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Moisture retention trends during the intervening period of differently established rice-wheat cropping pattern in sandy loam soil

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ABSTRACT

The objective of this study was to estimate the variation in moisture retention capacity of the surface soil (0-7.5 cm) in differently established harvested rice plots using time domain reflectometry (TDR). Conserving moisture in surface soil for a longer period of time is the need of the hour which may further be used to grow intervening crops. A number of resource conservation technologies (RCTs) have been proposed by the researchers to uplift the declining water productivity in the region viz direct seeded rice (DSR) and mechanical transplanting (MT) under puddle, conventionally tilled (CT) and zero tilled (ZT) plots. But there is a need to look into detail that how moisture retention capacity of differently established rice plots varied if it established with different methods. This study concluded that on an average ZT plots particularly double ZT plots viz ZTW-DSRZT (ZT wheat block and DSR-ZT plots) had highest moisture retention capacity for a longer period of time as these plots retain 8.1 per cent higher straw load on the soil surface while in CT plots residues buried in the soil. It was reported that MT plots had lower moisture content than the DSR plots which may be because of higher straw load in the later plots (38%) than the former plots. CTW-DSRP plots had the maximum moisture retention capacity while CTW-MTP plots had the lowest moisture. Finally it might be revealed that ZTW-DSRZT plots retained higher amount of moisture content for a longer period of time than any other establishment method which may be used for taking any intervening crops.

Keywords: Moisture retention; TDR; DSR; MT; CT; ZT plots

INTRODUCTION

NASA's gravity mapping satellite GRACE reported that in North India over an area of about 4,40,000 km^2 ground water declined at an alarming rate of 1 ft $year^{-1}$ which further resulted in the loss of 4 cm loss of raw ground water or 18 km^3 $year^{-1}$ (Soni 2012). Residual soil moisture is an important parameter in cultivating the short duration crops like peas in the rice-wheat cropping system for improving livelihood of the farmers of the region. Available soil moisture is an important factor which plays a significant role in the proper establishment and growth of plants. Therefore some new establishment methods of crops must be brought into practice which retain higher soil moisture in intervening period. A number of resource conservation technologies (RCTs) have been recommended in the region to improve livelihood of poor farmers but there is a need of real water saving techniques as these RCTs are site specific (Humphreys et al 2010). Thus information regarding the residual soil moisture and its distribution is important. Some establishment methods demand more irrigation water but they may conserve more water for the intervening crops while other methods may save some water during crop establishment but may demand higher quantity thereafter. Hence temporal variation of residual soil moisture in differently established rice plots is important in the intervening period (Kaojarern et al 2004).

There is a need to look into that which RCT under which scenario/soil type helps in retaining more moisture which in turn helps to grow intervening short duration crops. Time domain reflectrometry (TDR) has become an important method that measures the volumetric soil moisture content in the surface soil as it exploits the difference in the dielectric permittivity values of solid, liquid and gaseous phases. Generally at TDR frequency dielectric frequency of pure water is 80, air has 1 and that of solid phase has a range from 4-16 (Hallikainen et al 1985, Wraith and Or 1999). This contrast permits the dielectric permittivity of soil very sensitive to the variation in volumetric variation in soil moisture content. Hence in the present study TDR is preferred for estimating volumetric variation of soil moisture content as compared to any other method as once properly calibrated and installed this technique is highly accurate. Precise measurements may be made near the surface which is an important advantage compared to other techniques such as the neutron probe. Research has shown (Evett et al 2001, Pedro-Vaz and Hopmans 2001) that the dielectric permittivity of the soil is nearly independent of soil type and bulk density and relatively unaffected by soil salinity.

Proper understanding about temporal variation of residual moisture retention trend in differently established harvested paddy plots during intervening period is a must to grow short duration crop during that period. Keeping this objective in mind the present study was carried out from an ongoing experiment to study the temporal variation in residual soil moisture content in differently established harvested paddy plots.

MATERIAL and METHODS

The study was carried out at the research farm (30°542 N, 75°982 E, 247 m above sea level) of Punjab Agricultural University, Ludhiana, Punjab where conventionally tilled (CT) and zero tilled (ZT) wheat (PBW 621) established during

Rabi 2012-13 within the main plots (total 6 plots) while during Kharif season paddy (PR-115) established in CT and ZT blocks under direct seeded rice (DSR) and mechanical transplanting (MT) using puddle, conventionally tilled and zero tilled plots in the sub-plots with three replications (total 36 plots) and the soil type was sandy loam.

DSR plots were established on 5th June with seed cum fertilizer drill with row to row spacing of 20 cm while MT plots were sown using mechanical transplanter with spacing of 30 cm row to row and 17 cm plant to plant on 1st July 2013. Paddy crop under both the methods viz DSR and MT was sown using recommendations of the PAU, Ludhiana. The DSR crop was harvested on 10th of Oct while MT plots were harvested on 17th of Oct. TDR was used to predict the temporal variation in volumetric moisture content from 14th to 18th Oct in all the DSR plots while from 18th Oct onward daily readings were done in all the plots at a depth of 7.5 cm (for 0-15cm soil depth) up to the very first irrigation (for brining field to field capacity for sowing of wheat using Happy seeder). The objective was to evaluate the best rice-wheat establishment method which could retain maximum moisture for a longer period of time during the intervening period.

The TDR sensors consist of two 7.5 cm long waveguides which are inserted

Fig 1. Photographs showing the recording of volumetric moisture content up to 7.5 cm using time domain reflectrometer (TDR)

in the soil to give an estimate of volumetric moisture content in the soil. By the TDR technique measurements of soil moisture content are made through a relationship with the velocity of an electromagnetic wave that is passed along the waveguides determined by measuring the time-of-travel. These sensors provide an average soil moisture measurement.

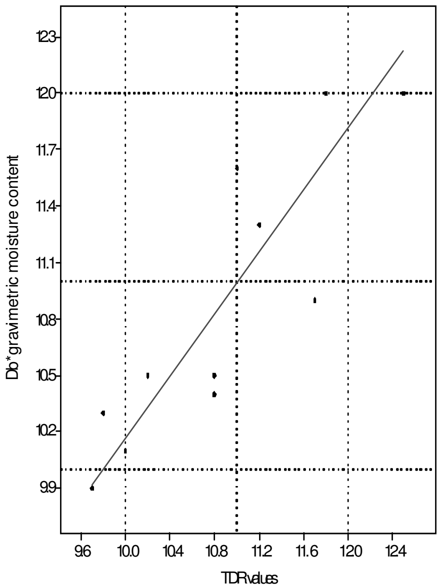
Calibration of the TDR: TDR was calibrated on 28th of Oct using bulk density and the gravimetric moisture content of the surface soil. TDR readings up to 7.5 cm depth gave moisture on the volume basis (cm^3) (Fig 1) while gravimetric moisture content was on mass basis (g). For calibration of TDR readings from first replication of the experiment were noted and thereafter bulk density using core method and gravimetric moisture content was estimated from the same plots and a relationship was established in between them using the PAST software (Fig 2A) which showed a good relationship between them (r2 = 0.76) and it means that TDR could be used for monitoring the temporal variation in the residual soil moisture in differently established harvested paddy plots.

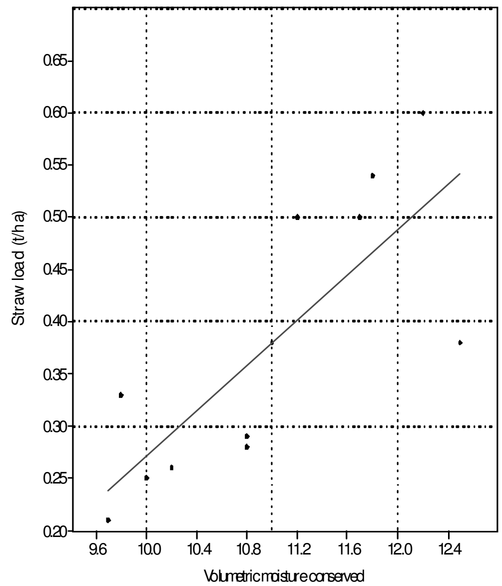
RESULTS and DISCUSSION

During the initial stage (4 DAH) it was observed that CTW-DSRP had the highest moisture retention in the CT scenario as tillage seal the soil pores and does not allow much water vapour to diffuse out easily followed by CT and lastly by the ZT plots (Fig 4A). Similar trends were observed in the ZT plots under DSR plots while ZTW-DSRZT on 5 and 6 DAH showed the maximum moisture retention. It may be due to the greater albedo, lesser open pore spaces and the presence of the mulch which further avoided the direct contact of sunrays with the bare soil while in CT scenario there was no mulch present on the soil surface (Fig 4A).

On 7th DAH soil moisture was highest in CTW-DSRP and ZTW-DSRZT as puddling in the CTW plots caused sealing of the soil pores as puddling dispersed the soil aggregates and then sand followed by silt and finally clay might have sealed the soil pores and permited lesser water vapours to diffuse freely in atmosphere which would not happen in ZTW-DSRP as puddling in ZT fields might not be much effectice as in the CT plots. In ZT plots mean weight diameter might have been affected adveresely which further altered its moisture retention capacity (Fig 4A).

Straw load after rice: DSR plots were harvested earlier than the MT plots because of their earlier maturation and after harvesting left over crop residue acted as mulch and helped in conserving the soil moisture (Fig 2B). It is clearly depicted in Fig 3 that on an average ZT plots ZTW-DSRZT (ZT wheat block and DSR-ZT plots) had highest straw load while in the CT plots CTW-DSRP (CT wheat block and DSR-P plots) had the maximum



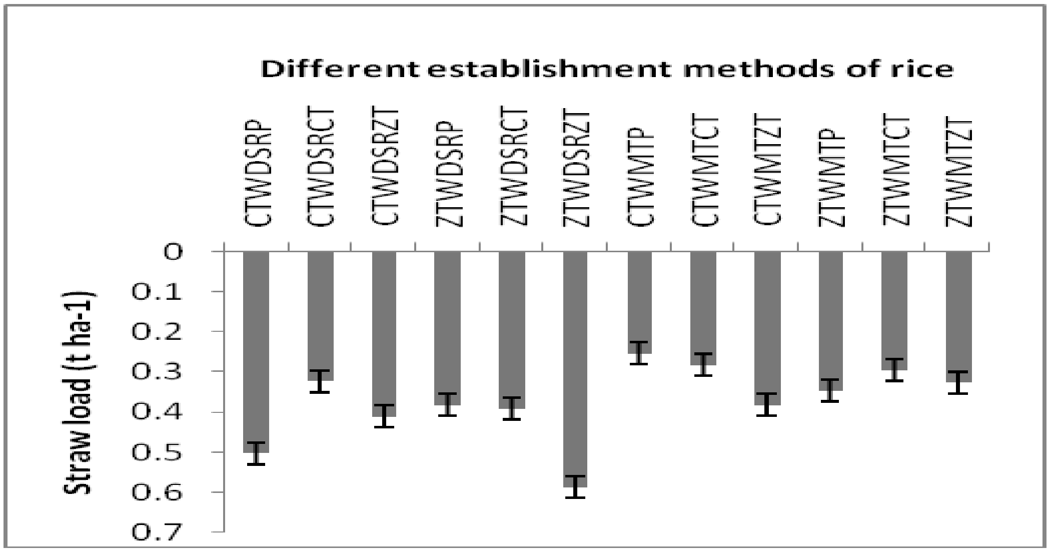


(A) **(B)**

Fig 2. Graph depicting relationship between TDR (cm^3) values and Db ($g\ cm^{-3}$) x gravimetric moisture content (g) ($r^2 = 0.76$) (A) and straw load (t/ha) and conserved soil moisture ($r^2 = 0.62$) (B) using PAST software

retained moisture. On an average it was found that DSR plots had lower straw load (38%) than the MT plots. Further it was found that CTW-DSRP plots had the maximum moisture retention capacity which might be due to highest straw load in CTW plots while CTW-MTP plots had the lowest straw load which caused lesser albedo, more evaporation and finally lesser moistureretention (Bhatt and Khera 2006) (Fig 3).

In the CTW plots DSR plots had higher moisture content as compared to the MT plots and it might be because of the differential row to row spacing (Fig 4C) and different straw load left after the rice. All the MT treatments except MTZT showed higher or equal moisture as retained by the DSRZT and the scenario was not much different for the ZT plots as here also DSR plots retained higher moisture than the MT plots while on 28th of Oct 2013 MTCT showed higher moisture as compared to that of DSRCT (Fig 4D). It seems that in CTW plots DSR plots particularly in the puddle conditions had higher moisture content than the CT and ZT plots while the performance of ZT plots in MT plots crossed that of the puddled and CT plots



Error bars using Standard Error

(ZTW= zero tilled wheat, CTW= conventionally tilled wheat, DSRZT= direct seeded rice sown in undisturbed plots, DSRCT= direct seeded rice sown in conventionally tilled plots, DSRP= direct seeded rice sown in puddle plots, MTZT= mechanically transplanted rice in undisturbed plots, MTCT= mechanically transplanted rice in conventional tilled plots, MTP= mechanically transplanted rice in puddle plots)

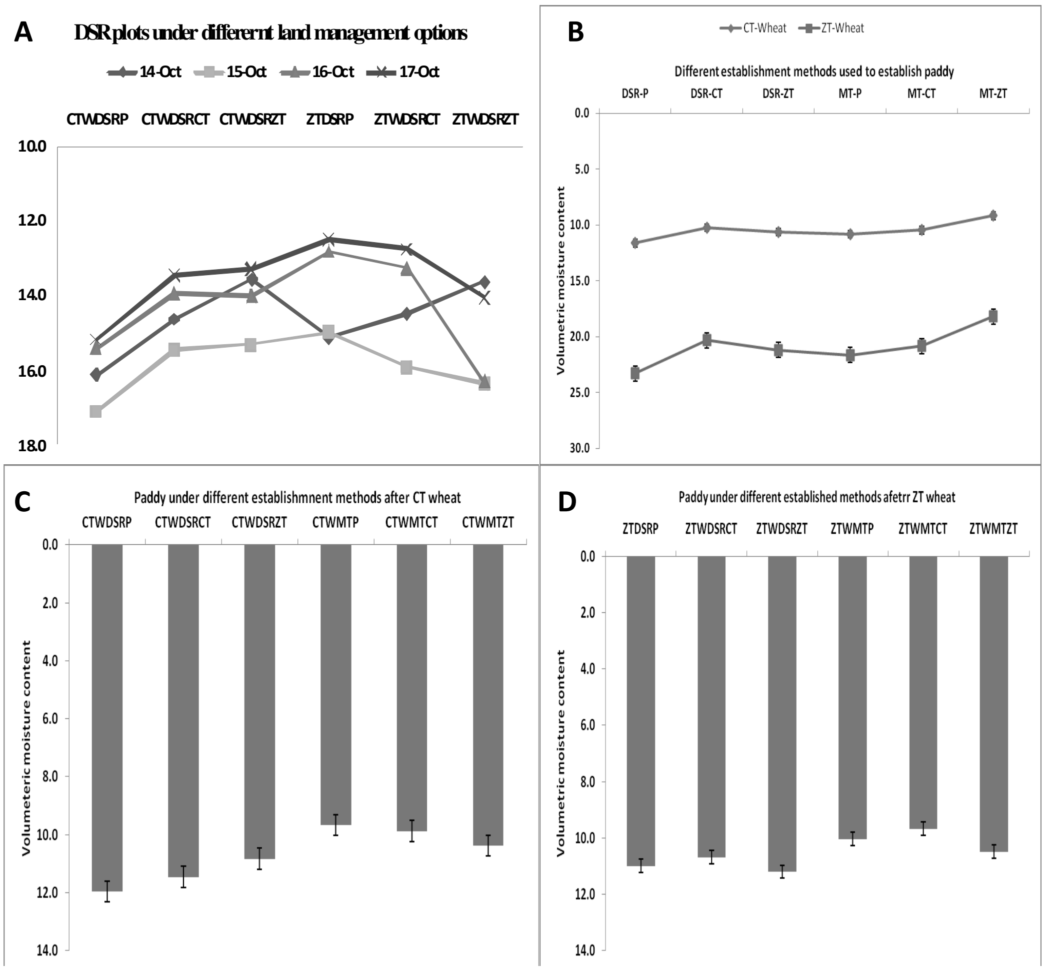
Fig 3. Effect of differently established harvested paddy plots on the Straw load (t ha^{-1}).

and was at par with the MTZT (Fig 4A) as in ZT plots while in the ZTW plots DSRZT and MTZT plots had an edge over all the other respective CT and puddled plots in retaining the moisture content during the intervening period as it completed the double ZT system both in wheat and in paddy (Fig 4A) which further improved the physico-chemical properties of soil which helped in retaining more moisture.

While coming over to the performance of different establishment methods used to establish paddy averaged over tillage treatments it was observed that ZT plots retained higher moisture content than the CT plots (Fig 4B) and that is because of presence of mulch on rather in the soil which further shared the benefits of mulch to retain more moisture (Bhatt and Khera 2006).

CONCLUSION

Depending upon the above discussion it can be concluded that in differently established harvested paddy plots



Error bars using Standard error

(ZTW= zero tilled wheat, CTW= conventionally tilled wheat, DSRZT= direct seeded rice sown in undisturbed plots, DSRCT= direct seeded rice sown in conventionally tilled plots, DSRP= direct seeded rice sown in puddle plots, MTZT= mechanically transplanted rice in undisturbed plots, MTCT= mechanically transplanted rice in conventional tilled plots, MTP= mechanically transplanted rice in puddle plots)

Fig 4. Effect of differently established harvested paddy plots on the volumetric moisture content (A), average moisture conserved by different tillage treatments (B), volumetric moisture conserved in CT plots (C) and in ZT plots (D) the moisture variation in the sandy loam soils is as under:

1. ZT plots particularly double ZT plots retained more moisture content than the CT plots because of presence of mulch on rather than in the soil and higher albedo as reflectance of sunrays was higher in ZT plots because of higher surface area of tilled CT plots absorbed more sunrays which finally resulted in higher evaporation and lesser albedo retained lesser moisture.
2. DSR plots under any scenario retained higher moisture content than the mechanically tilled plots because of higher retained straw load (Fig 4).
3. In CTW plots DSRP and MTP plots retained the highest and lowest moisture content respectively while in ZTW plots DSRZT and MTZT retained more moisture than their respective treatments viz P and CT.
4. It may be suggested that ZTW-DSRZT plots retain higher amount of moisture content than any other establishment method and thus could be used successfully for taking any intervening crop.

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