plant height

Significantly taller plants at all stages of observation at Palampur were recorded in conventional tillage which was at par with reduced tillage while significantly shorter plant were recorded in natural farming (Table 2). The higher plant height in case of conventional tillage might be due to more

Table 2. Effect of tillage practices on plant height (cm) of different wheat varieties at Palampur and Malan (Pooled over two years)

Treatments	Plant height (cm)									
	Palampur					Malan				
	30DAS	60DAS	90DAS	120 DAS	Harvest	30DAS	60DAS	90DAS	120 DAS	Harvest
Cultivation practices										
Reduced Tillage	11.2	28.9	56.5	90.2	92.6	12.7	31.4	57.6	95.1	96.0
Zero Tillage	10.6	27.6	53.8	86.3	88.5	11.4	27.3	51.0	89.1	89.9
Conventional Tillage	11.8	29.8	58.3	92.6	95.1	13.1	33.6	61.4	98.8	100.0
Natural farming	10.1	22.2	40.7	65.5	68.1	9.4	20.8	38.1	64.6	65.9
SEm ±	0.6	1.0	1.3	1.5	1.4	0.5	0.8	1.2	1.3	1.3
CD (P = 0.05)	NS	3.1	4.0	4.4	4.2	1.6	2.5	3.7	4.0	4.0
Varieties										
HPW 349	11.4	28.3	54.0	85.9	88.2	12.1	29.1	53.4	88.7	89.8
HPW 368	11.0	27.3	52.4	83.7	86.0	11.7	28.2	52.1	86.7	87.9
HS 562	10.3	25.7	50.5	81.5	84.0	11.2	27.6	50.6	85.3	86.4
SEm ±	0.5	1.0	1.2	1.3	1.3	0.3	0.6	1.0	1.2	1.1
CD (P = 0.05)	NS	NS	3.3	3.8	3.8	NS	NS	NS	3.3	3.2

vigorous and healthy seedling at initial growth period of crop. Hazarika and Sarmah (2017) reported that conventional tillage improves the physical condition of the soil by manipulating and pulverizing the soil which not only provides suitable environment to the germinating seed and emerging seedlings but also supplies free oxygen, availability of higher moisture and essential nutrients to plants and ultimately improves the growth of plant. Significantly shorter plants were obtained under natural farming treatment could be attributed due to inadequate supply of nutrients to the wheat crop, particularly during initial stage of plant growth which resulted in poor growth of the crop. Results were in conformity with Seth *et al*. (2019) Pandey and Tanka (2020) and Saini *et al*. (2022). The variety HPW 349 recorded significantly taller plants which was at par with HPW 368. Similar trend was also observed at RWRC, Malan at all the stages of observation with conventional tillage and natural farming producing significantly taller and shorter plants, respectively.

Dry matter accumulation

Among cultivation practices significantly higher dry matter accumulation was recorded in conventional tillage, which was followed by reduced tillage at both the locations (Table 3). Higher dry matter accumulation under conventional tillage may be due to better physical condition of the soil brought about by conventional tillage which resulted in better initial growth including deep and extensive root system resulting in better growth through out the life cycle resulting in higher dry matter accumulation at all stages of observation. Similar results were also reported by Seth *et al*. (2019) and Saini *et al*. (2022). Significantly lower dry matter accumulation was recorded under natural farming treatment, the reasons for which have been explained rarlier at both the locations. Among the different varieties tested, HPW 368 recorded significantly higher dry matter accumulation, except at 30 days after sowing. The higher dry matter accumulation recorded in this variety may be due to rapid initial growth (as indicated by plant height), more tillering and higher leaf area

Table 3. Effect of tillage practices on dry matter accumulation (g m^{-2}) of different wheat varieties at Palampur and Malan (Pooled over two years)

Treatments	Dry matter accumulation (g m^{-2})									
	Palampur					Malan				
	30DAS	60DAS	90DAS	120 DAS	Harvest	30DAS	60DAS	90DAS	120 DAS	Harvest
Cultivation practices										
Reduced Tillage	12.8	71.1	348.0	684.2	1007.1	14.9	77.6	393.7	738.7	1084.4
Zero Tillage	12.3	68.3	329.6	653.3	954.7	14.8	75.4	373.1	699.8	1033.5
Conventional Tillage	13.4	72.6	361.7	705.6	1042.5	15.7	78.8	405.5	758.6	1111.2
Natural farming	7.7	33.5	154.6	307.8	414.0	10.0	47.1	199.0	391.4	530.2
SEm ±	0.3	1.0	8.7	13.7	17.6	0.3	1.2	8.1	14.1	17.1
CD (P = 0.05)	0.9	3.1	26.3	41.6	53.4	1.0	3.7	24.5	42.8	51.9
Varieties										
HPW 349	11.2	59.0	286.2	562.1	820.7	13.4	67.9	328.9	622.4	895.0
HPW 368	11.8	63.3	309.9	611.3	888.1	14.2	72.1	359.8	682.8	1006.4
HS 562	11.5	61.7	299.4	589.7	855.6	13.9	69.1	339.9	636.3	918.1
SEm ±	0.2	0.8	4.4	8.1	10.8	0.3	0.9	7.1	9.5	16.1
CD (P = 0.05)	NS	2.3	12.7	23.3	31.2	NS	2.7	20.4	27.5	46.3

(data not reported) which resulted in higher photosynthetic efficiency leading to higher dry matter accumulation.

Absolute growth rate

The highest absolute growth rate at all the growth stages was recorded in conventional tillage which was at par with reduced tillage while the latter was also at par with zero tillage while significantly lower value of AGR was recorded in natural farming treatment during all the growth stages (Table 4 and 5). The higher AGR value found in conventional tillage might be due to better crop growth under improved soil physical and

Table 4. Effect of tillage practices on Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate of different wheat varieties at Palampur

Treatments	Absolute growth rate(cm day^{-1})			Crop growth rate (g m^{-2} day^{-1})			Relative growth rate (mg g^{-1}day^{-1})		
	30-60 DAS	60-90 DAS	90-120 DAS	30-60 DAS	60-90 DAS	90-120 DAS	30-60 DAS	60-90 DAS	90-120 DAS
Cultivation practices									
Reduced Tillage	0.59	0.92	1.12	1.94	9.23	11.21	57.28	52.97	22.53
Zero Tillage	0.57	0.88	1.08	1.87	8.71	10.79	57.28	52.50	22.81
Conventional Tillage	0.60	0.95	1.14	1.97	9.64	11.46	56.37	53.53	22.28
Natural farming	0.40	0.62	0.83	0.86	4.04	5.11	49.23	51.04	22.97
SEm ±	0.01	0.02	0.03	0.04	0.18	0.20	1.08	0.65	0.39
CD (P = 0.05)	0.04	0.06	0.10	0.13	0.54	0.61	3.28	1.96	NS
Varieties									
HPW 349	0.56	0.86	1.06	1.59	7.57	9.20	55.42	52.64	22.51
HPW 368	0.54	0.84	1.04	1.72	8.22	10.05	56.03	52.96	22.65
HS 562	0.51	0.83	1.03	1.67	7.92	9.68	56.02	52.67	22.60
SEm ±	0.02	0.02	0.02	0.03	0.11	0.12	0.56	0.23	0.23
CD (P = 0.05)	NS	NS	NS	0.09	0.32	0.35	NS	NS	NS

Table 5. Effect of cultivation practices on Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate of different wheat varieties at Malan

Treatments	Absolute growth rate (cm day^{-1})			Crop growth rate (g m^{-2} day^{-1})			Relative growth rate (mg g^{-1} day^{-1})		
	30-60 DAS	60-90 DAS	90-120 DAS	30-60 DAS	60-90 DAS	90-120 DAS	30-60 DAS	60-90 DAS	90-120 DAS
Cultivation practices									
Reduced Tillage	0.62	0.88	1.25	2.09	10.54	11.50	55.18	54.15	20.97
Zero Tillage	0.53	0.79	1.27	2.02	9.92	10.89	54.29	53.32	20.95
Conventional Tillage	0.68	0.93	1.25	2.11	10.89	11.77	53.94	54.63	20.87
Natural farming	0.38	0.58	0.88	1.24	5.07	6.41	51.70	48.09	22.54
SEm ±	0.02	0.03	0.04	0.05	0.22	0.24	0.68	0.63	0.59
CD (P = 0.05)	0.07	0.09	0.12	0.16	0.67	0.73	2.06	1.91	NS
Varieties									
HPW 349	0.57	0.81	1.18	1.82	8.70	9.79	54.16	52.61	21.26
HPW 368	0.55	0.80	1.15	1.93	9.59	10.77	54.22	53.60	21.36
HS 562	0.55	0.77	1.16	1.84	9.03	9.88	53.62	53.11	20.89
SEm ±	0.01	0.02	0.02	0.03	0.14	0.16	0.49	0.43	0.28
CD (P = 0.05)	NS	NS	NS	0.09	0.40	0.46	NS	NS	NS

chemical properties like lower bulk density, higher macro and micro nutrient availability due to faster decomposition of crop residue throughout the crop growth stages (Data not reported). In case of varieties, no significant effect on AGR was found at both the locations. Numerically, HPW 349 recorded the highest absolute growth rate at both the locations which was due to the taller plants of this variety.

Crop growth rate

CGR is the rate of daily increment in dry matter accumulation by the particular crop. Significantly higher value of CGR between 30-60, 60-90 and 90-120 DAS at both the locations was recorded under conventional tillage followed by reduced tillage and zero tillage in that order with conventional tillage and reduced tillage and reduced tillage and zero tillage being at par with each other at 60-90 and 90-120 DAS while between 30-60 DAS all the three tillage treatment behaved in a statistically similar manner. The results so obtained could be explained by the better initial growth in conventional tillage which resulted in higher LAI and higher photosynthetic activity resulting in higher dry matter accumulation. Significantly lower values of CGR at all the stages (30-60, 60-90 and 90-120 DAS) were observed in natural farming treatment which was due to inadequate supply of nutrients which resulted in significantly lower photosynthetic activity and ultimately dry matter.

Among the varieties tested, significantly higher value of CGR was recorded in HPW 368 which by followed by variety HPW 349 while lowest value of CGR was recorded in case of HS 562 at both the locations (Palampur and RWRC, Malan).

Relative growth rate

Different cultivation practices significantly influenced the relative growth rate (RGR) at different stages of observation except 90-120 DAS (Table 4 and 5). Between the periods of 30-60 DAS and 60-90 DAS all the three tillage options of conventional tillage, reduced tillage and zero tillage remaining at par with each other, resulted in significantly higher RGR that natural farming treatment. The similar trend was observed in both the locations of Palampur and Malan. Among different varieties tested, no significant difference on RGR was found at all stages of observation.

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

Conclusion

From the present study it can be concluded that conventional tillage resulted in higher values of growth (plant height, dry matter accumulation), growth indices and yield while natural farming resulted in lower values indicating poor crop growth. Among varieties tested HPW 368 gave better results in terms of growth, growth indices and yield.

Conflict of interest: The authors declare that there is no conflict of interest in this research paper.

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