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Response of tillage methods on yield of wheat (*Triticum aestivum*) cultivars

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ABSTRACT

The present experiment was conducted during winter (*rabi*) seasons of 2019–20 and 2020–21 at Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, to assess the impact of tillage and farming practices on the crop yield and yield attributes of three wheat (*Triticum aestivum* L.) cultivars. Two-year results show that conventional tillage produced significantly higher grain yields (4,469 kg/ha), straw yields (6,257 kg/ha), and biological yields (10,726 kg/ha) than natural farming treatment, which produced lower grain yields (1,646 kg/ha), straw yields (2,597 kg/ha), and biological yields (4,242 kg/ha). While the natural farming treatment had much lower values of wheat yield attributes, the conventional tillage treatment, which was followed by the reduced tillage treatment, had significantly higher values. Among the cultivars assessed, HPW 368 had noticeably higher grain yield (3,714 kg/ha), straw yield (5,415 kg/a), and biological yield (9,128 kg/ha) values. This was because the variety's yield attributes were much greater. According to the results of this study, the wheat crop produced more under conventional farming conditions, and HPW 368 was the cultivar that performed the best out of all those evaluated.

Keywords: Conventional tillage, Cultivars, Natural farming, Tillage, Zero tillage

Wheat (*Triticum aestivum* L.) is an essential cereal crop that makes a major contribution to the nutritional and food security worldwide. In India, wheat is a vital and the second most significant food crop after rice contributing about 35.27% of the total food grain production of the country. It is considered an excellent health-building food comprising roughly 12% protein, 78% carbohydrates, 2% fat and minerals, and a substantial amount of vitamins (Kumar *et al*. 2011). In India, wheat is grown on an area of 30,544 thousand ha with a total harvest of 1,06,413 thousand tonnes and an average productivity of 3,484 kg/ha (Singh 2022).

Traditional techniques of tillage are easy to use and generate a clean crop area. However for longer time period these practices were used to produce a variety of crops, including cereals, but now they are observed to be fuel and labour intensive methods. Unnotable risks of erosion subsist with traditional tillage. Agricultural trash and residue are embedded in the completely inverted soil, making the area susceptible to erosive effects from wind and water (Ankit *et al*. 2022a, Ankit *et al.* 2022b, Ankit *et al.* 2022c and Ankit *et al.* 2022d). Prolonged erosion adversely affects soil productivity. Conservation tillage can help overcome all of these challenges (Mathew *et al*. 2012)

Over the past few period, conservation agriculture (CA) techniques have obtained universality as farmer aims to lessen changing cultivation and energy costs, associated with soil preparation and planting of crop. These goals can be met by executing cultivation operations with reduced intensity. Among these techniques, zero tillage (ZT) has shown itself to be more practical, economical, and ecologically benevolent than conventional planting methods (Filipovic *et al.* 2004). Utilizing no-tillage and minimal tillage methods, which ensure appropriate sowing and successful germination by utilizing the soil's residual moisture, can lower production costs (Shilpa *et al.* 2021 and Manhas *et al.* 2024).

Breeders worldwide have created a number of disease-resistant, high-yielding wheat types. However majority of these cultivars and their agronomic practices have developed for use under traditional tillage. Different growth conditions can affect how well different varieties of wheat perform. The performance of wheat cultivars may be significantly impacted by changes in the field's microclimate caused by different cultivation techniques (Ankit *et al*. 2022c). Although very little work was done on this aspect at universal level with certain cultivars recommended for conservation tillage (Buczek *et al.* 2021) relatively very less research has been done in India. Therefore, it is crucial to do study on this innovative concept in one of the state's most important grain crop.

MATERIALS AND METHODS

The present experiment was conducted during winter (*rabi*) seasons of 2019–20 and 2020–21 at Chaudhary

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Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh,. The geographical area reflects the Himachal Pradesh mid-hills sub-humid zone, which has moderate summers and chilly winters. Micro-Kjeldahl's method (Subbiah and Asija 1956), the flame photometer method (AOAC 1970), and the ascorbic acid blue colour method (Olsen *et al.* 1954) were used to determine the field research site's phosphorus, nitrogen, and potassium contents, respectively. It was found that the soil had a silty loam texture, having *p*H 5.6, with available phosphorus (16.4 kg/ha), potassium (276.4 kg/ha), organic carbon (11.0 g/kg), and nitrogen levels (376.3 kg/ha) were moderate.

Throughout the trial, a split plot was employed. In the main plot, four methods of tillage were used ("zero tillage", "conventional tillage", "reduced tillage" and "natural farming"). Each of the main plots' sub-plots had three different kinds of wheat planted (HPW 349, HPW 368, and HS 562). Consequently, the experiment was duplicated three times, with each replication containing 12 treatment combinations. The wheat crop was sown at 20 cm spacing on the regular sowing dates, and it was grown using the suggested methods and materials. For wheat, the inorganic fertilizers such as urea, SSP, and MOP were applied at rates of 120:60:40 kg NPK/ha to all plots except those that were used for natural farming. During the planting and tillering phases, nitrogen was delivered in two splits, but phosphorus and potassium were given in full at sowing. On zero-tillage plots, paraquat was applied before planting. With the exception of the natural farming treatment, where weeds were removed by hand weeding, all wheat plots were treated with vesta (clodinafop propargyl + metsulfuron methyl) at a rate of 400 g/ha. In natural farming plots, all the recommendations given by natural farming expert Mr. Subhash Palekar (Palekar 2011) for such type cultivation was adopted.

The straw of rice @3 t/ha was applied in natural farming and reduced tillage. At physiological maturity, the number of effective tillers/m^2 was calculated from two randomly selected metre row lengths. Grain was physically separated from each of the 10 randomly chosen spikes, and the total number of grains was then counted. The number of grains/spike was calculated using the mean value of 10 spikes. From each plot, 10 spikes were chosen at random and threshed. The grains were weighed after being cleaned, and the grain weight/spike was calculated using the mean weight of 10 spikes. A representative grains sample was collected from net plot of each treatment at harvest, and a digital seed counter was used to count 1000 grains. Then 1000 grains were weighed on an electronic balance and expressed as 1000-grain weight.

Following the last harvest, the wheat crop was sun-dried before the weight was measured and reported as biological yield, which was subsequently translated to kg/ha. After threshing, the grains were washed and weighed. Grain weight was converted to kg/ha. The grain yield was adjusted at a moisture content of 14% after the moisture content of the grains was tested using a moisture meter. The yield at 14% moisture content was adjusted using the formula below:

$$\text{Grain yield (At 14\% moisture)} = \frac{[100 - \text{moisture (\%) in grain}]}{(100 - 14)} \times \text{grain yield at recorded moisture}$$

The straw yield was calculated and given in kg/ha by subtracting the grain yield from the biological yield. Gomez and Gomez (1984) methodology was used to statistically analyse the data. The critical difference (CD) was calculated for variables that had a significant impact at the 5% probability level.

Table 1 Effect of tillage methods on yield attributes of different wheat cultivars

Treatments	No. of effective tillers/m^2		No. of grains/spike		Grain weight/spike		1000-grain weight (g)	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
Main factor: Tillage methods								
Reduced tillage	283.9	282.7	52.94	54.21	2.21	2.32	40.39	41.27
Zero tillage	271.8	268.5	50.01	51.74	2.06	2.19	39.82	40.76
Conventional tillage	292.0	293.8	53.84	55.18	2.28	2.37	40.87	41.98
Natural farming	171.6	164.5	32.74	34.18	1.35	1.41	37.35	38.14
SEM±	5.4	5.7	1.39	0.91	0.05	0.04	0.27	0.32
CD (*P*=0.05)	18.6	19.7	4.83	3.16	0.16	0.14	0.92	1.10
Sub factor: Cultivars								
HPW 349	243.2	239.8	46.39	47.75	1.92	1.99	39.28	40.18
HPW 368	259.0	263.5	48.53	49.64	2.03	2.16	40.12	41.02
HS 562	262.3	253.8	47.23	49.09	1.98	2.06	39.43	40.41
SEM±	3.5	4.2	0.61	0.55	0.03	0.04	0.19	0.23
CD (*P*=0.05)	10.6	12.6	1.83	1.64	0.08	0.12	0.57	0.68

RESULTS AND DISCUSSION

Tillage methods and cultivars influence on yield attributes of wheat

No. of effective tillers/m²: Data on the impact of cultivars and tillage techniques on the quantity of efficient tillers/m² are shown (Table 1). A thorough examination of the data revealed that tillage practices and cultivars had a major impact on the number of effective tillers/m², with conventional tillage recording a much higher value of this parameter in both the 2019–20 and 2020–21 years. This treatment was comparable to zero tillage, which was comparable to reduced tillage. In the natural farming treatment, there were noticeably fewer effective tillers/m². Tillage possess the capacity to untie the soil particles, increase absorbency, and permit proper air exchange and growth of roots may be the reason for the larger number of effective tillers/m² observed in conventional tillage. More crop establishment and a higher number of panicles/m² value are the results of its enhanced root development, that enables to make a larger soil profile available for the plants water and nutrient absorption. These findings are consistent with those of Gupta and Seth (2007), Seth *et al*. (2019) and Aryal *et al*. (2022).

The wheat cultivar HPW 349 had a much lower number of effective tillers/m², while HS 562, which was still having a considerably greater number of efficient tillers than HPW 368 in both the 2019–20 and 2020–21 years. One possible explanation for the variations in effective tillers/m² between cultivars is their ability for tillering, which is mostly a genetic element.

Number of grains/spike: The number of grains/spike was shown to be strongly influenced by cultivars and tillage techniques, according to an analysis of the data in Table 1. Throughout the two study years, conventional tillage produced a noticeably higher quantity of grains/spike, which was roughly equivalent to reduced tillage. The treatment of natural farming had the notably lowest quantity of grains/spike. It has already been mentioned why conventional tillage produces more grains/spike. While HS 562 was comparable to HPW 368 among the wheat cultivars evaluated in both the 2019–20 and 2020–21 years, HPW 368 recorded a significantly greater number of grains/spike, and HPW 349 recorded a significantly lower number of grains/spike.

Grain weight/spike: A further examination of the data in Table 1 showed that cultivars and tillage techniques had a considerable impact on the weight of grains/spike. In both the 2019–20 and 2020–21 years, the natural farming treatment showed significantly lower grain weight/spike, while conventional tillage showed significantly higher grain weight/spike. Natural farming methods were unable to provide the wheat crops with the nutrients they needed, leading to a reduced grain weight per panicle and poor crop growth over the growing season. Improved soil chemical and physical characteristics, such as reduced bulk density and increased availability of macro and micronutrients as a result of improved aeration, lead to improved crop development, that may be the cause of the higher value of this parameter recorded in conventional tillage. The higher values of this parameter recorded in reduced tillage were due to the addition or incorporation of crop residue which on decomposition resulted in an increased supply of both macro and micronutrients which resulted in better growth. Also, the residue addition improved the soil's organic status, which resulted in better growth due to a better moisture regime throughout the growing season. These findings are consistent with those of Seth *et al*. (2019). The wheat cultivar HPW 349 had a much lower grain weight/spike than the other cultivars evaluated, whereas HPW 368 had a significantly higher number of grain weight/spike, comparable to HS 562 in both the 2019–20 and 2020–21 years.

1000-grain weight: Table 1 provides information on the impact of various treatments on 1000-grain weight. According to an analysis of the data, conventional tillage produced a far greater 1000-grain weight in both years, which was about equivalent to decreased tillage and the latter treatment was also comparable to zero tillage. In the natural farming treatment, this parameter's value was noticeably lower. The conventional, reduced, and zero tillage treatments recorded higher 1000-grain weight values than the natural farming treatment due to the optimum dosage of fertilizer application, which ensured a sufficient and sustained supply of nutrients throughout the crop cycle. A sufficient and steady supply of nitrogen and phosphorus remobilised the dry matter accumulation and increased photosynthetic efficiency brought about by these treatments' constant nutrient availability, resulting in bold grains and a greater 1000-grain weight. Natural farming practices failed to meet the nutrient needs of wheat crops, resulting in poor early development, reduced photosynthetic efficiency, and ultimately poor remobilization of photosynthates to the grain, which led to a significantly lower 1000-grain weight. Better aeration in root and shoot growth by conventional tillage may have contributed to the variations in 1000-grain weight across tillage treatments, whereas the addition of residue in reduced tillage treatment increased nutrient availability through crop residue decomposition, which raised 1000-grain weight. Similar results have been reported in a previous study by Seth *et al*. (2019) and Aryal *et al*. (2022). The 1000-grain weight of the cultivars varied significantly as well. While cultivar HPW 349 reported a lower 1000-grain weight, although this cultivar was comparable to HS 562 for this criterion, HPW 368 recorded a much greater 1000-grain weight in both years.

Tillage methods and cultivars influence on yield (kg/ha) of wheat

Grain yield: Table 2 provides an overview of data regarding the impact of various cultivars and tillage techniques on wheat grain yield. During the two experimental years, there was a notable difference in the wheat production due to tillage techniques and cultivar treatments. Conventional tillage produced noticeably more

Table 2 Effect of tillage methods on yield (kg/ha) of different wheat cultivars

Treatments	Grain yield (kg/ha)		Straw yield (kg/ha)		Biological yield (kg/ha)		Harvest index (%)	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
Main factor: Tillage methods								
Reduced tillage	4,334	4,203	6,227	5,874	10,561	10,077	41.03	41.72
Zero tillage	4,000	3,988	5,886	5,675	9,887	9,664	40.47	41.28
Conventional tillage	4,480	4,458	6,291	6,223	10,771	10,681	41.60	41.76
Natural farming	1,680	1,611	2,688	2,505	4,368	4,116	38.50	39.14
SEM±	72	78	111	94	178	165	0.18	0.21
CD (*P*=0.05)	250	270	384	327	615	571	0.62	0.78
Sub factor: Cultivars								
HPW 349	3,488	3,407	5,055	4,836	8,543	8,243	40.48	40.96
HPW 368	3,725	3,702	5,487	5,342	9,212	9,044	40.03	40.67
HS 562	3,658	3,587	5,277	5,030	8,935	8,617	40.70	41.30
SEM±	44	40	70	64	109	98	0.21	0.24
CD (*P*=0.05)	133	120	209	191	326	295	NS	NS

grain in both years, followed by reduced tillage, which was thereafter equal to zero tillage. During the two experimental years, natural farming had a noticeably lower wheat grain output. Grain yield under conventional tillage may be higher when contributing qualities or yield attributes have higher values. During field preparation, conventional tillage softens the soil. Crop roots grow more effectively in soft soil than in decreased or zero tillage. Increased root development facilitates the extraction of more nutrients from the soil, improving treatment growth and yield. Because of increased nitrogen immobilisation, leftovers from less tillage on the soil surface may initially hinder growth and ultimately lower output. Several researchers reported similar findings (Singh *et al*. 2006, Seth *et al*. 2019, Seth *et al*. 2020, Saini *et al*. 2022, Seth and Manuja 2022, Aryal *et al*. 2022, Ankit *et al.* 2023, Saini *et al*. 2023, Saini *et al*. 2024a, Saini *et al*. 2024b and Saini *et al.* 2024c).

Of the wheat cultivars examined, HPW 368 produced a noticeably larger grain yield, whereas HPW 349 produced a noticeably smaller yield. Having more effective tillers/m^2, more grains/spike, and a higher test weight all helped this cultivar produce the highest yield recorded in HPW 368. The yield of this cultivar was considerably reduced in HPW 349 when all of these characteristics had lower values.

Straw yield: An analysis of the data on how tillage practices and cultivars affected wheat straw production showed that both factors had a significant impact on this metric in both experimentation years (Table 2). The straw yield from conventional tillage was noticeably higher than that from decreased and zero tillage. When compared to natural farming, conventional tillage may result in higher straw output because of better root growth, greater nutrient availability and absorption, and higher photosynthetic activity. Similar findings have been reported in a previous study by Saini *et al*. (2022), Aryal *et al*. (2022), Seth and Manuja (2022), Ankit *et al.* (2023), Saini *et al*. (2023), Saini *et al*. (2024a), Saini *et al*. (2024b) and Saini *et al.* (2024c). A closer look at the data shows that the natural farming approach has a significantly lower wheat straw yield because it does not provide enough nutrients.

In both 2019–20 and 2020–21, HPW 368 outperformed the other cultivars in terms of straw yield, followed by wheat cultivar HS 562. Because of this cultivar's superior tillering capacity, which allowed it to make better use of the resources at its disposal, such as nutrients and radiation, HPW 368 produced more straw and had higher photosynthetic activity. The yield of straw in HPW 349 was noticeably reduced.

Biological yield: The effects of different tillage methods on the biological yield of different wheat cultivars are shown in Table 2. According to an analysis of the data, the natural farming treatment resulted in a significantly lower biological output of wheat in both research years, whereas conventional tillage yielded a much higher biological yield, followed by lowered tillage and zero tillage. A higher biological output under conventional tillage may result from increased photosynthetic activity, enhanced fertiliser availability and uptake, and increased aeration, which encourages better root growth and better starting growth.

The maximum biological yield of all the cultivars examined was found in HPW 368 during both experimentation years, followed by HS 562 and HPW 349. This cultivar produces more tillers, which increases leaf area and, ultimately, photosynthetic activity, which accounts for the increased biological output seen in HPW 368.

Harvest index: Table 2 displays the information related to the harvest index. Both years (2019–20 and 2020–21) has shown a considerable impact on the harvest index values acquired using various tillage techniques. Although this was equivalent to reduced tillage in the first year and to reduced tillage and zero tillage in the second year. Conventional tillage recorded a much higher harvest index in both years, while the natural farming treatment displayed a significantly lower harvest index. In traditional tillage, a greater harvest index value resulted from optimal photosynthetic transfer to

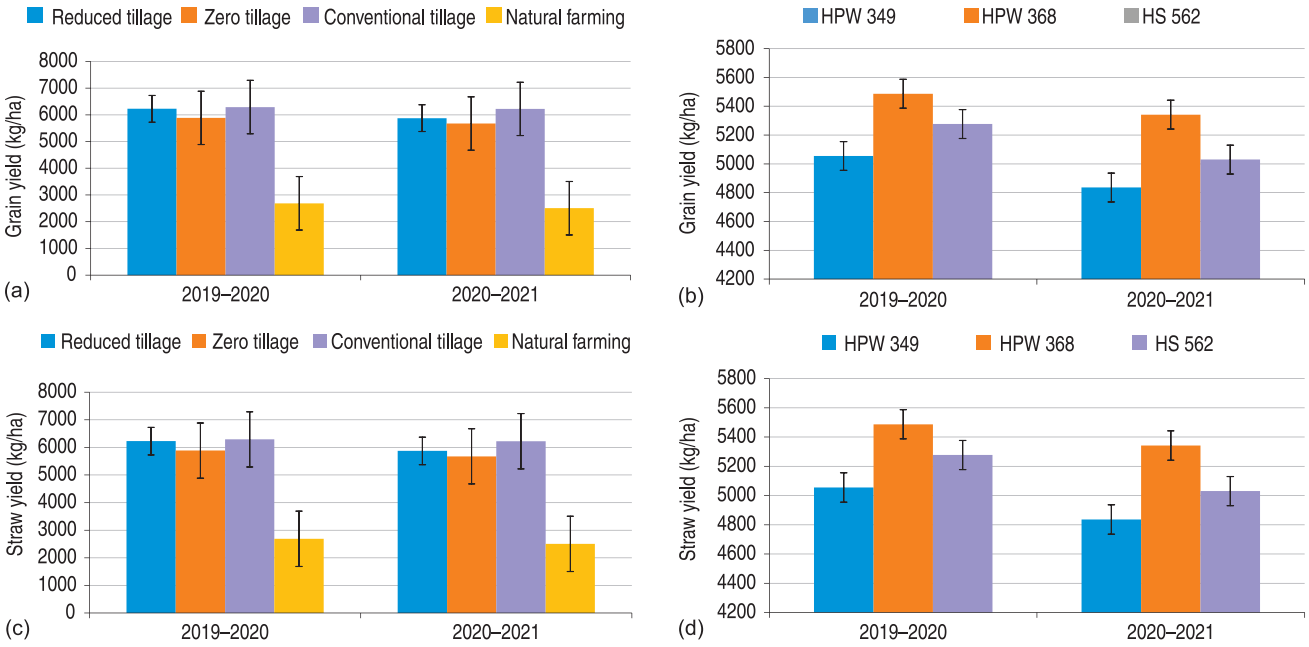

Fig. 1 (a) and (b) Effect of tillage methods on grain yield of different wheat cultivars; (c) and (d) Effect of tillage methods on straw yield of different wheat cultivars.

the economic component (grain) due to an adequate supply of nutrients during the blossoming and maturity phases. A reduced harvest index results from poor photosynthetic translocation caused by insufficient nitrogen and phosphate availability under natural farming conditions, especially during the flowering period. The cultivars examined for harvest index in the two years of the study, did not differ significantly from one another. More than a genetic trait, the harvest index focusses upon the accumulation of dry matter after heading and the remobilization into the grain. There was no discernible relationship between cultivars and tillage techniques for any of the yield characteristics listed above or for the wheat crop's yield.

From the present investigation it can be concluded that conventional tillage is a better option for obtaining higher wheat productivity as compared to conservation tillage (zero tillage and reduced tillage) in a shorter run though conservation tillage may give better yield if implemented over a longer period of time. Adoption of natural farming practices resulted in significant decline in wheat productivity, hence may not be recommended for this crop. All the cultivars evaluated in this study performed in a similar manner under different tillage practices with HPW 368 giving higher yield.

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