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Effect of tillage practices on productivity of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted at the research farm of ICAR-Indian Agricultural research Institute, New Delhi during the *rabi* season 2014-15 to study the effects of various tillage practices on biophysical parameters, yield attributes and yield of wheat in pigeonpea-wheat cropping system. The experiment was conducted in a randomized block design (RBD) replicated thrice. The following treatments were included such as zero tilled permanent narrow bed (PNB), zero tilled permanent narrow bed plus residue (PNB+R), zero tilled permanent broad bed (PBB), zero tilled permanent broad bed plus residue (PBB+R), zero tilled flatbed (ZT), zero tilled flatbed plus residue (ZT+R). The yield attributes *viz*. plant height, plant biomass, leaf area index (LAI) *etc.* were significantly influenced with tillage practices. Yield was recorded significantly higher under PBB+R followed by ZT+R, ZT, PBB, PNB+R, PNB and CT.

Key words: Biomass, LAI, plant height, tillage, wheat, yield attributes and yield.

Wheat is grown on 29 M ha and meets the nutritional requirement of majority of the people. The crop contributes towards the livelihood of a large number of people in India. It is sown mainly through intensive tillage agricultural practices. There are various constraints under traditional/ conventional agricultural practices like soil degradation & compaction, depletion of water resources and loss of biodiversity *etc*. In the western Indo-Gangetic Plains (IGP), water is increasingly becoming scarce because agriculture is facing rising competition from the urban and industrial sectors (Toung and Bhuiyan, 1994). In many parts of the region, over-exploitation and poor groundwater management has led to decreased water table and negative environmental impacts (Saharawat *et al.*, 2010). Deterioration of land quality due to different forms of soil degradation and excess residue burning are other pervasive problems in the region (Das *et al.*, 2013). These factors lead to consideration of conservation agriculture (CA) for sustained productivity, profitability and soil quality (Kassam *et al.*, 2011). CA has three principles: (i) minimizing mechanical soil disturbance; (ii) cover crops and / or crop residues (mainly residue retention); (iii) diversification of crops in associations, sequences and rotations to enhance system resilience (FAO, 2011). CA reported to enhance soil organic carbon (SOC) content, input use efficiency and has the potential to reduce greenhouse gas emissions (Bhattacharyya *et al.*, 2013). Baumhardt and Jones (2002) reported that no-tillage +crop residue management better than tillage for dry land crop production. No-tillage and crop residues retention on soil surface enhanced the organic matter in cultivated soil (Lal *et al.*, 2003) and found more suitable in dry land crop production (Baumhardt and Jones, 2002) because of moisture conservation (Lampurlanes *et al.*, 2001).

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This research paper mainly for analysis of different conservation practices and their impact on biophysical parameters and production of wheat crop in semi-arid region.

Materials and Methods

The experiment was conducted at Indian Agricultural Research Institute (IARI), New Delhi. The soil sample was taken after the uniformity trial from 0-15 cm soil layer of the experimental site. Soil was sandy clay loam in texture, with pH 7.7, Walkley-Black C (oxidizable SOC) 5.2 g kg^{-1}, EC 0.64 dS m^{-1}, $KMnO_4$ oxidizable N 182.3 kg ha^{-1}, 0.5 M $NaHCO_3$ extractable P 23.3 kg ha^{-1} and 1 N NH_4OAc extractable K 250.5 kg ha^{-1}. The soil contained sufficient amounts of $CaCl_2$ extractable S and DTPA extractable micronutrients as all of these were above the critical deficiency limits. The climate of the research farm is semi-arid with dry hot summer and cold winters. May and June are the hottest months with mean daily maximum temperature varying from 40 to 46°C, while January is the coldest month with mean daily minimum temperature ranging from 6 to 8°C. The mean annual rainfall is 710 mm, of which 80% is received during the southwest monsoon from July to September, and the rest is received through the 'Western Disturbances' from December to February. Air remains dry during most part of a year. The mean wind velocity varies from 3.5 km h^{-1} during October to 4.3 km^{-1} in April. The pan evaporation varied between 3.5 and 13.5 mm d^{-1} and reference evapo-transpiration from 9 to 15 mm d^{-1}. The weather condition during crop growing period is shown in fig. (1). During *Rabi season* 2015-16, wheat (*Triticum aestivum* L.) variety HD 3117 shown on 11thDecember. The field experiment was conducted with seven treatment combinations which were conventional treatment (CT), zero tilled permanent narrow-bed (PNB), zero tilled permanent narrow-bed sowing with residue retention (PNB + R), zero tilled permanent broad-bed (PBB), zero tilled permanent broad-bed with residue (PBB + R), zero tilled flatbed (ZT), zero tilled flat bed with residue (ZT+R) arranged in a RBD with three replications. The plot size was 9·0 × 8·4 m^2. In PNB plots, there were 12 narrow beds and in PBB, there were six broad beds. In PBB plots, there were five wheat rows within nearly110 cm broad beds (110 cm bed and 30 cm furrow), whereas in PNB plots there were three wheat rows within 40 cm narrow beds (40 cm bed and 30 cm furrow).A common fertilizer dose of 120 kg N : 60 kg P_2O_5 : 40 kg K_2O / ha was applied, of which the total amount of P and K were applied as a basal dressing along with 50% of total nitrogen (N), while the remaining N was top-dressed in two equal splits after the first and second irrigations.

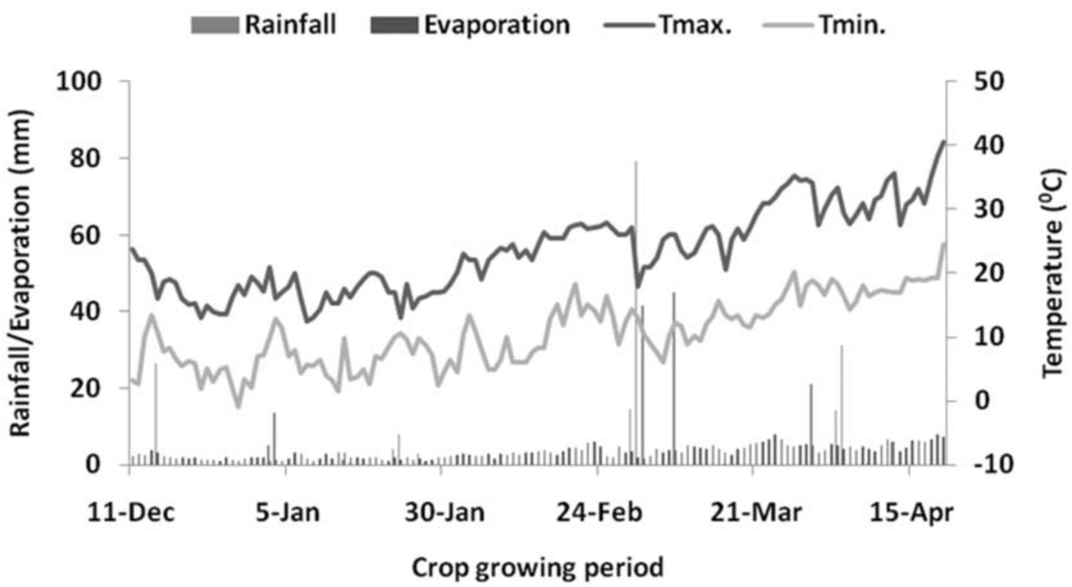

Fig. 1. Daily weather data during *rabi* season (2014-15)

Observations on different crop growth parameters such as leaf area index, plant height, biomass, and yield etc were recorded at different crop growth stages. The leaf water potential was measured with the help of pressure bomb (PMS Instruments Co, USA). The plant height was measured from three randomly selected plants with help of digital scale.

Relative water content (RWC) was calculated using the following formula.

$$\text{RWC (Relative water content): } \frac{\text{Fresh wt - Dry wt}}{\text{Turgid wt - Dry wt}} \quad ..(1)$$

Chlorophyll content measured using Spectrophotometer Spectronic-20. The total chlorophyll content was calculated using the following formula.

$$\text{Total Chlorophyll content (mg/g of fresh weight)} = \frac{[20.2\text{x}A_{645} + 8.02A_{663}]V}{100\ W} \quad (2)$$

where, A_{645} = Absorbance at 645 nm, A_{663} = Absorbance at 663nm, V = Final volume of chlorophyll extract in DMSO and W= Weight of plant sample

For biomass three plants were selected randomly in each plot and oven dried at 65°C for 48 hours or more and weighed by using electrical digital balance until a constant weight was achieved. Dry biomass produced was expressed in g m^{-2}. Grain yield were measured after harvest. Statistical analysis *viz.*, computation of correlation coefficients, critical difference and student t test was carried out using Excel and SPSS packages (Version 10.0). The required graphs were drawn using MS Excel software packages.

Results and Discussion

Plant growth parameters

Plant height

Tillage treatments significantly influenced plant height during the experiment, the highest plant height was observed under PBB+R followed by ZT+R and ZT. The plant height was 25% higher under PBB + R and 23% under ZT+R over the conventional tillage practice treatment which recorded lowest height (Fig. 2). Pervaiz *et al.* (2009) also reported that maize grew taller under greater mulch levels because of availability of more soil moisture contents for plant growth under mulch condition influenced the plant height.

Biomass

Wheat biomass starts with slow in initially growth phase till the end of thirty days after sowing followed by a rapid growth in all

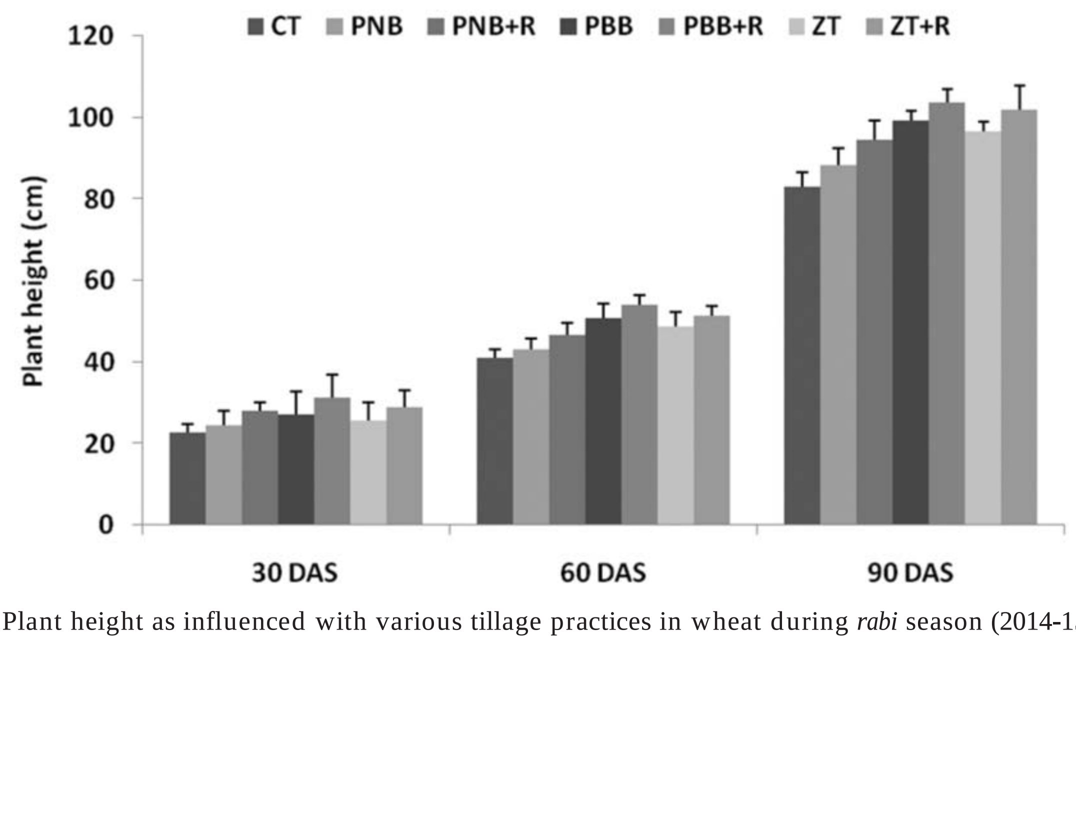

Fig. 2. Plant height as influenced with various tillage practices in wheat during *rabi* season (2014-15)

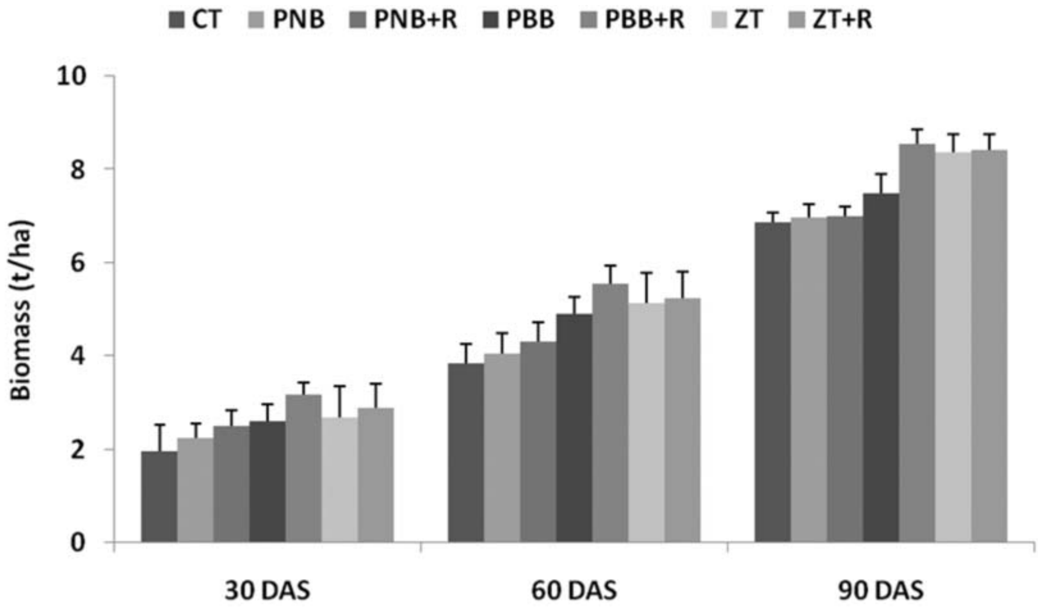

Fig. 3. Biomassas influenced with various tillage practices in wheat during *rabi* season (2014-15)

treatments. PBB+R, ZT+R and ZT treatments were remained at par in term of biomass accumulation at 30, 60 and 90 DAS. The highest biomass was recorded in PBB+R treatment followed by ZT+R. PBB+R treatment enhance the biomass accumulation by 29% as compared to CT treatment at 90 DAS (Fig. 3). Moreno *et al.* (1997) recorded marginally higher biomass in wheat and sunflower in the conservation tillage treatment (CT) than in the traditional tillage.

Leaf area index (LAI)

The leaf area index is an important parameter for the crop growth studies since it is useful in interpreting the capacity of a crop for producing dry matter in term of the intercepted utilization of radiation and amount of photosynthesis synthesized. The lowest LAI was recorded under CT treatment. LAI was found maximum at 90 DAS, increase in leaf area index was 21% higher under PBB+R treatment followed by 15% under

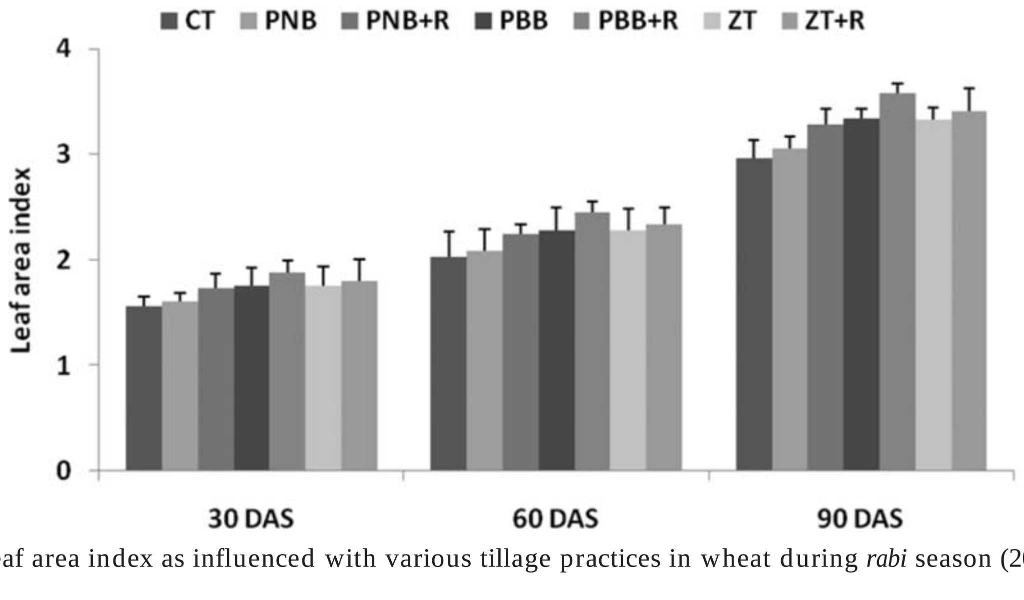

Fig. 4. Leaf area index as influenced with various tillage practices in wheat during *rabi* season (2014-15)

ZT+R treatment as compared to CT treatment (Fig. 4). Increased quantity of surface residue was found to have a significant effect on plant available water, thus lowering the water stress and causing increase in LAI (Scopel *et al.*, 2004). The leaf area indices of cassava and sweet potato were increased by 21% in cassava and 10% in sweet potato under incorporation of legume leaf mulchrevealed by Sangakkara *et al.* (2004).

Relative water content and water potential

The various tillage practices significantly improved the soil hydrological properties which effect relative water content (RWC) in crops. RWC was measured at different days after sowing in the plant grown under different conservation practices during rabi season. At initial vegetative phase maximum RWC observed which gradually decreased upto physiological maturity. Result showed that maximum RWC found under PBB+R treatment followed by ZT+R, ZT. Wheat RWC values wasincreased10-14% under PBB+R and ZT+R treatments. These treatments perform similar in case of RWC values and had significantly higher RWC than other treatments (Fig. 5).

Water potential

It is widely used to quantify the water deficits in leaf tissues; it measures the energetic status of water inside the leaf cells. This showed that due to deteriorated soil condition in conventional treatment plants are in more stress than the plant grown under other conservation treatments. Lowest water potential found under CT treatment which performs similar to PNB treatment. Increase in water potential of wheat as compare to CT was around 10-14% under PBB+R and ZT+R treatments (Fig. 6). Li-Ping *et al.* (2006) observed that RWC of corn was reduced from 92.8% to 79.9% under adequate water to severely stressed conditions at silking stage of corn growth. Similarly Flexas *et al.* (2006) also observed that leaf and shoot RWC decreased by 75% under water stress.

Chlorophyll content

The Chlorophyll was significantly influenced with tillage practices. The highest chlorophyll content in wheat under pigeon pea-wheat cropping system was found under PBB+R treatment (14-20%) as compared to CT treatment (Fig. 7). Boomsma *et al.* (2009) who stated that

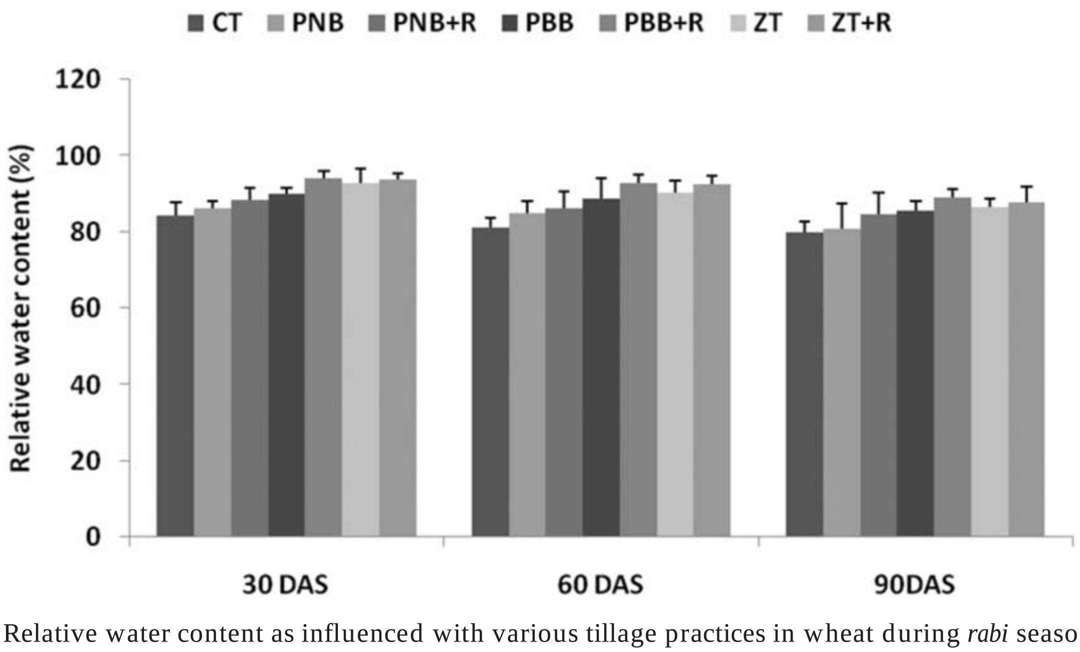

Fig. 5. Relative water content as influenced with various tillage practices in wheat during *rabi* season (2014-15)

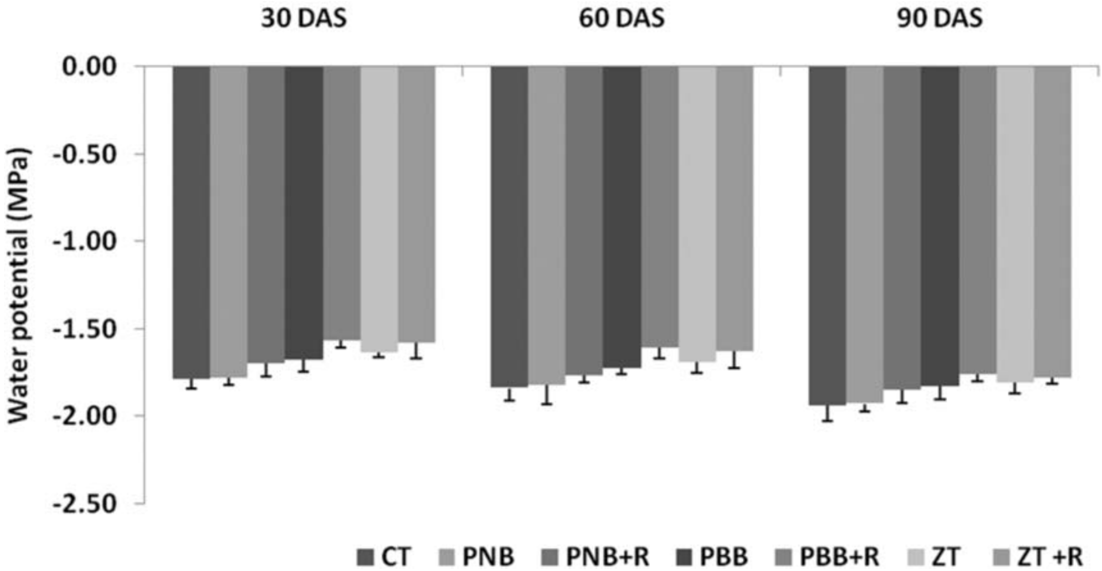

Fig. 6. Water potential as influenced with various tillage practices in wheat during *rabi* season (2014-15)

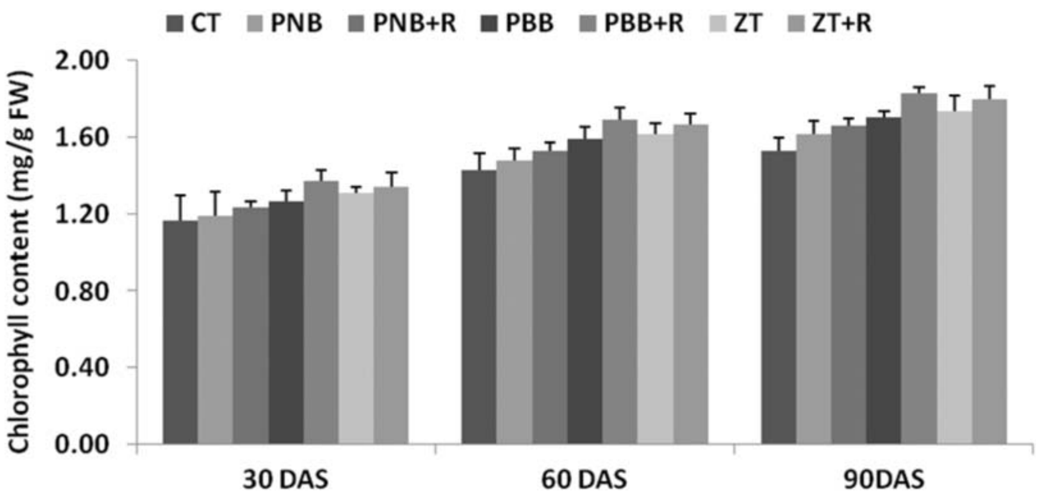

Fig. 7. Chlorophyll content as influenced with various tillage practices in wheat during *rabi* season (2014-15)

zero tillage maize grownup took the nitrogen and water up to 40 cm depth which increased chlorophyll contents and thus causing more protein contents.

Yield and yield attributes

The number of spikes / m^2 was found higher in PBB+R treatment (365) followed by ZT+R (358) and ZT (351). PBB+R, ZT+R, ZT treatments were found at par in case of number of spikes / m^2. The numbers of grains / spike were obtained greater in conservation treatments (45.7-49.1) than CT. Maximum grains / spike under PP+B treatment (49.1) and lowest value found under CT treatment (43.9) (Table. 1). The 1000-seed weight within different treatments had range between 40.8-43.1g. 1000-seed weight had highest value under PBB+R treatment but values of 1000-seed weight had no significant difference among all treatments. No-tillage and crop residues retention on soil surface enhanced the organic matter in cultivated soil (Lal *et al.*, 2003) and was more beneficial for dry land crop production (Baumhardt and Jones, 2002) because of moisture

Table 1. Effect of various tillage practices on yield and yield attributes of wheat.

Treatment	Plant height at flowering stage (cm)	Spikes m^{-2}	Grains $spike^{-1}$	1000-seed weight (g)	Grain yield (kg/ha)
CT	82.9	308.48	42.9	40.3	4533
PNB	88.3	322.67	43.6	40.7	4873
PNB + R	94.6	337.31	44.2	41.2	4877
PBB	99.4	343.74	44.9	43.3	4950
PBB + R	103.8	376.82	50.3	43.9	5308
ZT	96.7	351.13	46.7	43.1	5071
ZT + R	101.86	362.13	48.3	43.4	5243
SEm±	2.68	9.73	1.26	1.19	176
LSD(0.05)	7.8	26.18	3.91	NS	517

conservation (Lampurlanes *et al.,* 2001).The highest grain yield was obtained under PBB+R (5294 kg/ha) followed by ZT+R (5174 kg/ha), ZT (5012kg/ha) and PBB (4912 kg/ha). PBB+R treatment had 19%, ZT+R had 16%, ZT had 12% and PBB had 9% higher yield as compared to CT treatment. Izumi *et al.* (2004) reported that uninterrupted no-tillage practice progressively enriched the soil state for the root system development and also, improve the crop growth and yield, through improving the growth attributes.

Conclusion

It was observed that among all the conservation treatments permanent broad bed with residue (PBB+R) was better than other treatments followed by zero tilled flatbed plus residue (ZT+R), zero tillage flatbed (ZT), permanent broad bed (PBB) in wheat crop. The yield increases under CA can be substantial and depend on local conditions and weather with considerable variation in yield benefits. CA offers the promise of a locally adapted, low-external-input agricultural strategy that can be adopted by resource-constrained farming communities, as well as by those with access to different levels of mechanization and external inputs.

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