Effects of Tillage, Mulching and Site-Specific Nutrient Management on Soil Temperature, Flowering, Bulk Density and Soil Organic Carbon in Wheat

ABSTRACT

The effects of tillage, mulching and site-specific nutrient management on soil temperature, flowering, bulk density, and soil organic carbon in wheat" studied during *rabi*,2021-22, at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi. The experiment with 24 treatment combinations was laid out in a split-plot design and replicated thrice. The main plot treatments included six different crop establishment methods (conventional tillage without residue, conventional tillage with residue incorporation, zero tillage without residue, zero tillage with residue, permanent raised bed without residue and permanent raised bed with residue retention and sub plot treatments consist of four nutrient management options (STBR, STBR+GS, NE and NE+GS based recommendation). PRB with residue retention has 1-2ºC soil temperature higher up to 70-75 DAS and started to decline after 75 DAS till harvest. Mulching protects the crop from winter and summer stress. Maximum soil organic carbon (SOC) values (0.39%) were noted under ZT+R, which was Higher compared to CT-R after harvest the crop. Soil bulk density (BD) under ZT+R (1.28 g/cm^3) was lower as compared to rest of the treatments. Number of days required to 50% flowering was (83.6 DAS) and to 75% flowering was (88.2 DAS) in PRB+R which was on par with other treatments. it was concluded that the combination of maize straw mulch, zero tillage and permanent raised beds were proved fruitful in improving soil thermal properties and soil carbon sequestration.

Keywords:organic carbon,Nutrient Expert,

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1. INTRODUCTION

Crop growth and productivity are significantly impacted by tillage. Tillage of the soil enhances its physical characteristics and allows plants to develop to their maximum potential. A good seed is provided for root growth and development, weeds are controlled, crop residues are managed, soil erosion is decreased, and the soil is leveled for planting, irrigation, drainage, and the addition of both organic and inorganic fertilizers [1]. Given that frequent use of tillagetechniques has a significant impact on the physical characteristics of soil. In order to prevent the degradation of soil structure and to sustain crop output, it is crucial to utilize appropriate tillage methods in the soil. In this regard alternative best crop management choices, such as conservation agriculture (CA) methods such as zero tillage (ZT) and permanent beds (PB), have shown potential gains on crop yield and profits while saving water, energy, and improving soil health across a variety of ecologies [2]. In comparison to traditional tillage, maize and wheat crops had higher water productivity in zero tilled permanent broad beds with residue retention. Retention of crop residue in CA significantly improved the soil organic carbon concentration in the top 0-5cm of soil layer. Conservation agriculture practices boost the soil microbial activity, carbon sequestration and reduce greenhouse gas emission, which is a major cause for climate change. The ZT causes favourable changes in the physical, chemical [3] and biological qualities of soil, while also conserving water and reducing agricultural energy needs. Crop residues are a source of organic carbon (C) input in maize-based cropping systems and they are linked to better soil physico-chemical properties and a higher carbon sustainability index. The crop residues retention on the soil surface, along with no-tillage, has additional benefits in terms of soil temperature buffering, nutrient availability, and other ecosystem services [4]. Mulches moderate the soil temperature and increases the soil moisture retention. Mulches like straw and grass clippings help to hold the soil moisture. Favourable soil temperature throughout the crop growth period enhances the root growth Soil mulching helps to increase leaf area of maize by moderating soil moisture during early growth stage. Site specific nutrient management (SSNM) practice is a method of providing nutrients to plants that best matches their inherent spatial and temporal needs for supplemental nutrients by utilising various SSNM instruments such as Nutrient expert, Leaf colour chart (LCC), GreenSeeker (GS). On the one hand, site-specific nutrient management (SSNM) examines the soil's indigenous nutrient supply and productivity targets, while on the other, it ensures the restoration of soil fertility. The SSNM captures the spatial and temporal variability of soil fertility in smallholder production systems and proposes a method for "feeding" crops with all of the nutrients they require based on their nutritional requirements.As a result, crop yields, soil, and environmental quality improves in turn would reduce nutrient losses and increase fertilizer use efficiency.Nutrient Expert (NE), a simple nutrient decision support tool based on the principles and guidelines of SSNM, will assist crop advisors in developing fertiliser N, P, and K management strategies tailored to a farmer's field or growing environment. GreenSeeker is an another SSNM tool, offers more efficient and precise way to manage crop input i.e., nitrogen. Nitrogen recommendation is based on yield potential and the response index (RI). GS is an integrated optical sensing, variable rate application& mapping system that measures crop nitrogen requirements. NE and GreenSeeker provides an opportunity to increase productivity of crops and fertilizer efficiency through field-specific precision nutrient fertilizer prescription. An integration of precision nutrient management strategies along with a CA-based system provides opportunities to further enhance the productivity, profitability, and resource use efficiency. The present investigation planned to determine theeffects of tillage, mulching and site-specific nutrient management on soil temperature, flowering, bulk density, and soil organic carbon in wheat.

2. experimental details

The research study was undertaken in *rabi*,2021-22 at the MB-3B block of the ICAR–Indian Agricultural Research Institute (IARI) research Farm in New Delhi, India. In May and June, the average yearly maximum temperature is 41 to 46 ^{0}C, while the average annual lowest temperature is 5 to 7 ^{0}C in December. The average wind speed varies from 3.5 km/hr in October to 7.6 km/hr in April. The mean relative humidity reaches a maximum of 85 to 95 % during the south-west monsoon and a minimum of 30 to 45 % during the summer months.The experiment with 24 treatment combinations was laid out in a split-plot design and replicated thrice. The main plot treatments included six different crop establishment methods (conventional tillage without residue, conventional tillage with residue incorporation, zero tillage without residue, zero tillage with residue, permanent raised bed without residue and permanent raised bed with residue retention (CT-R), (CT+R), (PRB-R), (PRB+R), (ZT - R) and (ZT+R) and sub plot treatments consist of four nutrient management options (STBR, STBR+GS, NE and NE+GS based recommendation). The sub plot treatments included soil test-based recommendation (STBR), Nutrient Expert® based (NE), Soil test-based nutrients + Green seeker (STBR+GS) and Nutrient Expert®based + GreenSeeker based (NE+GS) recommendations in sub-plots.Ridges were made or reshaped using a bed planter. Fertilizers were given out in line with the treatment. on CT, zaaboo seed drills are used to sow wheat seeds (HD 2967) at a rate of 100 kg seed/ha. Bed planters are utilized to sow seeds on permanent raised beds at 20 cm (row to row). There are five irrigations given to wheat in total, including the pre-sowing irrigation. Soil thermometer was used to measure temperature of soil by every 3 days interval from morning 7A.M and afternoon 2 P.M.Days from sowing to 50% of the inflorescence having at least one open flower per metre row length were observed. It is calculated as the number of days it takes to reach 50% flowering in DAS. Days from planting to 75 percent inflorescence, with at least one open flower per metre row length, are recorded as days taken to 75 percent blooming. During the beginning of the experiment and at harvest of wheat 2020 in each plot, the bulk density of soil was evaluated using the core sampler method from three randomly chosen places. The core sampler method was used to estimate the bulk density of surface soil (0-5,5-15 and 15-30 cm) [5]. At the beginning and end of two crop cycles, soil samples (0-15 cm depth) were collected in tiny polythene bags from each plot of the experimental field. The samples were air dried, and the organic carbon content of soil samples was measured using the Walkley and Black techniques [6].

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3. results and discussion

3.1 effect on soil temperature:

Under different crop establishment methods, the soil temperature was significantly affected. The morning soil temperature was 1-2 ^{0}C higher while growing wheat on PRB with residue retention up to 70-75 DAS. After that, it began to decline till harvest at a rate of 1-2 ^{0}C(fig:1).Other options for crop establishment have little impact on the soil temperature in the morning. When comparing the morning and afternoon soil temperatures, the PBR+R plot showed a fluctuation of 0.5 to 1.0 °C, but the ZT+R, ZT-R, CT-R, CT+R, and PRB- R plots show variations of 2 to 6 °C(fig:2). According to medium-term studies on wheat by [4], the retention of residue aided in buffering soil temperature by 3.5 to 10.1^{0}C during the winter months while lowering minimum and maximum soil temperatures by 1.2 to 4.7^{0}C and 0.5 to 6.6 ^{0}C, respectively, under +R compared to -R during relatively hot months. In residue-retained plots, the lower soil temperatures, particularly during the grain filling stage, have a favourable influence on lowering canopy temperature, which in turn reduces the effects of terminal heat on crop yield [7].

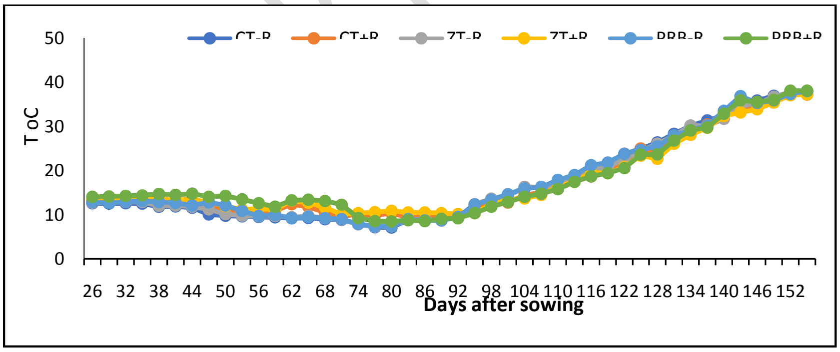

Figure 1: Effect of crop establishment methods along with and without crop residues on soil morning temperature in *Rabi* season in wheat crop during 2021-22 (Morning 7 A.M)

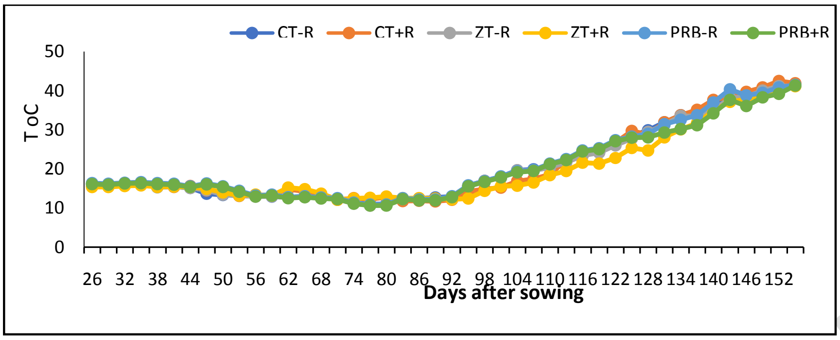

Figure 2: Effect of crop establishment methods along with and without crop residues on soil temperature in *Rabi* season in wheat crop during 2021-22 (Afternoon 2 P.M)

3.2 effect onDays to 50% and 75% flowering:

Data revealed that, ZT+R required lesser number of days put the number of days to attain 50% and put the number of days 75% flowering than other crop establishment methods, while ZT-R (87.2, 92.2), PRB+R (83.3 ,88.25), PRB-R (91.5, 93.4) CT-R (92.4,95), CT+R (86.5, 91.9) needed for 50% and 75% days to flowering respectively(Table:1).Days to 50% and 75% flowering under different nutrient management options were lower in NE+GS (85.1 DAS and 89.7 DAS) which was at par with NE (87.5 DAS and 90.7 DAS) significantly lower in comparison to STBR+GS (87.8 DAS and 92.1 DAS) and STBR (92.6 DAS and 95.4 DAS) (Table:1).

3.3 effect on bulk density:

The information pertaining to bulk density at 0-5, 5-15 and 15-30 cm depth is presented in Table (1) after the completion of crop cycle, there was a significant difference noted in bulk density (BD) due to different crop establishment methods. Soil bulk density (BD) under ZT+R (1.28 g/cm^3) was lower as compared to CT+R (1.32 g/cm^3), ZT-R (1.30 g/cm^3), PRB+R (1.31g/cm^3), PRB-R (1.33g/cm^3), CT-R (1.33g/cm^3) at (0-5) cm respectively (Table:1). Similar trend of BD was observed for ZT+R<ZT-R<PRB+R<PRB-R<CT+R<CT-R in 5-15 and 15- 30 cm depth. Different nutrient management options did not produce any significant influence on soil bulk density during study. Many researches have previously observed that crop residue retention has a positive impact on soil Db at the surface and up to 5 cm below the surface [8]. It has been found that adding residue and root + stubble increases soil organic carbon or organic matter, improving porosity, and decreasing Db at 0-5 cm and to a lesser amount at 5-10 cm soil depth [9]. There were significant differences in soil organic carbon among different crop establishment options. Maximum soil organic carbon (SOC) values (0.39%) were noted under ZT+R, which was Higher compared to CT-R after harvest the crop.But no significant results were observed among nutrient management options. [10] reported that agricultural residue retention has led to an increase in soil organic carbon.

3.4 effect on soil organic carbon:

Significant improvement in soil organic carbon compared to initial level (0.35) were observed in ZT+R (0.39) (Table:1)at after harvesting. But no significant results were observed among nutrient management options. accumulation of organic C in the top layer as a result of repeated mulching applications over a 4-6-year period in several cropping systems [11].

Treatment	**Days to flowering (DAS)**		**Bulk density (g/cm$^{3)}$**			**Organic carbon (%)**	
	50% flowering	**75% flowering**	**0-5 cm**	**5-15 cm**	**15-30 cm**	**Before Sowing (initial)**	**After harvesting (final)**
Crop establishment method							
CT-R	92.4	95.0	1.33	1.45	1.59	0.30	0.32
CT+R(3t/ha)	86.5	91.9	1.32	1.43	1.56	0.33	0.36
ZT-R	87.2	92.2	1.30	1.40	1.55	0.32	0.34
ZT+R(3t/ha)	85.6	91.2	1.28	1.35	1.52	0.35	0.39
PRB-R	91.5	93.4	1.33	1.44	1.57	0.31	0.32
PRB+R(3t/ha)	83.3	88.2	1.31	1.42	1.55	0.34	0.36
SEm±	0.9	0.94	0.006	0.1	0.1	0.006	0.009
LSD (P≤0.05)	2.83	2.97	0.02	0.6	0.4	0.02	0.03
Nutrient Management Options							
STBR	92.6	95.4	1.32	1.43	1.58	0.32	0.32
NE	87.5	90.7	1.31	1.42	1.54	0.33	0.32
STBR+GS (2 splits)	87.8	92.1	1.32	1.42	1.55	0.32	0.33
NE+GS (2 splits)	85.1	89.7	1.30	1.39	1.53	0.32	0.32
SEm±	0.49	0.58	0.01	0.01	0.01	0.01	0.01
LSD (P≤0.05)	1.40	1.66	NS	NS	NS	NS	NS

Table 1: Effects of Tillage, Mulching and Site-Specific Nutrient Management on Flowering, Bulk Density and Soil Organic Carbon in Wheat

4. Conclusion

The physical characteristics of the soil are greatly influenced by tillage and residue management, which has a substantial impact on crop growth and yield. Reduced, minimal, and zero tillage, together with residue retention on the soil's surface, created a soil microclimate that was very conducive to crop development. The bulk density and compaction of the soil are decreased when crop residue is present on the surface, facilitating seed emergence and germination. The preservation or assimilation of residue improves soil organic carbon, soil temperature modification, and soil hydrothermal regime management. Therefore, by enhancing the physical characteristics of the soil over time, conservation tillage combined with residue management raises sustainability in soil health.

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