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Long term effect of different tillage systems on soil physical properties and yield of wheat

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Abstract

The one of the most predominant cropping systems of Indo-Gangetic Plains (IGP) of India is rice–wheat cropping system. Intensive tillage in this era of fast crop cycle resulted in declining of soil physical condition which causes stagnant productivity. Keeping in view the importance of the system for food security of the country, this research performed to investigate the effects of different soil tillage practices on soil physical properties, growth and yield’s components of wheat. This experiment was conducted with rotary tillage, and conventional tillage and four replicates in some of the farmlands of Malhendi village of shamli, UP during 2017-18 to investigate the effect of long term rotary tillage on physical fertility of soils and their effect on crop growth and yield of wheat under rice-wheat system. The results obtained showed that different soil tillage practices could cause significant changes in the soil bulk density, penetration resistance and crop growth and yield. The continuous rotary tillage (RT) for more than 10 years in wheat resulted in increase in bulk density and penetration resistance in subsoil layer depth as compared to conventional tillage (CT). This increased soil penetration resistance and effect of compact plough sole hindered root growth in deep soil layer under rotary tillage as compared to conventional tillage this two different systems of soil management significantly affect yield and yield components of wheat. In this case, the conventional tillage produced the increased level of grain yield (5909.63 kg.ha-1) as opposed to the rotary tillage system (4594.12 kg.ha-1). In the present study, the highest and lowest number of grains per spike, were obtained under the conventional tillage (46.38 grains per spike) and the rotary tillage (35.64 grains per spike) respectively. Also, highest and lowest levels of spikelet per spike were observed in the conventional tillage system (46.38) and the rotary tillage (37.24), respectively while spike length were (10.13cm) in conventional tillage and (8.14 cm) in rotary tillage systems. The grain weight per ear has been obtained in the conventional tillage system and the rotary tillage system were 2.99g & 2.73g while that of the1000 grain weight were 49.9g and 36.52g respectively. Similarly the plant height were observed in the conventional tillage (109.20 cm) and no tillage systems (98.25cm). On this ground of performance studies of longer time use of rotary tillage, some deep soil loosening tillage system combined with rotary tillage at certain specified interval of years may be better option.

Keywords: soil management, soil physical properties, wheat yield, rotary tillage, conventional tillage

Introduction

Soil tillage and management is the most important component of crop production, as it plays a vital role crop growth and crop yield economically. Various tillage methods greatly affect the physical and chemical properties which can make differences in plant establishment, root growth, aerial cover and eventually crop yield. There are wide range of tillage methods are practiced throughout the world such as no tillage, minimum tillage, conservation tillage and conventional tillage. In India, conventionally tillers and disc harrows are used for preparation of loose friable seed beds. Rotary tillage is a superior to conventional tillage methods and viable option to achieve maximum soil pulverization during seedbed preparation. It is also as an effective tillage tool in this intensive agriculture system because it pulverizeses soil in short time and saves 15-20 per cent of fuel. Rotary tillage has enormous potential for cutting, mixing topsoil and preparing the seedbed directly. Besides this it can be is used as both the primary and secondary tillage machine, which has additionally, mixing ability of rotary tillage is seven times more than that of a plough. As it prepares seedbed in single pass, it is considered to be time and energy efficient tillage implement. Thus, rotary tillage also reduces the time required to prepare an optimum seedbed by combining the primary and secondary tillage operations in one pass. Owing to these reason it has been in extensively used on Indian farms. Off course tremendous increase in agricultural mechanization occurred over the last decades leading to easier and fast operations. On the other hand there have been certain drawbacks related to it such as increasing risk of machine induced soil compaction.

As we know rotary tillage excessively pulverize the soil, which alters the soil structure and therefore altering the pore space in between the soil particles. So the time and frequency of tillage implements in tillage also affects crop yield as it loosens the top soil but tends to cause sub soil compaction. These implements increase the porosity and infiltration rates at the surface but may form a compacted layer below the tillage depth. The compacted layer is often referred to as hard pan. So the intensive use of rotary tillage have been certain drawbacks related to it such as degradation of the soil structure, which further leads to reduced crop yields. In recent years, rotary tillage has been in extensive use on Indian farms. Hence subsoil compaction due to continuous use of rototilling has been speculated as a serious problem in agriculture. Whereas, the rotary tillage not only compacted the 0-20 cm layer, but also induce to the compaction of the 20-30 cm layer. So the rotary tillage also becomes the intact part of tillage induced subsoil compaction. In fact severe use of rototilling and its longer run leads to destruction of soil aggregates. Even if, long term repeated tillage also oxidizes the natural binder organic matter that is crucial for soil aggregation which degrades the soil structure. The churning effect of tillage tools in the plough layer destroy the structure by exposing the soil organic matter to air making it dense and compact. Appropriate tillage can improve soil related constrains, whereas redundant tillage methods can cause a undesirable processes such as destruction of soil structure, reduction of organic matter, organic carbon and plant nutrients. Since soil compaction caused by rototiller becomes challenging the for the most part. With the above said information, there arises a need to determine soil compaction effected by continuous prolonged use of rototilling. Hence it is necessary to carry out investigation directed towards the extent of compaction caused by machinery such as rototiller and the effects of compaction on soil physical properties and crop growth. This may help in alleviation of compaction and the consequences of physical processes related to soil compaction.

Materials and Methods

For the present research work, the survey was conducted in the Saharanpur division (Shamli district) of the UP. Shamli district was selected on basis of intensive use of rotary tillage from last 10-12 years in rice wheat cropping system and some serious opinions from farmers of the region regarding bad impact of excessive use of it. Shamli forms a part of the Upper Indo-Gangetic plain region and lies between north latitudes $29^0$45’49.33” and $29^0$42’33.33” and it falls in Survey of India Toposheet No. 53G. Indo- Gangetic plain predominated in Rice -Wheat cropping system India and is considered as food bowl of India, as it contributes about 53 per cent of total area of rice and wheat crops. About 80% of the total geographical area of the shamli district is under cultivated area and agriculture is the backbone of economy. The main *rabi* crop is wheat while paddy is the main crops of kharif. Shamli has a monsoon-influenced sub humid and it is characterized by general dryness except in the brief period during the monsoon season the average temperature range is 28–38°C. The average annual rainfall is 869 mm. The maximum rainfall (80%) occurs during the monsoon period is June to September. July is the wettest month. Summer is hot and winter is pleasant cold season May is the hottest month. The mean daily maximum temperature is about 40^0C, mean daily minimum temperature is about 24^0C and maximum temperature some time rises to 44^0C In the winter seasons the temperature rests around 21^0 C & minimum temperature remains around 10^0 C. Rainy season commences in the middle of June & continues till September. January is the coldest month with mean daily temperature at about 20^0C and mean daily minimum at 7^0C. The air is dry during the major parts of the year. In southwest monsoon season, the air is very humid and April and May are usually driest months. The mean monthly relative humidity is 67%. The mean wind velocity is 6.70 Km.p/h. The potential evapotranspiration is 1545.90 mm. The rice and wheat crop yield in the area are dependent on climatic situation mainly on south west monsoon. In this study, three treatments and three replicates of each, were selected and examined in experimental design. The treatments included conventional tillage (CT), rotary tillage (RT). According to management systems implemented, three units of arable land were selected. In order to investigate the physical and chemical properties of various parts of the lands, nine random samples from each replicate were taken by the Auger of 0-25 cm depth and then transported to the laboratory for further analysis. To obtain soil weighted moisture content, the amount of 10 g of soil was poured into metal cans and was placed in the oven for 24 hours at a temperature of 110°C. Once cooled, the moisture content was calculated based on the oven-dried soil. To determine yield components at the beginning of each iteration, wheat was harvested from four plots of 1 × 1 m and weighed. After weighing the sample, trial combine was used to separate the grains. To determine stem height, number of 15 samples were randomly picked from each plot and measured and the obtained value was assigned as the average height of each plot. To determine spike length, number of 15 samples were randomly picked from each plot and measured and the obtained value was assigned as the average spike length of each plot. To determine number of grains in each spike, number of 15 samples were randomly picked from each plot and measured and the obtained value was assigned as the average number of grains in each spike of each plot. In the middle of each plot 3 samples of 1m2 were selected and its plants were harvested in order to obtain the yield. Harvested Plants were weighed and expressed as the biological performance. Plants in the plots of 1 × 1 m were threshed by the trial combine, and the threshed grains were weighed and by identifying the difference between biological performance (Straw + grains) and grain yield, produced straw was calculated for each hectare of the field. To determine the amount of the thousand grain weight, one thousand grains were separated by means of a counting machine and weighed. Once plants are matured, being concurrent with yellowing leaves, spikes and stems as well as grain hardening time, they were harvested by hand with a scythe. Traits measured in this experiment are some morphological characteristics (number of tillers, plant height) and some agronomic traits (thousand grain weight, seed yield, biological performance and harvest index) of wheat plants.

Results and Discussion

The results of variance analysis showed that tillage systems have a significant effect on the amount of soil bulk density at the level of 5%. In mean comparison of this variable based on the showed that the highest value found in rotary tillage while and lowest amount of bulk density exist in conventional tillage systems (Table 2).Using rotary tillage lead to lower bulk density in top soil strata and also high soil porosity due to high production of soil aggregate and upturning topsoil. There is increase in bulk density in lower subsoil layer. This is due to that the large number of passes of rotary tilling influenced the bulk density at different soil depth layers. This is also in support of study as reported by Abdel- Galil (2007) that successive passes of the rotary tilling reduced the soil bulk density in the upper horizon i.e, 0-20cm. It was found that there is higher reduction in soil bulk density and cone index values when tilling at moderately higher moisture levels. This results are in accordance with Wang *et al*. (2015) and Hugo *et al*. (2013). It was observed that, soil cone index decreased in depth of 0-15 cm and remained stagnant beyond 15 cm. The number of passes and soil moisture content influenced the cone index values as observed by Mustafa and Nihat (2007) and Makange and Tiwari (2015). findings. In lower depth high compression and soil bulk density are created due to the traffic of machines. They stated that the amount of soil porosity in rotary tillage is higher than conventional tillage system due to using rotavator blades that convert soil to lower aggregates and decrease soil compression subsequently. Different tillage methods had significant effects on soil moisture content such that there was highest soil moisture content in case of conventional tillage treatments. This was due to fact that diminishing of soil compaction leads to increase of spaces among aggregates in conventional tillage system results in increasing soil moisture content. It was also found that the effects of decreasing soil compaction on soil moisture is very high in short time. This result is supports with the findings of Rahimzade and Navid (2011) [8]. Mean comparison of soil physical properties viz bulk density and penetration resistance under tillage systems using t test assuming equal variance.

Table 1: t-Test of bulk density: Two-Sample

t-Test: Two-Sample Assuming Equal Variances		
	CT	***RT***
Mean	1.54687	1.622744
Variance	0.004622	0.015463
Observations	27	27
Pooled Variance	0.010043	
Hypothesized Mean Difference	0	
df	52	
t Stat	-2.78184	
P(T<=t) one-tail	0.003757	
t Critical one-tail	1.674689	
P(T<=t) two-tail	0.007513	
t Critical two-tail	2.006647	

Table 2: t-Test of penetration resistance

t-Test: Two-Sample Assuming Equal Variances		
	CT	***RT***
Mean	1861.488	2383.698
Variance	727963.2	1573487
Observations	43	43
Pooled Variance	1150725	
Hypothesized Mean Difference	0	
df	84	
t Stat	-2.25724	
P(T<=t) one-tail	0.013294	
t Critical one-tail	1.663197	
P(T<=t) two-tail	0.026588	
t Critical two-tail	1.98861	

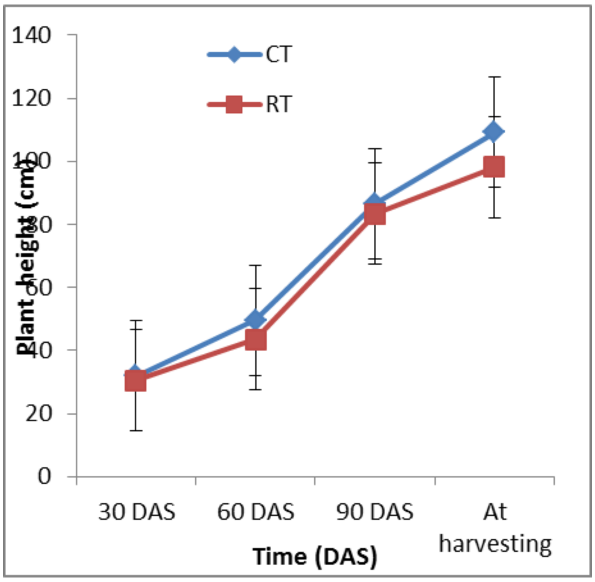

Fig 1: plant height at different growth stages under two tillage system

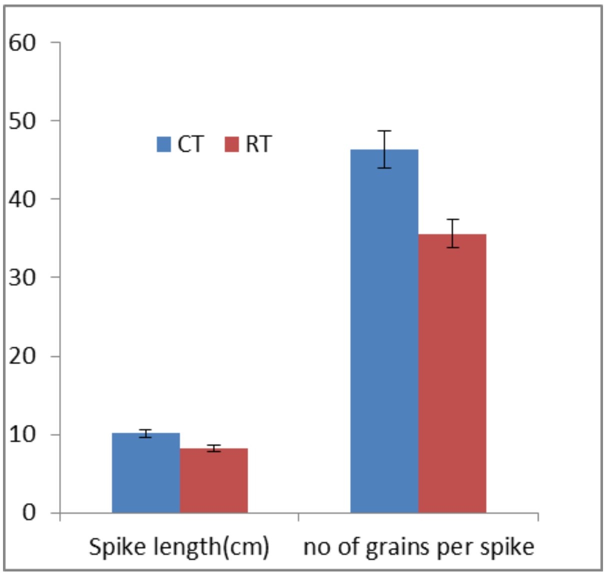

Fig 2: Spike Length and number of grains per spike under different tillage system

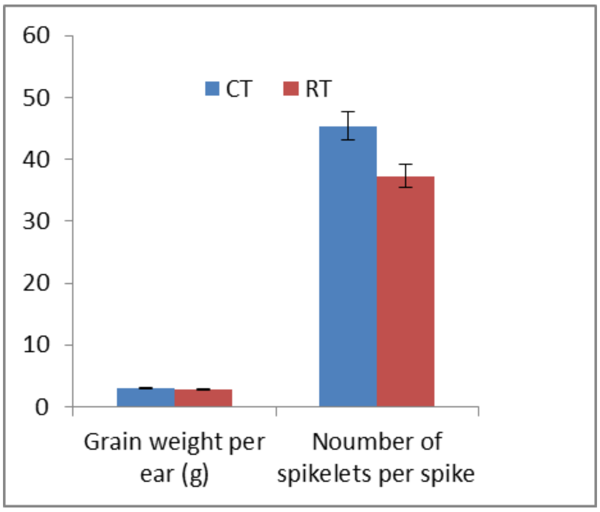

Fig 3: Grain Weight per ear and Number of Spikelets per Spike under different tillage system

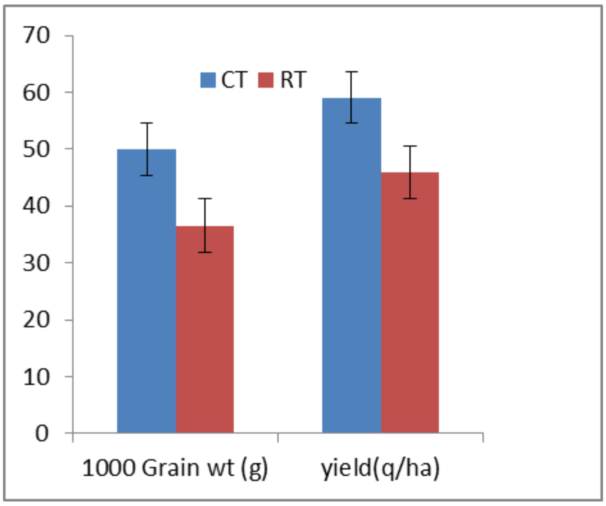

Fig 4: Thousand grain weight and yield per hectare under different tillage system

On the basis of data analysis concerning biological performance of wheat under different tillage system of the study, it was found that different methods of tillage have significant effect on yield.

In the present study, the highest grain yield was obtained in the conventional tillage (5909 kg ha) and the lowest grain yield per square meter in rotary tillage system (45.94 kg per ha). Sadeghnejad and Islami (2006) [9] in their studies found that reducing tillage operations, and addition to the compaction of soil clods could make a reduction in the yield. In his study also found that the continuing tillage operations at same depth on fine textured soils result in compaction which leads to poor aeration and reduces yield. Periodic use of the moldboard will enhance performance. Conventional tillage leads to less soil compaction and penetration resistance which allow the plant roots in the lower depths of soil profile, causes root development and improves available water and soil root environment this could improve yield. The results of Sadeghnejad and Eslami (2006) [9], are similar to the results of this study and confirmed our results in the field of product yield.

In the present study, the highest and lowest number of grains per spike, respectively, were obtained under the conventional tillage (46.38 grains per spike) and the rotary tillage (35.64 grains per spike). Also, highest and lowest levels of spikelet per spike were observed in the conventional tillage system (46.38) and the rotary tillage (37.24), respectively.in present study the highest and lowest levels of spike length were observed in conventional tillage (10.13cm) and rotary tillage systems (8.14 cm) respectively. In this study the grain weight per ear has been obtained in the conventional tillage system and the rotary tillage system were 2.99g & 2.73g respectively while that of the1000 grain weight were 49.9g and 36.52g respectively. While the highest and lowest levels of plant height was observed in the conventional tillage (109.20 cm) and no tillage systems (98.25cm).

Conclusion

In long run of rotary tillage at same depth leads to subsoil compaction and have inhibitory effect in various ways including grain yield, number of panicles per unit area, number of grains per panicle, thousand grain weight, straw weight and harvest index. In general, according to the results of this study it could be concluded that the reduction in yield and yield components of wheat under rotary tillage systems are due to the following reasons, Soil bulk density in rotary tillage system was greater than those of conventional tillage system which indicates the existence of hard layers due to constant shallow plow at this soil depth under this treatment. Effect of soil compaction on root growth may directly be affected by the mechanical strength of soil or indirectly by soil oxygen and nutrient availability and soil water status. Although conventional tillage in present study lead to higher performance. Therefore, the authors propose that some deep soil loosening tillage system combined with rotary tillage at interval of 3-4 years may be better system. So such studies for longer timescales and for different environmental and climatic conditions may be needed.

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