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RESEARCH PAPER

Soil carbon dynamics effect on growth and yield of Lentil (*Lens culinaris* L.) with varying tillage practices

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Abstract

Heavy tillage practices to conserve moisture from monsoon rains are common in rainfed regions. Rainfed regions have wheat (*Triticum aestivum*) as a main crop while rest of the year minor crops are grown such as lentil. Heavy tillage practices not only destroyed the soil structure but also caused loss of carbon. This study was designed to investigate impact of different tillage practices on yield of lentil (*Lens culinaris*) and carbon dynamics. Three tillage practices were considered as: T_1 = 6 cultivations (Control), T_2 = moldboard plough + 2 cultivations, T_3 = chisel plough + 2 cultivations. The experiment was conducted using a randomized complete block design with three replications to investigate the impact of tillage practices on carbon dioxide (CO_2) emission, soil organic carbon (SOC), dissolved organic carbon (DOC), and the yield of lentil crop. Results indicated that during both the years (2018–2019), moldboard plough with 2 cultivations (T_2) reduced CO_2 emission (40.28%), DOC (22.58%) and SOC (51.07%) and increased lentil yield (56.39%) as compared to control. Results of soil carbon monitoring indicated that use of moldboard and chisel plough along with 2 cultivations before the onset of monsoon under rainfed conditions can reduce CO_2 emission and improve the yield compared to conventional tillage practices. Results of the experiment suggest the farmers of the rainfed area that they should use moldboard and chisel plough along with 2 cultivations before the onset of monsoon so that CO_2 emission can be minimized, and they can get more better yield compared to conventional tillage practices which causes loss of CO_2 and nutrients.

Keywords

Soil organic carbon, tillage, CO_2 emission, yield, lentil

Introduction

In Indo-Pakistan sub-continent, Lentil (*Lens culinaris*) is used in culinary dishes, while in the Middle East, soup is prepared. Western countries use Lentil as alternative to meat. Lentil is also known as a 'poor man's food', as it is used by all socioeconomic societies in Southeast Asia region (Bhatty 2017). It is the best source of proteins, vitamins, minerals, and some soluble and insoluble dietary fibers. The lipid fraction of lentils serves as a valuable reservoir of bioactive components, such as phytosterols, squalene, and tocopherols (Ryan et al. 2015). Rainfed regions face several challenges in crop production, including low soil fertility, erratic rainfall patterns, low-yielding genotypes, inadequate soil conditions, and suboptimal crop management practices. Besides this the farmers of the region utilize intensive tillage combined after collecting crop stubble for livestock fodder. The reasons for doing these practices include weed control and creating a clean, uniform seedbed that facilitates crop sowing and establishment. Besides that, deep ploughing has some disadvantages, it causes environmental pollution, increase of carbon emission and reduction of soil micro-organisms. Deep tillage invariably entails significant expenses in terms of both fuel consumption and time investment (Ozturk et al. 2006).

In the past 25 years, there has been widespread adoption of crop residue retention and reduced tillage practices in many countries (Lahmar et al. 2007). To address concerns associated with deep tillage practices, extensive research has been conducted to assess various conservation tillage techniques (Karamanos et al. 2014). These studies encompass a broad spectrum, spanning from farmer's fields to research plots, to gauge crop responses to these conservation tillage methods. The variability in crop growth and yield can be attributed to diverse climatic factors, soil types, and cropping systems, which may differ significantly from region to region, farm to farm, and even within individual fields. Consequently, selecting the most suitable tillage system for a specific field can be a complex endeavor. The success of conservation tillage hinges on factors such as the choice of tillage system, the timing of operations, crop management practices, and residue management. Additionally, the impact of soil quality, climate conditions, crop rotation, pest control measures, fertility practices, and weed management strategies all play pivotal roles in determining the efficacy of conservation tillage methods and their subsequent impact on yield.

In recent years, numerous conservation tillage practices have been developed to mitigate soil emissions (Cantero-Martinez et al. 2017). However, verifying the effectiveness of these practices requires their application across diverse soil, climate, and management conditions, as tillage impacts soil and crops differently under varying circumstances. Research on the influence of tillage systems on crop performance sometimes yields contradictory results. For instance, in a trial comparing tillage systems across two wheat-legume-watermelon (*Citrullus lanatus*) rotations, deep tillage did not yield significant improvements in soil moisture storage or crop yield compared to a conservation tillage practice involving shallow tillage operations (Pala et al. 2019). The minimum tillage system suited legume crops in which a smaller number of tillage operations were conducted. Long-term effects of tillage were examined on N, soil depth, carbon emission and precipitation on yield. Results of the study revealed that yield was significantly greater for the one-time application of moldboard plough before the sowing of leguminous crops than for the subsurface sweep, more use of cultivator and the offset disk (Camara et al. 2003). The proportion of soil carbon depends on various factors including degree of mixing organic matter, soil agitation (Dębska et al. 2010; Puget and Lal 2015). Tillage practices are main factor of C losses which cause biological degradation of plant biomass due to more supply of oxygen (Lopez-Fando and Pardo 2009; Di Bene et al. 2011). Tillage practices affected the soil organic matter transformations (IPCC 2007; Lee et al. 2009; Svobodova et al. 2010).

CO_2, N_2O and CH_4 are important greenhouse gases. Global climate change (GCC) is an apparent fact which that critically affects biota on Earth. In this scenario, CO_2 is the most prevailing gas among most observed gases (Goh 2004). Agriculture is known as one of the important source of CO_2 (Chenu et al. 2021). Agriculture plays an important role in carbon sequestration as it is a tool for the change in climate if not managed in properly for the sequestration of CO_2 There is a growing interest in utilizing degraded agricultural soils to sequester atmospheric CO_2 as carbon, serving as a tool for climate change mitigation (Mondal et al. 2020). Additionally, soil organic carbon (SOC) plays a pivotal role in climate change adaptation, as it is intricately linked to the development of soil structure, which is essential for water infiltration and storage, as well as erosion control strategies (Kristof et al. 2014). The quantity of CO_2 released from soil to air depends on total cultivated area (Melnick 2020). To enhance organic matter in soil, CO_2 released from soil can be decreased. The amount of CO_2 emission from soil is ten times more than that of fossil-fuel burning (Zhou 2003). About 5% CO_2 emission is due to agricultural practices including cutting of forests, blazing of biomass and crop farming systems (Rochette et al. 2007). During tillage practices, CO_2 releases, but afterward it gets preserved because of drought environment and conservation tillage practices (Luo et al. 2010; Busari et al. 2015).

The transition from deep soil transposal via ploughing (conventional tillage) to no-till management redistributes soil organic carbon (SOC) within the soil profile, resulting in enhanced SOC concentration in the upper surface layer (Ogle et al. 2019). No-till practices have long been advocated as a means to sequester carbon (Bauer and Black 2014). Soil carbon dynamics have a significant role in maintaining soil quality, and improving soil gaseous status, water preservation, nutrient cycle, and plant root growth (Sainju and Kalisz 2015; Robinson et al. 2016). Improvement in surrounding CO_2 is a key contributor to global temperature increase (Mader et al. 2002). Considering the positive impact of conservation tillage on soil organic carbon (SOC) reserves, integrating no-till practices into organic farming could represent a progressive step towards an agricultural system with heightened SOC sequestration capacity and additional benefits, such as biodiversity enhancement (Reicosky et al. 2013). Inappropriate tillage practices contribute to the depletion of fertile soil (Paustian et al. 2014). Effective soil and crop management practices play a pivotal role in mitigating atmospheric CO_2 levels and curbing environmental pollution (Paustian et al. 2014; Lal et al. 2015). The present study was undertaken to assess the influence of tillage practices on soil CO_2 emissions and identify optimal tillage techniques conducive to enhancing lentil yields under rainfed conditions.

Materials and methods

A two-year study was conducted from 2018 to 2020 at the Experimental Research Farm of Hazara University Mansehra, Pakistan, situated at 34°14' to 35°11' north latitudes and 72°49' to 74°08' east longitude, to investigate the impact of tillage practices on carbon dynamics, growth, and yield of lentil. The pH of the study area ranged from 7 to 8, with soil classified as clay to clayey loam, containing nitrogen, phosphorus, and potassium contents ranging from 0.31 to 0.98 mg kg^{-1}, 3.13 to 4.43 mg kg^{-1}, and 53 to 70 mg kg^{-1}, respectively. Additionally, the soil in the experimental area exhibited a bulk density ranging from 1.32 to 1.65 g cm^{-3} and soil carbon contents (SOC) ranging from 1.5 to 8.5 g C kg^{-1}. Three different tillage practices were used i.e. T_1: Control (6 cultivations with cultivator), T_2: 1 Mold board plough + 2 cultivations with cultivator and T_3: 1 Chisel plough + 2 cultivations with cultivator. These tillage practices were chosen specifically as these are the prevailing tillage practices in rainfed areas of Pakistan. The experiment was arranged in a randomized complete block design (RCBD) with three replications, featuring a net plot size of 24 m^2 (4 × 6). Lentil crop was sown during the first week of November in both study years. Lentil seed rate is used at the rate of 30 kg ha^{-1} with row spacing of 30 cm. The NPK fertilizers were applied at the rate of 35-40-20 kg ha^{-1}. All fertilizers were applied as basal doses at sowing time with no subsequent application of fertilizer during growth period of lentil crop. In tillage treatment (T_1), 6 cultivations were performed using a cultivator. After each ploughing, planker was used for land leveling. Two tillage operations were performed before monsoon i.e., June to July during both the study years and other four were practiced before sowing. Whereas, in tillage treatment (T_2), one cultivation was done by using mouldboard plough before onset of monsoon and other two tillage operations were done with the help of a cultivator before sowing of crop. After each ploughing, planker was used for land leveling. Before onset of monsoon in T_3 tillage practice, the field was ploughed for one time with chisel ploughing followed by 2 cultivations before sowing. Seed sowing was done by using seed bed planter.

Soil sampling

Soil samples were collected at a depth of 0–15 cm before sowing and after each tillage practice by taking one-month interval during crop growth period. The samples were dried, ground and sieved through a 2 mm stainless steel sieve and further stored in plastic chambers. Data regarding SOC dissolved organic carbon (DOC), and CO_2 flux were recorded after each tillage practice, before the sowing of crop and after one month intervals during crop growth period.

Carbon emission

The soil CO_2 emission was determined using static chamber method through CO_2 meter (Lutron GC-2028). A chamber rim was fixed into groove of a collar placed in field at random determination of gas flux. Gas samples were measured after 30 days interval. Flux was determined by transformation in headspace concentration over a measured period using the formula:

$$Flux = \left(\frac{dGas}{dt}\right) \times 10^{-6} \times \left(\frac{(V_{chanmber} \times P \times 100 \times MW)}{R \times T \times A}\right) \times 10^{-6}$$

$dGas/dt$ denotes the change in concentration over time and measured in ppm h^{-1}; $V_{chamber}$ is the volume of the chamber; p is atmospheric pressure; MW is the molecular weight; R is a gas constant, 8314 J mol^{-1} K^{-1}; T is temperature taken in Kelvin and A is the chamber area. The flux of CO_2 gas was taken over a hectare and converted to kg CO_2-C ha^{-1} h^{-1} (Zhang et al. 2010).

Dissolved organic carbon

Dissolved organic carbon (DOC) was determined by taking 2 g of soil sample and mixed in 20 mL distilled water and shaken well for 24 h. After that DOC was analyzed by using total organic carbon (TOC) analyzer (Azeem et al. 2021).

Soil organic carbon

Soil organic carbon (SOC) was determined by taking 1 g of soil in a 500 mL beaker. Then 10 mL of 1 N potassium dichromate solution and 20 mL of conc. H_2SO_4 was added in a flask and swirled to mix the suspension. The suspension was allowed to set for 30 minutes. After that 200 mL distilled water was added following the addition of 10 mL of H_3PO_3 to the suspension. Then 10 drops of diphenylamine indicator were added, and the solution was titrated against 0.5 N ferrous ammonium sulfate solution till the color changed from blue to sharp green (Nelson and Sommers 1982).

$$\%\, Total\ Organic\ Carbon \left(\frac{w}{w}\right) = 1.334 \times Oxidizable\ Organic\ Carbon$$

Height of the lentil plant was determined by selecting 10 plants randomly from each plot and average was determined. The number of pods per plant was determined from 10 randomly selected plants. Number of seeds per pod was calculated at maturity stage of crop by selecting 10 plants randomly from each plot. A number of nodules per plant was calculated when lentil plants attained its physiological maturity. In total 10 plants were randomly selected from each plot to calculate a maximum number of nodules per plant. The biological yield was calculated by weighing above-ground biomass of all lentil plants from each plot and total biomass was taken. Grain yield was determined by removing grains from pods of lentil plant and average grain yield was taken in kg ha^{-1}. Harvest index was determined by dividing the grain yield of the lentil crop biological yield.

$$HI\ (\%) = \left(\frac{Grain\ yield}{Biological\ yield}\right) \times 100$$

Statistical analysis

Data obtained were analyzed for analysis of variance (ANOVA) by one-factor factorial in a completely randomized block design and mean comparisons ($p \leq 0.05$) were carried out by Least Significant Difference (LSD) test using M-Stat-C Statistical software (Steel et al. 1997).

Results

Tillage impact on soil carbon

Results of different tillage practices on carbon dynamics were observed from soil depth (0–15 cm) at each monthly interval from sowing till harvesting of lentil. The effect of tillage practices on CO_2 emission was also collected. In tillage treatment T_1 (Control), CO_2 emission was 38.05 kg CO_2-C ha^{-1} h^{-1} during the first year and 40.50 kg CO_2-C ha^{-1} h^{-1} during the second year, that was maximum among all treatments (Fig. 1). Tillage treatment T_2 (moldboard plough + 2 cultivations) showed lowest CO_2 emission rate which was about 22.72 CO_2-C ha^{-1} h^{-1} during the first year and 23.56 CO_2-C ha^{-1} h^{-1} during the second year. Tillage treatment T_3 (Chisel plough + 2 cultivations) showed a value of 27.40 kg CO_2-C ha^{-1} h^{-1} during the first year and 30.52 kg CO_2-C ha^{-1} h^{-1} (Fig. 1). Tillage treatment T_2 produced 40.28% less CO_2 in comparison to T_1 and T_3 during both the growing seasons (Fig. 1). Results showed that DOC was highest in tillage treatment T_1 which was about 3.41 g C kg^{-1} during the 1st year and 3.67 g C kg^{-1} during the 2nd year whereas,

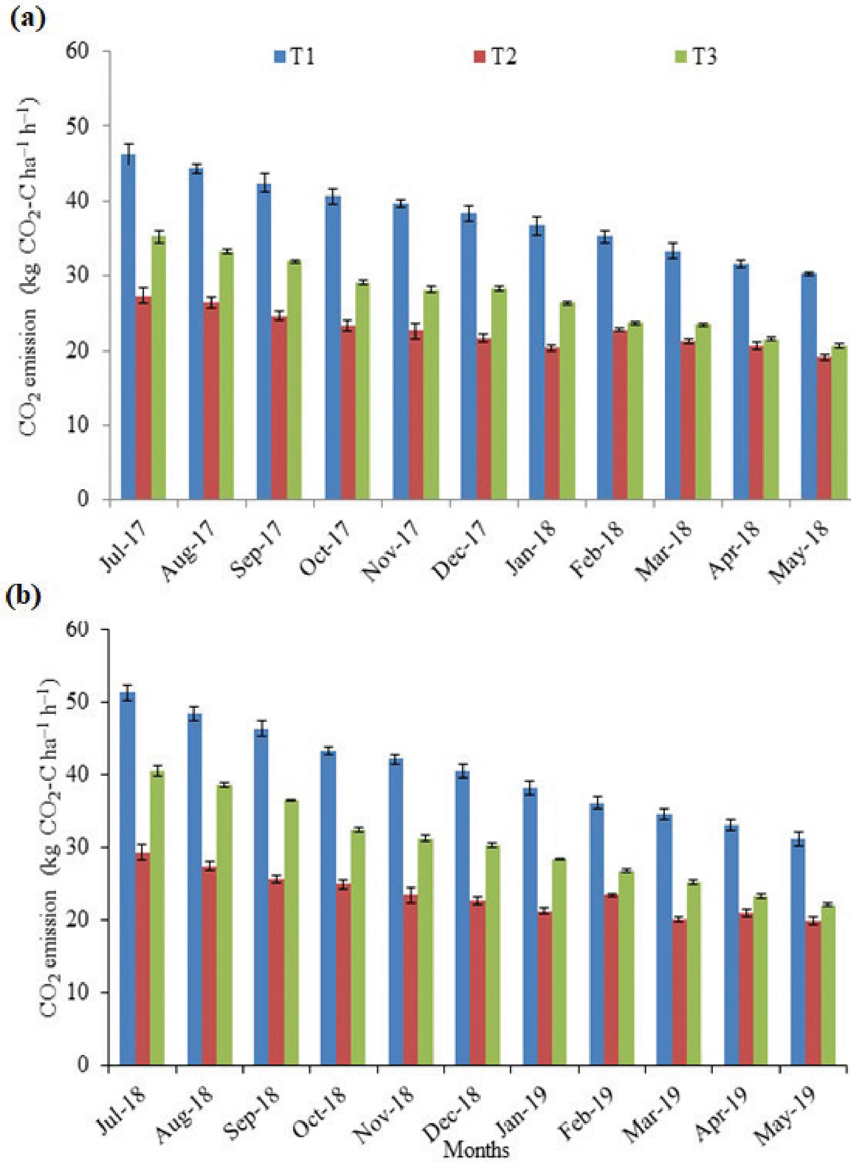

Figure 1. Effect of different tillage practices on CO_2 emission (kg CO_2-C ha^{-1} h^{-1}) at a depth of (0–15 cm) during July 2017- May-2018 (**a**) and July 2018–May 2019 (**b**). Data are the means of three replicates with standard error (S.E) shown by vertical bars. T_1: Control (Farmer practice); T_2: Moldboard plough + 2 tillage practices with cultivator; T_3: Chisel plough + 2 tillage practices with cultivator.

tillage treatment T_2 showed lowest DOC 2.64 g C kg^{-1} during the first year and 2.87 g C kg^{-1} during the second year (Fig. 2). Tillage treatment T_3 showed value of 2.88 g C kg^{-1} during the first year and 3.27 during the second year that was higher than T_2 (Fig. 2). Tillage treatment T_2 produced 22.58% less DOC in comparison to T_1 and 8.33% less than T_3 (Fig. 2). Tillage practices are one of the major causes to reduce soil organic matter contents. Results of the study also revealed that organic carbon content loss was maximum in T_1, that was a farmer practice in which six tillage practices were applied before sowing of lentil. The SOC loss was 6.03 g C kg^{-1} in tillage practice T_1 during the 1st year and 6.48 g C kg^{-1} (Fig. 3). In T_2, 2.95 g C kg^{-1} carbon loss was found during both years, that was 51.07% less than T_1 and 31.55% than T_3 (Fig. 3).

Tillage impact on yield and yield parameters of lentil

Yield parameters of lentil were assessed to determine the impact of tillage practices on lentil crop yields. Plant height was taken after 5 months of sowing. Results revealed that maximum 37.41 cm plant height was observed in tillage treatment T_2 and a minimum 19.86 cm height was obtained in T_1 during the first year and during second year maximum and minimum plant heights were 40.25 cm and 21.34 cm respectively (Fig. 4). Tillage treatment T_3 gave 64.75% more plant height than T_1 during first year and 66.21% during the second year (Fig. 4). Number of pods per plant was taken by selecting 10 plants randomly from each plot at maturity stage. During both the years on average basis maximum number of pods per plant collected

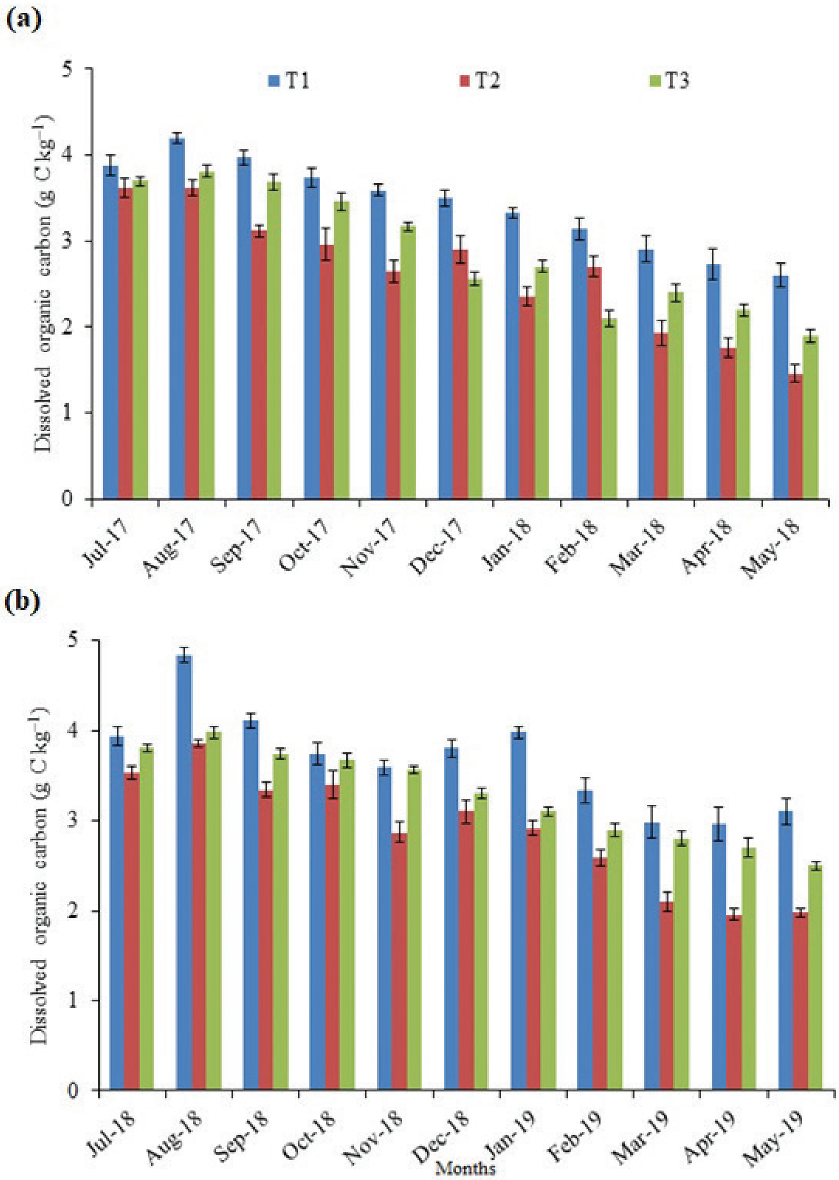

Figure 2. Effect of different tillage practices on dissolved organic carbon (g C kg^{-1}) at a depth of (0–15 cm) during July 2017–May 2018 (**a**) and July 2018–May 2019 (**b**). Data are the means of three replicates with standard error (S.E) shown by vertical bars. T_1: Control (Farmer practice); T_2: Moldboard plough + 2 tillage practices with cultivator; T_3: Chisel plough + 2 tillage practices with cultivator.

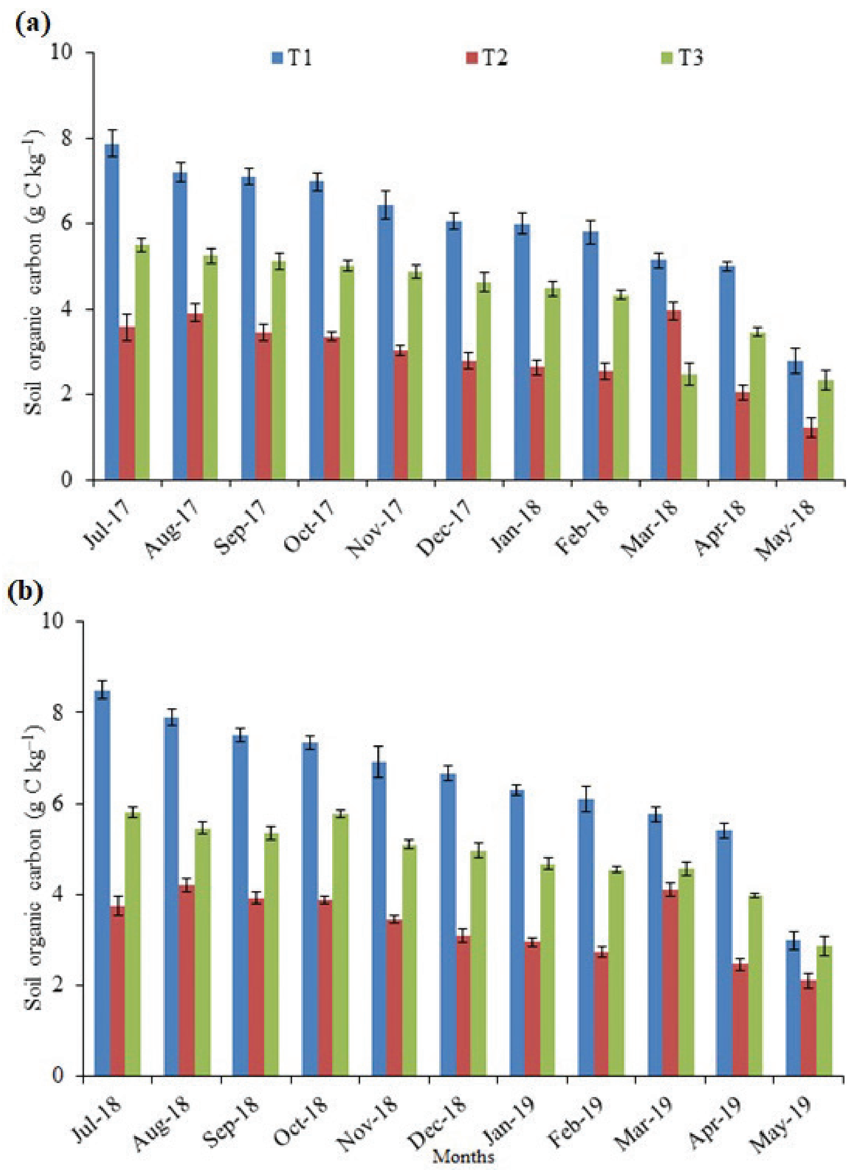

Figure 3. Effect of different tillage practices on Soil Organic Carbon (g C kg^{-1}) at a depth of (0–15 cm) during July 2017–May 2018 (**a**) and July 2018–May 2019 (**b**). Data are the means of three replicates with standard error (S.E) shown by vertical bars. T_1: Control (Farmer practice); T_2: Moldboard plough + 2 tillage practices with cultivator; T_3: Chisel plough + 2 tillage practices with cultivator.

from T_2 was 74 whereas, minimum 50 pods per plant were obtained from T_1 (Fig. 4). Results showed that a minimum number of seeds per pod was observed in tillage treatment T_1, which was 5 seeds per pod and maximum 6 seeds per pod was obtained in T_2 during the first year and 6 and 10 seeds per pod were given by T_1 and T_2 respectively. Tillage treatment T_3 had more seeds per pod than T_1. The treatment T_2 showed 37.5% more seeds per pod than T_1 and 25% than T_3 during both years. Results of the study revealed that minimum number of nodules per plant were observed in tillage treatment T_1, that were 8 nodules per plant during first year and 9 nodules per plant during the second year, whereas maximum 16 nodules were observed in T_2 during first year and 18 nodules per plant during the second year. Tillage treatment T_3 produced 33.33% more nodules per plant than T_1 during both study years. Biological yield was calculated by taking above ground biomass of lentil plants from each plot and then mean values were calculated. It is evident from Fig. 5 that tillage treatment T_2 showed significant results than rest of tillage treatments. Tillage treatment T_2 produced 50% more biological yield as compared to T_1 and 18.45% more than T_3 during the first year and 52.58% more biological yield than T_1 and 16.85% more than T_3 (Fig. 5). Results revealed that on average basis of both the years tillage treatment T_2 showed more significant results than rest of tillage treatments. Tillage treatment T_2 produced 56.39% more grain yield as compared to T_1 and 23% more than T_3 (Fig. 5). Harvest index was also calculated, which showed that tillage practice T_2 gave maximum value i.e., 33.23% and lowest obtained from tillage practice T_1 i.e., 28.37% during both years on average basis (Fig. 6).

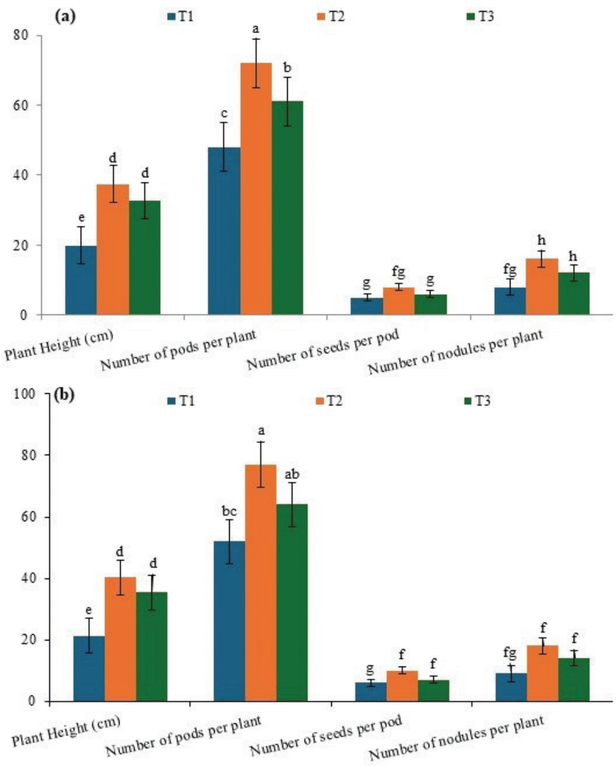

Figure 4. Effect of different tillage practices on plant height, number of pods plant^{-1}, number of seeds pod^{-1} and number of nodules plant^{-1} of lentil (*Lens culinaris* L.) crop during July 2017–May 2018 (**a**) and July 2018–May 2019 (**b**). Data are the means of three replicates with standard error (S.E) shown by vertical bars. Means sharing the same letters do not differ significantly (P ≤ 0.05). T_1: Control (Farmer practice); T_2: Moldboard plough + 2 tillage practices with cultivator; T_3: Chisel plough + 2 tillage practices with cultivator.

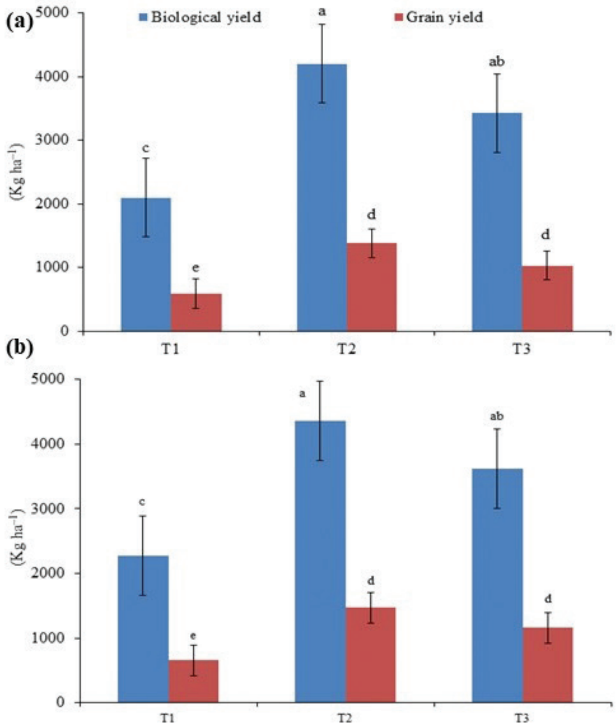

Figure 5. Effect of different tillage practices on Biological Yield and Grain Yield of lentil (*Lens culinaris* L.) crop during July 2017–May 2018 (**a**) and July 2018–May 2019 (**b**). Data are the means of three replicates with standard error (S.E) shown by vertical bars. Means sharing the same letters do not differ significantly (P ≤ 0.05). T_1: Control (Farmer practice); T_2: Moldboard plough + 2 tillage practices with cultivator; T_3: Chisel plough + 2 tillage practices with cultivator.

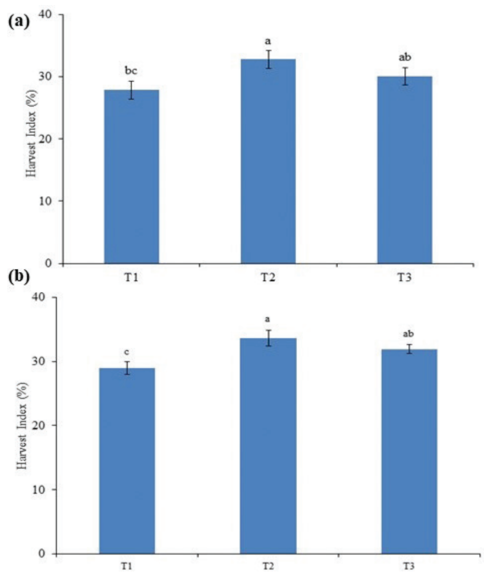

Figure 6. Effect of different tillage practices on Harvest Index of lentil (*Lens culinaris* L.) crop during July 2017–May 2018 (**a**) and July 2018–May 2019 (**b**). Data are the means of three replicates with standard error (S.E) shown by vertical bars. Means sharing the same letters do not differ significantly (P ≤ 0.05). T_1: Control (Farmer practice); T_2: Moldboard plough + 2 tillage practices with cultivator; T_3: Chisel plough + 2 tillage practices with cultivator.

Discussions

Changes in CO_2 emission may be due to less disturbance in soil i.e., less tillage practices. More number of tillage practices cause soil disturbance and emission of CO_2 along with other gases that are hazardous to land (Smith et al. 2016). Our findings align with those of Widen and Lindroth (2015), who noted that deep tillage practices and an increased frequency of tillage operations can exacerbate CO_2 emissions from soil. Tillage treatment T_2 showed less DOC which may be due to a smaller number of tillage practices as compared to control treatment. Less number of tillage practices disturbed the soil but not as drastically as damage caused by control practice. Our results are also in line with Kump (2018) who observed that deep tillage practices can cause loss of carbon from soil either in gaseous or volatilized forms. Deep tillage practices cause DOC loss through the soil which is disturbed again and again and causes breakage of soil clods that bind this carbon, leaching of essential nutrients may also enhanced due to deep tillage by which plants do not get these nutrients and the quality of underground water also become hazardous for plants growth (Altikat and Celik 2011; Kovacs et al. 2014). The SOC was higher in T_1 that may be due to more disturbances to soil as compared to rest of tillage treatments. In T_2 (moldboard plough + 2 cultivations) and T_3 (Chisel plough + 2 cultivations), only one tillage practice with moldboard plough and chisel plough was taken that disturbed soil only one time, which may cause less carbon loss from soil. Soil carbon loss was high in soil which was under high disturbance (Dunne and Harte 2017). Soils having poor structure due to more disturbance and degradation cause high organic carbon loss (Dunne and Harte 2015; Huang et al. 2019; Qiu et al. 2023).

Maximum lentil plant height in T_2 was attained and this may be due to deep tillage practice using moldboard plough which conserved moisture more efficiently during monsoon. Cultural practices in preparation of soil i.e., tillage practices can cause loss of moisture in rainfed areas, besides this deep tillage with moldboard plough before onset of monsoon can conserve more moisture (West and Post 2017). The results of our findings are also in line with Wright and Hons (2015) who reported that deep tillage can enhance crop yield as compared to conventional tillage practices. Maximum pods per plant in T_2 (Moldboard plough+2 cultivations) was attained and this may be attributed due to using moldboard plough which conserved monsoon moisture more in depth and used by the plant in dry season (Weil et al. 2013). Our findings are also following Novak et al. (2015); Ontl and Schulte (2016) who reported that yield of a crop depends on soil fertility and moisture content of soil and number of tillage practices can degrade moisture content and reduce soil fertility due to less soil microbial activities. Number of nodules per plant were counted and observed that nodules growth depends upon soil microbial activities, less disturbance to soil structure and soil organic matter, more the organic matter a soil contains, more nodules will produce (Thomas et al. 2017). It could be the reason that in our experiment T_1 (control) produced less number of nodules per pod due to more number of tillage practices. Welles et al. (2015) and Huang et al. (2023) reported that lentil crops can produce a greater number of nodules if soil is rich in moisture and organic matter, and this is possible by doing deep tillage practices instead of giving a greater number of tillage practices. Biological yield of a crop depends upon health of plant (Denmead and Reicosky 2014; Liu et al. 2023; Zhang et al. 2023). Our results are also in line with Elkoca et al. (2015) who reported that deep tillage practices before onset of monsoon under rainfed condition are useful in moisture conservation and root and nodules growth of crops as compared to conventional tillage practices. Grain yield was taken when plants get fully dried. Grain yield of a crop would be better if a plant is healthy by getting nutrients and moisture at required time (Aitkenhead and McDowell 2013; Yang et al. 2024). Our grain yield in T_2 may be more due to better moisture retention during monsoon which plants availed in moisture deficit condition. Carrillo-Gonzalez et al. (2013) and Liu et al. (2024) also reported that deep tillage under rainfed helps to conserve moisture which crops use in water deficit period as compared to conventional tillage practices which cause loss of moisture. Harvest Index (HI) was also calculated, and we found that HI is proof of better yield and good performance of tillage practice. Deep tillage practices can conserve moisture and nutrients under rainfed conditions and can ultimately enhance biological and grain yield of a crop (Xinshen et al. 2017; Li et al. 2023; Wang et al. 2024). Through the findings of our study, we suggest that if moldboard plough and chisel plough both along with two cultivation with cultivator can be used before onset of monsoon under rainfed conditions then we can control carbon emission which is hazardous to our environment and can get better lentil yield as compared to conventional tillage practices which not only degrade the soil structure but also lead toward carbon emission and poor crop yield.

Conclusions

Results of the study suggest that tillage practices played significant role in reducing soil carbon emission and yield improvement of lentil (*Lens Culinaris*) crop under rainfed condition. Our findings revealed that tillage practice T_2 = 1 Mold board plough + two cultivation with cultivator gave significant difference in carbon emission control and yield enhancement of lentil. Outcomes of the study manifested that by using moldboard and chisel plough before the start of monsoon season can retain the soil moisture in better amount and recycling of nutrients present in deeper soil layer as compared to control tillage practices in which soil moisture and nutrients lost occurred due to a greater number of tillage frequencies. In future other tillage practices such as no tillage and minimum tillage effects should be monitored in lentil crops based on carbon emission of the soil along with soil bulk density and C:N ratio.

Author Contributions

Mehmood Ul Hassan and Abdul Qayyum conceived the idea. Mehmood Ul Hassan conducted the experiment. Hesham S. Almoallim and Mohammad Javed Ansari collected literature reviews and provided technical expertise. Mazhar Rafique helped in statistical analysis. Abdul Qayyum proofread and provided intellectual guidance. All authors read the first draft, helped in revision, and approved the article. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

Available upon request from the corresponding author.

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