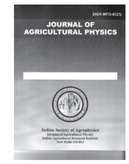
Vol. 17, No. 1, pp. 96-104 (2017)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in



Research Article

Effect of Different Conservation Practices on Growth and Yield of Wheat (*Triticum aestivum* L.) Crop

REKHA KUMARI MEENA[1], ANANTA VASHISTH[1]*, P. AGGARWAL[1], R. BHATTACHARYYA[2], T.K. DAS[3] AND S.D. SINGH[2]

[1]*Division of Agricultural Physics, ICAR-Indian Agricultural Research Institute, New Delhi-110012*
[2]*Division of CESCRA, ICAR-Indian Agricultural Research Institute, New Delhi*
[3]*Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi*

ABSTRACT

An experiment was conducted to found out suitable resource conservation technology during the *rabi season*, 2014-15 at the research farm of ICAR-Indian Agricultural research Institute, New Delhi to evaluate the effect of various tillage practices on micrometeorological and biophysical parameters of wheat crop in pigeonpea-wheat cropping system. The crop was sown under conventional and different conservation practices 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 flat bed (ZT), and zero tilled flat bed plus residue (ZT+R). Results showed that under different conservation practices, crops had better growth as compared to conventional tillage system. Conservation practices helped to improve crop productivity by modification of soil physical environment like moisture retention capacity, soil temperature etc., and thus might be recommended for semi-arid regions in India.

Key words: Wheat, Conservation practices, micrometeorological and biophysical parameters, yield

Introduction

Conservation agriculture (CA) is the application of modern agricultural technologies that water to improve production, while at the same time, protecting and enhancing the land resources on which production depends. Zero tillage, along with other soil conservation practices, is the cornerstone of CA (Dumanski *et al.* 2006). Positive changes in soil quality, in terms of physical structure, infiltration rates and carbon content as a result of CA, have been reported (Nyamadzawo *et al.* 2012). CA also promotes the optimization of yields and profits, typically decreases, labor demands which become more flexible, while the capacity of smallholder farmers to attain family food security increases. This approach is relevant, especially with the general consensus on increasing year-to-year variability in precipitation which lead to increase in both inter- and intraseasonal drought and flood events and high uncertainty about the onset of the rainy seasons. Yields for staple cereals are predicted to fall sharply with a 1-2°C change in temperature, compounded by more erratic rainfall patterns (Stige *et al.* 2006). Current dry spells lasting for more than 14 days in the basin occur every 2 years (Magombeyi and Taigbenu 2008; Mupangwa *et al.* 2011). This is likely to have an impact on the socioeconomic and cultural development of poor rural communities. Bouzza

*Corresponding author,
Email: ananta.iari@gmail.com

(1990) found that water storage increased from 50 to 85 mm as a result of surface applied straw as compared to conventional treatment. The no-tillage + crop residue management is potentially found better than tillage for dryland crop production (Baumhardt and Jones, 2002) because it maintained greater water content in the soil and greater root growth especially in years of low rainfall (Lampurlanes *et al*., 2001). Soil moisture storage under crop residue improved both the PARi (intercepted photoactive radiation) and RUE (radiation use efficiency), thereby significantly increasing the grain yield, probably because it stimulated physiological processes after soil drying episodes, leading to compensation or overcompensation in plant growth and grain yield (Deng *et al.*, 2006). Scopel *et al.* (2004) studied the effect of mulch on radiation and found that interception was significant and varied with residue quality and with the percentage of soil cover. The improvement in soil tilth, especially below seeding depth tended to promote root growth and seedling development, as shown by Zhang *et al*. (2006). Use of correct tillage methods may contribute to higher profits, crop yields, soil improvement and protection, weed control and optimum use of water resources since tillage has a direct impact on soil and water quality (Hanna *et al*., 2009). The current study discusses analysis of micrometeorological parameters under different conservation practices and their impact on biophysical parameters and production of wheat crop in a semi-arid region of Delhi. The objective was to quantify the eco-physiological responses of wheat to different conservation practices and conventional treatment.

Materials and Methods

The present study was carried out in the experimental farm of the Indian Agricultural Research Institute (IARI), New Delhi. The soil type is alluvium and texture is sandy clay loam (fine loamy, illitic, Typic Haplustept) with medium to weak angular blocky structure. The soil is non-calcareous and neutral in reaction and poor in available N, medium in available P and organic carbon. Water table of this site remained below 3.5 m deep from ground surface during crop growth period. During *rabi* 2014-15, wheat (*Triticum aestivum* L.) var. HD 3117 shown on 11th December with seven treatment combinations viz., 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 flat bed (ZT FB), zero tilled flat bed with residue (ZT FB+R)], arranged in a randomized block design (RBD) with three replications. Weather parameters like temperature and relative humidity were measured by pocket weather tracker at 11 A.M. and soil moisture measured by the gravimetric method. Weather condition during crop growing period is shown in Fig. 1. Observations on different crop growth parameters such as leaf area, biomass, yield were recorded at different growth stages. For biomass, three plants were selected randomly from each plot and oven-dried at 65°C for 48 h and weighed until a constant weight was achieved. Dry biomass produced was expressed in g m^{-2}. Seed yields were measured after harvest.

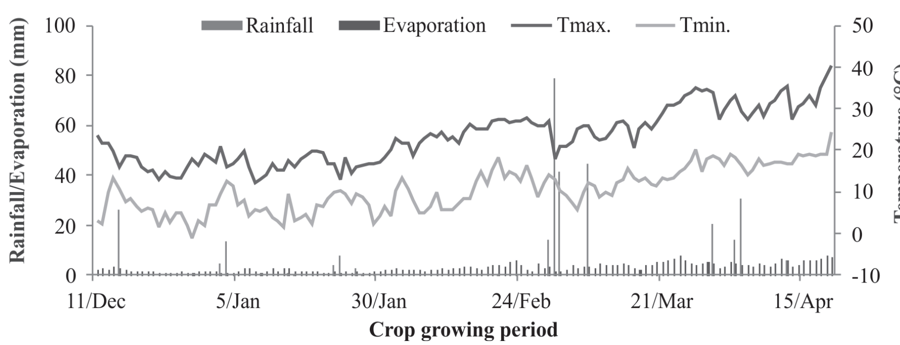


Fig. 1. Daily weather data during crop growing period

Leaf water potential was measured with the help of pressure bomb (PMS Instruments Co, USA) using the method of Scholander *et al* (1964).

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

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

Chlorophyll Content measured using Spectrophotometer Spectronic-20. The total chlorophyll content was calculated as:

Total Chlorophyll content (mg/g of fresh weight) =

$$\frac{[20.2xA_{645} + 8.02A_{663}]V}{1000W} \quad \ldots(2)$$

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

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 package.

Result and Discussion

Soil moisture and soil temperature

Soil moisture content had the highest values under ZT+R treatment and ZT, PBB+R, CT treatments had no significant difference in soil moisture content. The lowest amount of soil moisture was recorded under PBB followed by PNB treatment. The ZT+R had 8% higher moisture content than CT, while PNB+R had 6.5-8.4%, PBB 10-14% and PNB 19-22% lower soil moisture compared to the corresponding values in the conventional treatment (Fig. 2). Under wheat crop, maximum temperature was found under PNB treatment. Decrease in temperature was 0.4-0.7 °C under PBB, 0.9-1.62 ^{0}C under CT, 1.3-2.2 °C under ZT, 1.9-2.8 °C under PNB+R, 2.3-3.1 °C under PBB+R, 2.6-3.4 °C under ZT+R compared to PNB treatment (Fig. 3). Surface residue reflects solar radiation and insulates the soil surface to reduce the soil temperature (Shinners *et al*., 1993; Van Wijk *et al*., 1959). Crop rotation can help in enhancing the soil water content and availability especially in rainfed agriculture (Roder, 1989).

Biomass

Wheat biomass starts with an initially slow growth phase till the end of vegetative stage followed by a rapid increase in tassel stage initiation, and continued till physiological maturity stage in all treatments. Lowest biomass was found under ZT NB treatment followed by CT. Increase in wheat crop biomass as compared

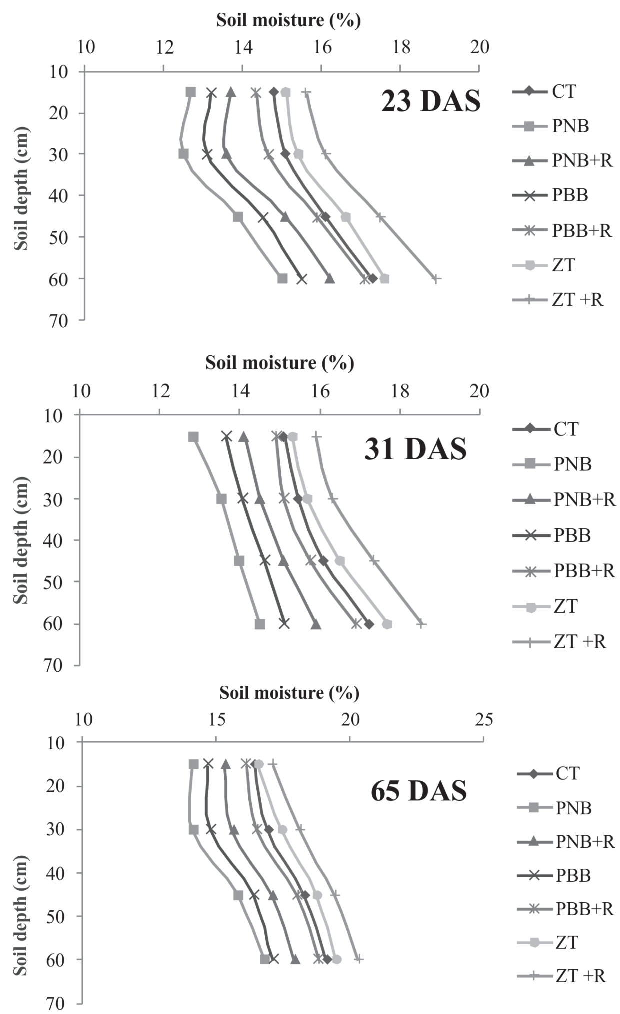


Fig. 2. Soil moisture under different conservation practices and conventional treatment in wheat during crop growing season

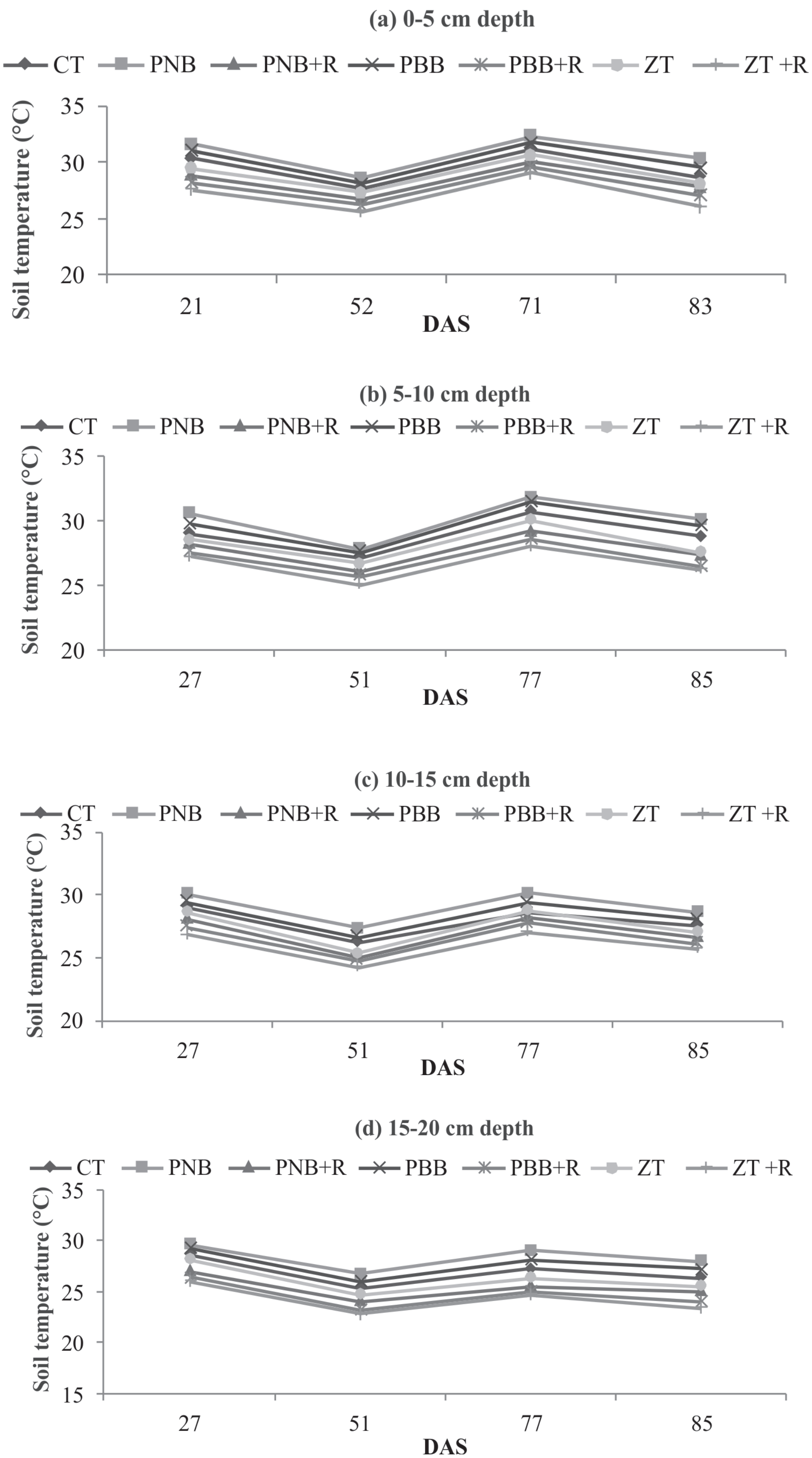


Fig. 3. Soil temperature under different conservation practices along with conventional treatment in wheat during crop growing season

to CT was 9-14% under PBB, 10-21.12% under ZT, 24-31.3% under ZT+R, 41-48% under PBB+R treatment (Fig. 4). Moreno *et al.* (1997) recorded marginally higher yields in wheat and sunflower in the conservation treatment (CT) than in the traditional tillage. Further they summarised that when the precipitation is far below the normal, CT appears highly effective in improving both soil water recharge and water conservation.

Leaf area

Leaf area 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. Results showed that in wheat, minimum leaf area found under PNB treatment. Increase in leaf area was 5-14% under PBB, 14-21% under ZT, 18.5-24% under ZT+R, 17-28% under PBB+R treatment as compared to CT treatment (Fig. 5). 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). Mulches increased leaf area and crop growth rates and the leaf area indices of cassava and sweet potato were increased (21% in cassava and 10% in sweet potato) by incorporation of legume leaf mulch founded by Sangakkara *et al.* (2004).

Relative water content and water potential

Different conservation practices significantly affected the soil hydrological properties which modified relative water content (RWC) in crops.

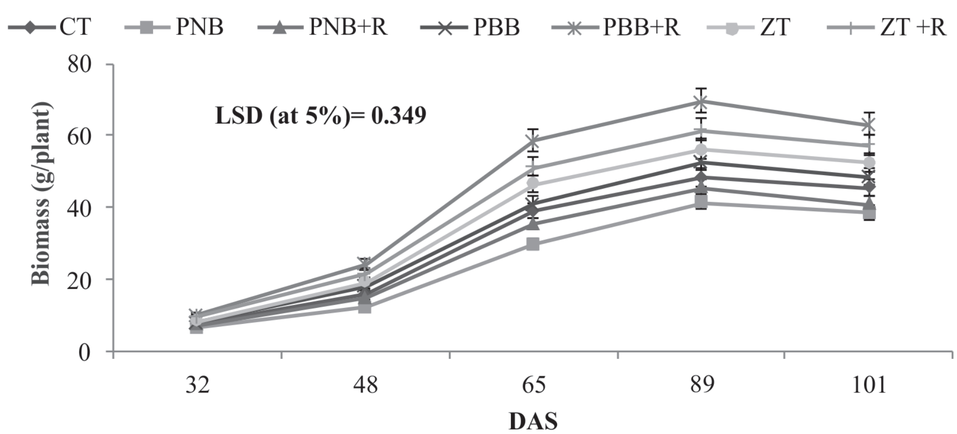


Fig. 4. Biomass under different conservation practices along with conventional treatment in wheat during crop growing season

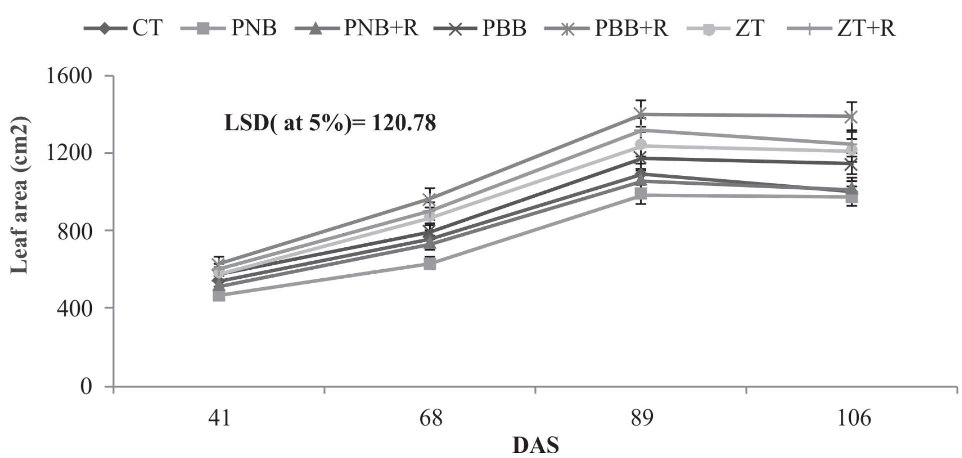


Fig. 5. Leaf area under different conservation practices along with conventional treatment in wheat during crop growing season

RWC was measured at different days after sowing in the plant grown under different conservation practices during *rabi* season. Result showed that maximum relative water content was found under PBB+R treatment followed by ZT+R.Increase in wheat RWC value was 6-13% under PBB+R, 5-10% under ZT+R, 5-7% under ZT, 4-6% under PBB treatment (Fig. 6).

Water potential 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 deteoriated soil condition in conventional treatment plants are in more stress than the plant grown under other conservation treatments. Lowest water potential was found under PNB treatment. Increase in water potential of wheat as compare to CT was around 3.6-9% under PBB, 7-11% under ZT, 8.6- 11.6% under ZT+R, 10-12.3% under PBB+R (Fig. 7).

Chlorophyll content and plant height

Chlorophyll content changed under different tillage practices. Highest chlorophyll contents in wheat under pigeon pea-wheat cropping system were found under PBB+R treatment (8-15%), ZT+R 5-11%, ZT FB 3-6%, while PBB had 1-5% more chlorophyll content as compared to CT treatment (Fig. 8). Lowest chlorophyll content found under PNB treatment. Boomsma *et al.* (2010) who stated that zero tillage maize grown may up took the nitrogen and water up to 40 cm depth, which increased chlorophyll contents and thus causing more protein contents.

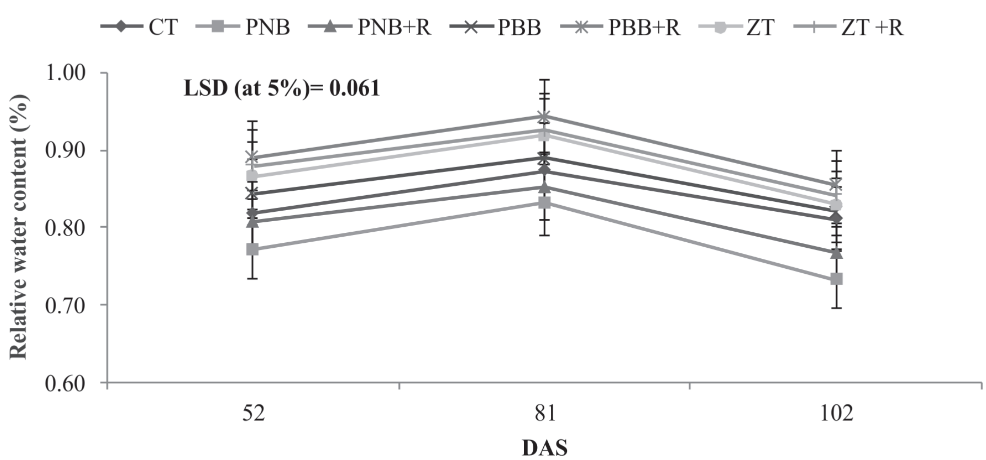


Fig. 6. Relative water content under different conservation practices along with conventional treatment in wheat during crop growing season

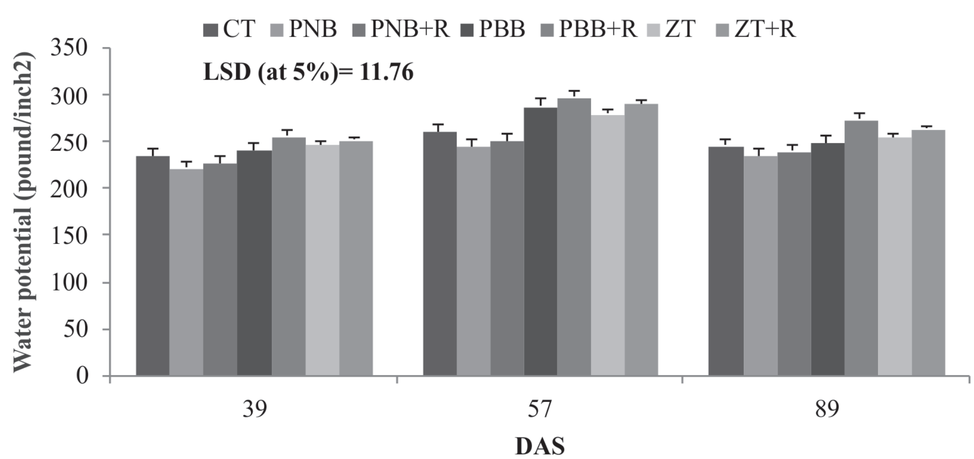


Fig. 7. Water potential under different conservation practices along with conventional treatment in wheat during crop growing season

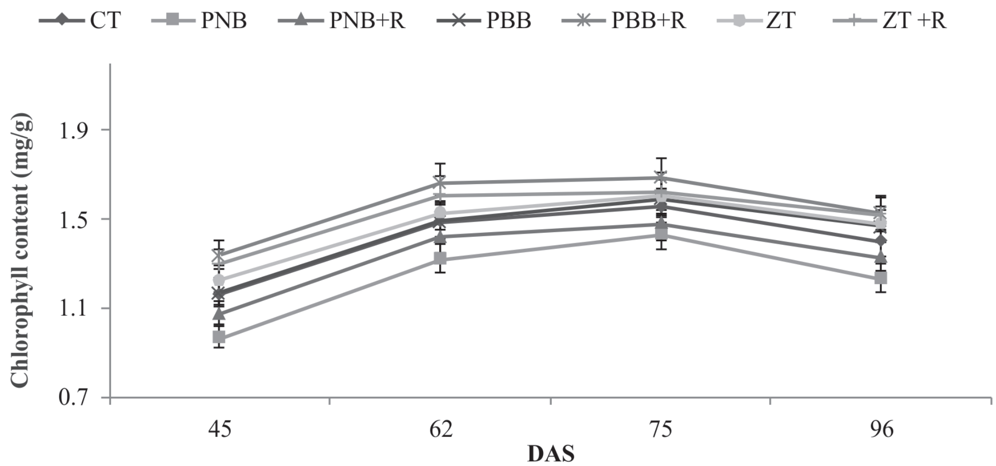


Fig. 8. Chlorophyll content under different conservation practices along with conventional treatment in wheat during crop growing season

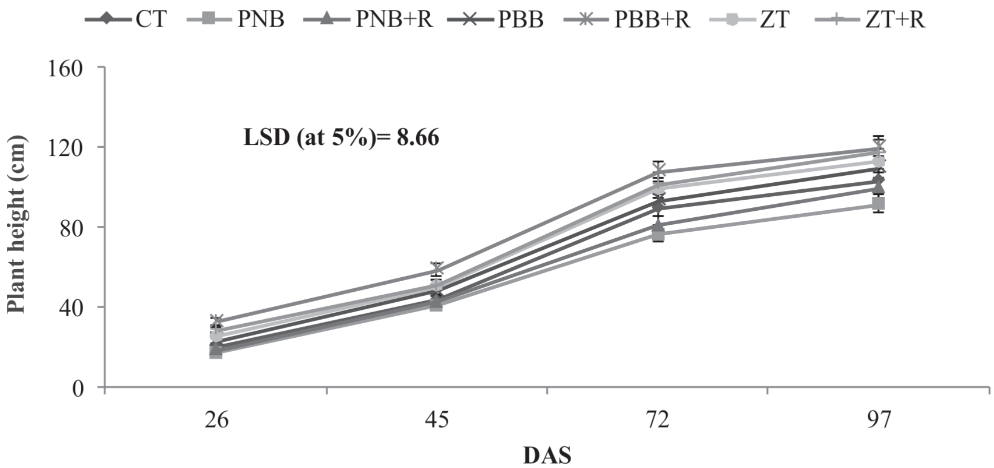


Fig. 9. Plant height under different conservation practices along with conventional treatment in wheat during crop growing season

Tillage treatments had significant impact on plant height, maximum plant height under ZT BB+R treatment found. In wheat crop, under PBB+R treatment, increase in plant height was 23-36% ,21-32% under ZT+R, 14-21% under ZT, 13-16.5% under PBB, 6.53-11 % under PNB+R as compared to CT treatment which had minimum height (Fig. 9). This could be attributed to lesser soil compaction and better soil aeration especially in early growth period and more uniform distribution of nutrients in soil profile (Bennie and Botha, 1986). 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.

Yield

Yield of wheat under different conservation practices with conventional treatment shown in table. ZT BB+R had maximum yield (5408±578 kg/ hac). PBB had 9%, ZT had 12%, ZT+R had 15.6%, PBB+R had 19.3% more yield as compared to CT treatment (Table 1). No-tillage and crop residues retention on soil surface enhanced the organic matter in cultivated soil (Lal *et al.*, 2003; Dalal and Chan, 2001; Heen and Chan, 1992) and was more beneficial for dry land crop production (Baumhardt and Jones, 2002) because of moisture conservation (Lampurlanes *et al.*, 2001).

Table 1. Yield of wheat under different tillage practices

Treatment	Yield (kg/ha)	1000 seed weight (g)
CT	4533± 574	41.2± 0.981
PNB	4177±368	40.3±2.134
PNB+R	4373±884	40.7±1.123
PBB	4950±789	43.3±0.871
PBB +R	5408±578	45.5±1.453
ZT	5071±422	43.1±2.897
ZT +R	5243±502	44.4±1.114
LSD(0.05)	513.79	6.12

Conclusion

From the study it was observed that for wheat crop among all the conservation treatments zero tilled permanent broad bed plus residue (PBB+R) was better than other treatments followed by zero tillage broad bed (PBB), zero tilled flat bed plus residue (ZT+R), zero tillage flat bed (ZT), zero tilled permanent narrow bed plus residue (PNB+R), zero tilled permanent narrow bed (PNB), conventional tillage (CT) system. CA methods provide positive results when combined with fertility improvements, such as micro dosing with N from organic and/or inorganic sources or with mulching. While yield increases under CA can be substantial, they depend on local conditions and weather, with considerable year-to-year 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.

Acknowledgement

The author thanks Post Graduate School, ICAR-IARI, New Delhi for financial assistance. Thanks are due to Director, ICAR-IARI, New Delhi for providing the facilities.

Refrences

Baumhardt, R.L. and Jones, O.R. 2002. Residue Management and Tillage Effects on Soil-water Storage and Grain Yield of Dryland Wheat and Sorghum for a Clay Loam in Texas. *Soil Till. Res.***68**: 71-82.

Bennie, T.P. and Botha, F.J.P. 1986. Effect of deep tillage and controlled traffic on root growth, water use efficiency and yield of irrigated maize and wheat. *Soil Tillage Res.* **7**: 85-95.

Boomsma C.R., Santini J.B., West T.D., Brewer J.C., McIntyre L.M., Vyn T.J. 2010. Maize grain yield responses to plant height variability resulting from crop rotation and tillage system in long-term experiment. *Soil and Tillage Research*. **106**: 227-240.

Bouzza, A. 1990. Water Conservation in Wheat Rotations under Several Management and Tillage Systems in Semi-Arid Areas. PhD. Dissertation, University of Nebraska, Lincoln, USA, 200 PP.

Dalal, R.C. and Chan, K.Y. 2001.Soil organic matter in rainfed cropping systems of the Australian cereal belt. *Aus. J. Soil Res.* **39**: 435-464.

Deng, X.P., Shan, L., Zhang, H.P., Turner, N.C. 2006. Improving agricultural water in arid and semiarid areas of China. *Agric. Water Manag.***80**: 23-40.

Du Y.J., Li, Z.Z. and Li, W.L. 2000. Effect of water control and plastic-film mulch on growth and the range of size inequalities in spring wheat (Triticum aestivum) populations. *New Zealand Journal of Agricultural Research* **33**: 251-260.

Dumanski, J., Peiretti, R., Benetis J., Mc Garry, D., Pieri, C. 2006. The paradigm of conservation tillage. Proceedings of World Association of Soil and Water Conservation, FAO, Rome, pp. 58-64.

Hanna, M. and Al-Kaisi, M.M. 2009. Resources conservation practices; Managing understanding soil compaction. Iowa University Extension article PM 1094. On line http://www.extension.iastate.edu/Publications/PM1901B.pdf.

Heen, D.P. and Chan, K.Y. 1992. The long- term effect of rotation, tillage and stubble management on soil mineral nitrogen supply to wheat. *Austn. J. Soil Res.* **30**: 977-998.

Lal, R., Follett, R.F. and Kimble, J.M. 2003. Achieving soil carbon sequestration in the United States: a challenge to the policy makers. *Soil Science* **168**: 827-845.

Lampurlanes, J., Angas, P. and Cantero-Martinez, C. 2001. Root growth, soil water content and yield of barley under different tillage systems on two soils in semiarid conditions. *Field Crop Res.* **69**: 27-40.

Li, F.M., Guo, A.H. and Wei, H. 1999. Effects of plastic film mulch on yield of spring wheat. *Field Crops Res*. **63**: 79-86.

Magombeyi, M.S and Taigbenu, E.A. 2008. Crop yield risk analysis and mitigation of South smallholder farmers at quaternary catchment level: Case study of B72A in Olifants river basin, Africa. *Physics and Chemistry of the Earth* **33**: 744-756.

Moreno, F., Pelegrin, F., Fernandez, J.E. and Murillo, J.M. 1997. Soil physical properties, water depletion and crop development under traditional and conservation tillage in southern Spain. *Soil and Tillage Research* **41**: 25-42.

Mupangwa, W., Walker, S. and Twomlow, S. 2011. Start, end and dry spells of the growing season in semi-arid southern Zimbabwe. *Journal of Arid Environments* **75**: 1097-1104.

Nyamadzawo, G., Nyamugafata, P., Wuta, M., Nyamangara, J. and Chikowo, R. 2012. Infiltration and runoff losses under fallowing and conservation agriculture practices on contrasting soils, Zimbabwe. *Water SA.* **38**: 233-240.

Pervez, M.A., Iqbal, M., Shahzad, K. and Hassan, A. 2009. Effect of mulch on soil physical properties and N,P,K concentration in maize (*Zea mays* L.) shoots under two tillage systems. *Int. J. Agric. Bio.* **11**(2): 119-124.

Roder, W., Mason, S.C., Clegg, M.D. and Kniefp, K.R. 1989. Yield-soil relationships in sorghum-soybean cropping systems with different fertilizer regimes. *Agronomy Journal.* **81**(3): 470-75.

Sangakkara, U.R., Bandaranayake, P.S.R.D., Gajanayake, J.N. and Stamp, P. 2004. Plant populations and yield of rainfed maize grown in wet and dry seasons of the tropics. *Maydica.* **49**: 83-88.

Scholander, P.F., Hammel, H.T., Hemmingsen, E.A., Bradstreet, E.D. 1964. Hydrostatic pressure and osmotic potential in leaves of mangroves and some other plants. *Proceedings of the National Academy of Sciences, USA*. **52**: 119-125.

Scopel, E., Fernando, A., Da Silva, M., Corbeels, M., François, A. and Maraux, F.I. 2004. Modelling crop residue mulching effects on water use and production of maize under semi-arid and humid tropical conditions. *Agronomie* **24**: 383-395.

Shinners, K.J., Nelson, W.S. and Wang, R. 1993. Effects of residue-free band width on soil temperature and water content. *Trans. ASAE*. **37**: 39-49.

Stige, L.C., Stave, J. and Chan, K. 2006. The effect of climate variation on agro-pastoral production in Africa. *Proceedings of the National Academy of Sciences* **103**: 3049-3053.

Tian, Y., Su, D.R., Li, F.M. and Li, X.L. 2003. Effect of rainwater harvesting with ridge and furrow on yield of potato in semiarid areas. *Field Crops Res*. **84**: 385-391.

Van Wijk, W.R., Larson, W.E. and Burrows, W.C. 1959. Soil temperature and the early growth of corn from mulched and unmulched soil. *Soil Sci. Soc. Am. Proc*. **23**: 428-434.

Wang, X.Q., Li, S.X. and Gao, Y.J. 1998. Effects of film mulch on physi-ecology and yield of spring corn. *Acta Agron. Sin.* **24**(3): 348-353.

Zhang, M., Zhang, R.Z. and Cai, L.Q. 2006. Leaf water potential of spring wheat and field pea under different tillage patterns and its relationship with environmental factors. *Ying Yong Sheang Tai Xue Bao.* **19**: 1467-74.

Received: February 18, 2017; Accepted: May 8, 2017