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Crop residue importance in zero tilled plots during intervening period in semi-arid tropics

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ABSTRACT

Tillage and mulch interactions significantly affected received solar radiations and hence, rate of phase change from liquid to gaseous phase which further escaped from the soil surface. The present investigation was conducted at a sandy-loam soil of Regional Research Station, Kapurthala, Punjab, India for expressing the this phase change *viz.* evaporation trends after rabi 2017-18 before the paddy transplanting as affected by mulch retention. It was revealed that conventional tillage (CT) plots conserved more moisture than zero tillage without crop residue (ZT-CR) plots in upper 30 cm soil surface due to reported higher evaporation (8.25%) in the later plots. Further, soil moisture in CT plots was 8.9%, 20.2% and 16.8% higher in 0-15, 15-30 and 30-45 cm, respectively compared with the ZT-CR plots at 7 DBP. Hence, straw absence in the ZT plots responsible for the higher evaporation rates in these plots. Hence, zero tillage plots must have crop residues of previous crop as mulch for retaining more moisture particularly during the intervening periods for sustainably cultivating legumes and other fodder crops in the region.

Keywords: Lysimeters, zero tillage, conventional tillage, crop residues, profile moisture, evaporation

INTRODUCTION

Rice-wheat cropping sequence has been greeted with many sustainability issues which is a major challenge now a days (Bhatt and Kukal, 2017; Bhatt *et al.,* 2019; Bhatt *et al.,* 2020a; 2020b). For handling these issues scientists had recommended certain technologies, out of them zero tillage has special place as it is being widely practiced at a comparatively larger area. Further, zero tillage (ZT) favours the crop production (Paccard *et al.,* 2015; Bhatt, 2016; Bhatt, 2017), water use efficiency (Bhatt, 2015; Guan *et al.,* 2015), carbon sequestration (Zhangliu *et al.,* 2015) and economic performance (Tripathi *et al.,* 2013) are well recognized. However, Bhatt and Kukal (2016) reported ZT plots with significantly higher weeds due to higher availability of sunlight and moisture to the surface placed weed seeds particularly in these plots. Conventional tillage (CT) responsible for the breakage of bigger aggregates (Das *et al.,* 2014; Kuotsu *et al.,* 2014; Roper *et al.,* 2013), wherein microorganisms oxidises the earlier trapped organic matter and emitted the green house gas viz. CO_2 which further responsible for the global warming. In reveres to CT, ZT with crop residue responsible for conserving higher moisture, regulates temperatures regimes and finally improves soil physic-chemical properties (Paccard *et al.,* 2015; Bhaduri *et al.,* 2014), which further improves both land as well as water productivities in the region (Zheng *et al.,* 2015; Palese *et al.,* 2014; Bhaduri *et al.,* 2014). But, till now role of crop residues in ZT plots needs further experimentation for reaching a concrete conclusion. Mostly scientists working on RCTs, during the intervening periods generally busy in analysing the effect of their applied treatments during the main season (Bhatt and Kukal, 2017a) and not bothered about their residual effects. Considering this fact in mind, present investigation planned after Rabi 2017-18, for delineating the role of crop residue as mulch from 4 DAH of wheat to 7 DBP to delineate the residual effects of tillage levels during the intervening period on profile moisture, soil evaporation and finally on soil moisture dynamics.

MATERIALS AND METHODS

Present experiment was conducted at Regional Research Station, Kapurthala in triplicate from 4 days of harvesting (DAH) of wheat 2017-2018 and 7 days before first puddling (DBP). Studied site generally is sandy loam, calcareous, mixed, hyperthermic and Typic Ustochrept. However, experimental soil has normal pH (8.37), EC (0.30), lower in organic carbon (0.0.36) however available N, P and K reported to be at 279.8, 20.75 and 95 kg ha^{-1}, respectively (Bhatt and Singh, 2020a). Among treatments, from the zero tillage, crop residue was removed after rabi 2017-18. Wheat harvested on 28-4-18 and first puddling did on 03-06-18. The studied period involved duration of 25 days starting from 2-5-18 to 26-5-18. Historical records revealed that earlier wheat established with conventional tillage during 2016-17 followed by puddled transplanted rice (PTR) followed by current experiments. Our objective was to delineate performance of ZT plots during intervening period when crop residues was completely removed in comparison to CT plots. Following parameters were used to delineate the soil moisture dynamics during the intervening period under the residual effect of divergent tillage methods.

A) Soil evaporation (using Mini-lysimeters)

Mini-lysimeters were quite effective in understanding fluctuating behaviour of evaporation under different establishment methods (Carlos *et al.,* 2013; Zhang *et al.,* 2009; Bhatt and Kukal, 2017; Bhatt and Singh, 2018; Bhatt and Meena, 2020). Mini-lysimeters prepared with PVC pipes of 8-inch length having diameter of 2.5 inches filled from both experimental plots viz. CT and ZT-CR plots. After fixing the end cap from one side the soil filled lysimeter placed in the bigger diameter pipe which was already fitted in the sampled plot at a representative spot (Fig. 1). Now, afterwards using digital balance, loss in the lysimeter recorded on the daily basis which further used to delineate the quantitative values of the evaporation. Throughout the water stressed regions, loss of water was through transpiration (Bhatt, 2017; Bhatt and Singh, 2020a).

Inner PVC tube was porous while the bigger diameter PVC pipe opened from both the ends. For installing the later one in the experimental plots, cylindrical auger used for creating a bigger hole in

Figure 1. Technique of measuring soil evaporation *viz.* mini-lysimeters for measuring soil evaporation in the field a. Fitting of lysimeter; b. Removal of filled lysimeter using chain-pulley arrangement; c. Filled lysimeter; d. Weighing of filled lysimeter on daily basis to have day to day evaporation in differently established plots (Bhatt, 2015)

the field which was 0.20 m long. Care was taken to remove any small weeds that may have been growing in the mini-lysimeters for having accurate readings to the extent possible. For recording reading of weight change of the inner lysimeter, bottom was levelled off, the outsides of the cylinders were cleaned and dried. After recording readings of the lysimeters, they were placed back into the outer holes.

B) Profile moisture variation

For recording the profile moisture variations from 0-15, 15-30, 30-60, 60-90 and 90-120 cm, thermo-gravimetrically method was used both during the start and end of the study from the single replication of the experiment. Fresh sample weight recorded and then samples oven dried for 24 hours at 105°C, afterwards oven dried samples were again weighted for getting moisture retained under their experimental plots.

RESULTS AND DISCUSSION

A. Variation in soil moisture evaporation

After wheat harvest, evaporation measured by the installed lysimeters (Bhatt and Singh, 2018). The ZT-CR plots had higher evaporation losses (8.25%)

than the CTW plots (Fig. 2) during intervening periods and that was mainly because of the continuity of the soil pores, higher soil temperature in the ZT-CR however in the CT plots due to intensive tillage continuity of soil pores broken up, thereby reducing diffusion losses of water vapours. Further, cumulative soil evaporation during the whole intervening period of 25 days was observed to be 40.81 mm in CTW as compared to the 44.18 mm in the ZT-CR plots (Fig 3). The absence of straw load in ZT plots resulting in direct hitting of hot solar radiations onto the soil surface could result in raising soil surface temperature which further increases the vapour pressure gradient and escape of the water vapours. Higher soil temperature in the residue removed plants already shown by many workers (Moraru *et al.,* 2012; Bhatt and Singh, 2018; Bhatt and Khera, 2006). Higher soil temperature encourages the phase change from liquid to gaseous phase and the greater vapour pressure gradients which finally resulted in greater diffusion of gaseous water vapours from the soil surface into the atmosphere (Bhatt and Khera, 2006; Bhatt and Singh, 2018).

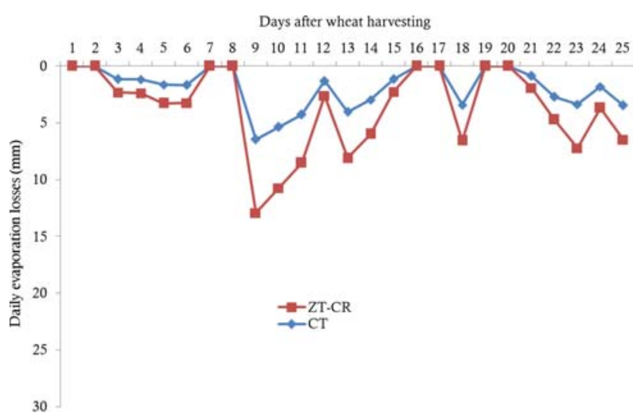

Figure 2. Intervening soil evaporation (mm) as influenced by residual effect of divergent tillage methods adopted after Rabi 2018-19.

B. Variation in profile moisture content

In the ZT-CR plots had lower soil moisture compared to the CT plots, but the trends reversed after 30 cm soil depth (Fig. 4). On an average, over the tillage treatment as a whole, the soil moisture throughout the profile was 18.04 % higher during 3 DAH compared to 7 DBP. On an average of the soil profile up to 120 cm, CTW pots had 16.2% higher while ZT-SL plots had 19.2% higher soil moisture during 3 DAH compared to 7 DBP. Soil moisture in

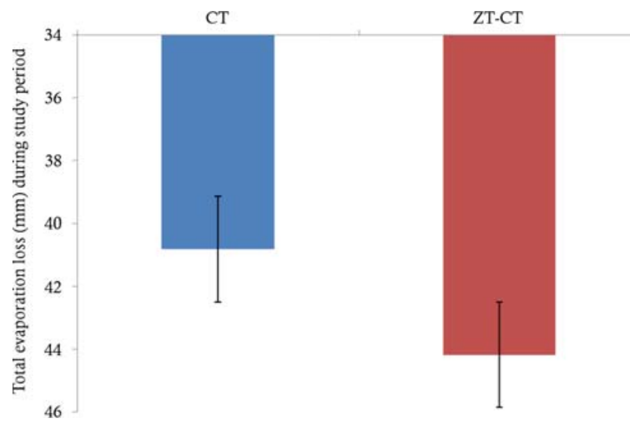

Figure 3. Cumulative soil evaporation occurred under different tillage methods during intervening period after Rabi 2018-2019.

CT plots was 8.9%, 20.2% and 16.8% higher in 0-15, 15-30, 30-45 cm, respectively compared to the ZT-CR plots during 7 DBP (Fig. 4). ZT-CR plots recorded with lower moisture content during intervening periods from 3 DAH compared to 7 DBP depicting importance of crop residues which stopped the hitting of hot sunrays, reduce diffusion of vapours and its lifting capacity by wind and hence evaporation (Bhatt and Khera, 2006; Bhatt and Kukal, 2017; Bhatt and Singh, 2018). Presence of crop residues otherwise certainly partition greater fraction of ET water to the T (transpiration) components after diverting it from the evaporation (E) component (Balwinder Singh, 2015) even under divergent tillage methods which directly improves the inflow of the nutrients in rhizosphere during the intervening period. However, in the ZT plots, removal of crop residues totally reversed the

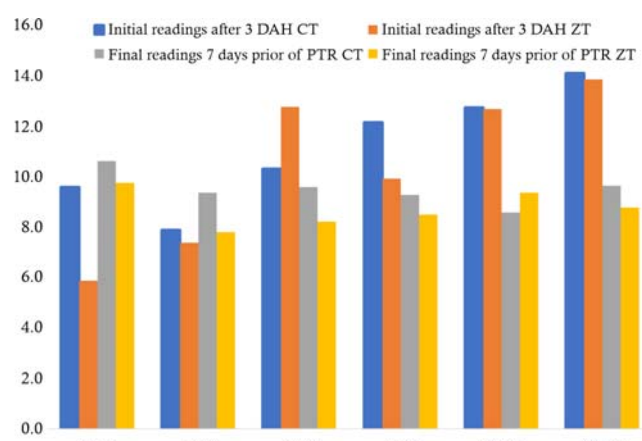

Figure 4. Soil profile moisture from 0-120 cm as affected by residual effect of divergent tillage methods viz. CT and ZT after Rabi 2018-2019.

conditions. This is the reason why higher evaporation and thereby lesser soil moisture profile observed in these plots because of higher energy levels in these plots as earlier reported by Bhatt and Singh (2018). Hence, presence of the crop residues of the previous crop is a must for harvesting the full benefits from this resource conservation technology, otherwise it proves to be inferior even from the conventional plots.

CONCLUSION

Our carried out research finally revealed the importance of crop in regulating the soil temperature, vapour pressure gradient, wind speed and its vapour lifting capacity to have better soil moisture dynamics for growing the intervening crops of legumes, green manuring and other fodder crops in the zero tilled previous wheat plots. In ZT plots, on crop residue removal (-CR), these proves to be even inferior than the CT plots in preserving the soil moisture. Presence of the crop residues as mulch responsible for partitioning the higher fraction of ET water to transpiration (T) component after diverting it from the evaporation (E) component, which is desired more particularly in the water stressed regions. Our final conclusion is to retain/maintain the crop residue loads on the ZT plots for having full benefits from this resource conservation technology. Further more such studies are required in the texturally divergent soils under the varied climatic conditions for reaching to a concrete conclusion applicable for the wider area.

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Conflict of Interest

The authors declare that they have no competing interests.

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