



Performance of Leguminous Crops under Different Tillage Practices in Silty Loam Soil of Balochistan

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Authors' contributions

This work was carried out in collaboration among all authors. All the authors were equally contributed from the conduction of experiment, analysis of samples and writing of this manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Balochistan is the province of Pakistan that facing serious issues such as soil erosion, structural instability, and nutrient depletion, and water scarcity, accumulation of excessive salts in soil and low contents of organic matter. Unfortunately, the current exhaustive cropping system and intensive ploughing further promoting the mentioned problems. The following study was designed with the objective i) to evaluate the effects of different tillage and legumes on soil organic carbon dynamic in upland of Balochistan. ii) To compare the outcomes of various tillage practices on legume crop manufacturing in upland of Balochistan. Treatments consist of zero tillage (ZT), minimal tillage (MT) and traditional tillage (CT) and crop become gram develop at some point of summer time season. Experimental results revealed that soil pH under ZT (8.1) MT (8) CT (8); EC under ZT (1.3 dsm^{-1}) MT (0.84 dsm^{-1}) CT (0.87 dsm^{-1}); MOC under ZT (0.27%) MT (0.24%) CT (0.25%); POC under ZT (0.45%) MT (0.42%) CT (0.4%), TOC under ZT (0.84%) MT (0.82%) CT (0.78%); OM under ZT (0.7%) MT (0.7%) CT (0.64%); MBC under ZT (0.53%) MT (0.52%) CT (0.46%); Moisture Content under ZT (16.51) MT (15.87) CT (15.16); temperature Under ZT (23.067) MT (22.867) CT (22.733) Plant emergence Under ZT (81.6%) MT (80%) CT (79%); Biological yield Under ZT (0.3933 kgm^{-2}) MT (0.38 kgm^{-2}) CT (0.38 kgm^{-2}); Grain Yield under ZT (0.14 kgm^{-2}) MT (0.13 kgm^{-2}) CT (0.12 kgm^{-2}). It is concluded that guar crop germination was a

serious problems under all the tillage practices. However, soil properties were improved with reduction of tillage practices especially buildup of organic carbon was observed under zero tillage practices.

Keywords: Conservation agriculture; soil organic carbon; zero tillage; land degradation; conventional tillage.

1. INTRODUCTION

Balochistan is the province of Pakistan that facing serious issues such as soil erosion, structural instability, and nutrient depletion, and water scarcity, accumulation of excessive salts in soil and low contents of organic matter [1]. Soil properties have many important effects on soil management, carbon dynamics and at the above 20cm the effect of tillage and crop residue mulch on bulk density is mainly enclosed. Tillage practices have a characteristic to disturb the pattern of soil organic carbon (SOC) as well [2].

Organic degradation and degradation associated with soil conditions and the environment under traditional farming in tropical and subtropical areas underscores the need to provide sustainable soil management systems [3]. Soil organic matter (SOM) take on many capabilities within side the soil, along with nutrient retention, water maintaining capacity, and soil aggregation and its miles a key indicator of soil quality. Soils organic matter ranges have declined over the past century in a few soils due to over-grazing grasslands and the conversion of grasslands to tilled farmland. Due to overgrazing on grassland soil organic matter level has decreasing from last century and grassland have been converted into tilled farmland. Soil fertility level is reduced due to this reduction. It requires increase in fertilization and some areas also need erosion control practices. Conversely, no-till practices in last decays and multiple times of recropping. Methane and Carbon dioxide (CO₂) are produced by the decomposition of soil organic matter (SOM). Carbon dioxide (carbon sequestration) is a net sink produced for agricultural land. By Maintaining the soil productivity soil organic matter (SOM) has important role and agriculture management practices also increase SOM and balance the chemical properties of soil [4]. Minor changes in SOC contents can considerably change soil C storage, due to the enlargement of terrestrial carbon pool [5].

After cereals; legumes bear the most valued food source in agriculture. Whereas the approach made in breeding food legumes, it is necessary

to boost (increase) up the legume productivity to enhancing the food requirements [6]. Legume crops are affluent in various amino acids and it is a very important group of plants which belongs to family Fabaceae or Leguminaceae. These legumes are very important and cheapest source for supply protein. For proper function of human body balanced amount of protein and essential amino acids are required [7]. For the purpose of humans legumes crops are being grown agriculturally. Biological Nitrogen Fixation advantages at this time no longer simplest legumes purchase succeeding the intercropped as well. Reducing the need for nitrogen fertilization. Soil low mineral nitrogen content, organisms which fix the nitrogen provide ammonium for legume biomass which increase the rate of growing than their plant competitors [8]. Biological Nitrogen (N₂) is a vital approach of sustainable and environmentally buddy for meals manufacturing and long term crop productivity. The thing which controls the quantity of N₂ is: efficiency of rhizobia host plant symbiosis, sink power, i.e., power of the host building to build N. Biological Nitrogen (N₂) is an important component of sustainable and natural partnerships in food production and long-term crop production. The four control elements that control the value of N₂ are: the function of the rhizobia host plant symbiosis, the power of the sink, that is, the power of the plant that will host the N-collection [9].

This is a kharif crop grown in arid and semi-arid areas as well as northwestern part of India. The guar crops are sown in the month of July and September – October is the harvested period respectively. Its market starts from October onwards. Guar Gums are extracted from guar seeds. Cattle feed and culinary are the other uses of guar. The extraction form guar seed which includes split/gum (30%), Korma (30%) and churi (40%). In drilling purpose of petroleum Gum is mainly used and in making ice-cream, bread, paste etc as well [10].

Keeping in view numerous soil problems in Balochistan and potential of leguminous crops to improve soil productivity, so the following study

was conducted with the objectives: To evaluate the effects of different tillage and legumes on soil organic carbon dynamic in upland of Balochistan. To evaluate the effects of different tillage practices on legume crop production in upland of Balochistan.

2. MATERIALS AND METHODS

2.1 Location and Experimental Layout

The soil and plant samples were taken under different tillage treatments during crop sowing and harvesting stages in the year of 2018-19 at field area of Bostan, Quetta (Fig. 1).

The experiment was conducted with randomized complete block design (RCBD) having three different tillage practices as treatments and each

treatment was replicated thrice. The initial characteristics of experimental site before the installation of experimental treatments are as under: (Table 1).

2.2 Treatments Details

Following three different tillage treatments were used to observe their impact on soil properties and Guar yield.

Guar (*Cyamopsis tetragonoloba*) was planted in all plots. Crop was planted in T₂ and T₃ plots with automatic seed drill machine, while in T₁ plots crop was planted same like traditional farmers i.e. broadcasted. Seed rates was 10-30 Kg.ha⁻¹ and the biomass was to be kept between 50-100 Kg.h⁻¹. The plant-plant and row-row distance was between 45 to 60 cm respectively.

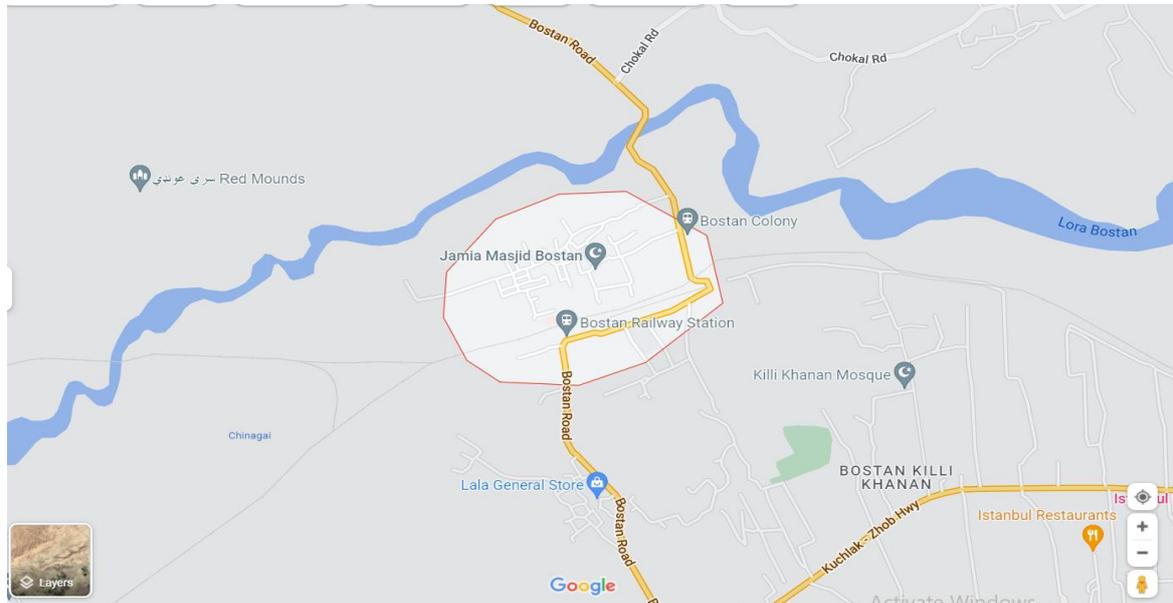


Fig. 1. Map of the experimental location, the Bostan, Balochistan

Table 1. Physico-chemical properties of experimental soil

Characteristics	Value	Remarks
Sand	52%	
Silt	28%	
Clay	19%	
Texture	Sandy loam	
Bulk density	1.40 Mg m ⁻³	Medium
ECe (1:1)	0.55 dS m ⁻¹	Normal
pH(1:1)	7.9	Alkaline
Total Organic Carbon	0.48%	Low
Active soil carbon	0.009%	Low
Slow soil carbon	0.10%	Low
Passive soil carbon	0.31%	Low

Table 1. Treatments details

Treatments	Description
T1: Conventional Tillage (CT)	Field was continuously ploughed through conventional cultivator upto 8 time in a year for moisture conservation, weed controlled and seed bed preparation
T2: Zero Tillage (ZT)	Field was not ploughed in the entire year, crop was sown with zero tillage drill and weeds were controlled through chemical herbicide
T3: Minimum Tillage (MT)	Field was three time ploughed in a year for weed control and moisture conservation and crop was sown with zero tillage drill

2.3 Soil Sampling and Preparation

Three composite samples were collected from each plot and analyzed for different physico-chemical properties in question for the research. For TOC of the soil, 1 gram of dry soil in the air was taken from a conical flask of 500 ml. Another 10 drops of Potassium Di-chromate (1N) were added to the samples in a conical flask containing 20 ml of concentrated sulfuric acid. The solution is thoroughly mixed and allowed to rest for 30 minutes. More than 200 ml of dirty water (DI) and 10 ml of ortho-phosphoric acid were added to the solution and the solution in a conical flask was left to rest to cool. After cooling, 10-15 drops of diphenylamine were added as a reference. The flask was placed in a magnetic stirrer and 0.5 M ferrous ammonium sulfate was carefully added until the color of the solution was changed from blue to green [11]. For particulate organic carbon in soil 10 g of soil sample was taken in a beaker and 30 mL Sodium hexametaphosphate (NaPO_3)₁₃ was added and Shaken on a reciprocal shaker one hour. The solution was crossed through the sieves of >53 μm . the soil particles that didn't cross the sieve and retained were POC. The POC was dried at room temperature and analysed for organic matter contents. For mineral associated organic carbon in soil 10 g of soil sample was taken in a baker and 30 mL Sodium hexametaphosphate (NaPO_3)₁₃ was added and shaken on a reciprocal shaker for one hour. The solution was crossed through the sieves of >53 μm . The soil particles that crossed the sieve was dried at room temperature and analyzed for organic matter contents (MOC). Moisture content in soil was measured by 10 g of wet soil sample was taken into a metal can dried and left for air-dried. Next day, when the soil was dried, reweights the samples. Measurement of MBC was done by fumigation extract method [12]. The protocol was followed by taking 10 g fresh soil sample in a 50 ml beaker and 10 g soil sample was taken in 125 ml water –tight bottle. According to the

procedure, 30 ml of alcohol free chloroform was taken in another 50 beaker a placed in a desiccator at 250°C for 24 hours. The sample was then extracted with 50ml 0.5 M K_2SO_4 and shaken for 30 minutes and filtered. Another sample of soil was extracted similarly but without fumigation. A 4 ml sample was put in digestion tube in which 0.0667 M potassium dichromate was added. The sample in the digestion tube was added with 5 ml of concentrated sulfuric acid and was heated at 150°C for 30 minutes. The digested contents were transferred into 100 ml conical flask in which 3-4 drops of O-phenanthroline monohydrate indicator. Finally the titration was done with the ferrous ammonium sulphate. Soil pH was analyzed by preparing the soil solution in a ratio of 1: 2 soil and water respectively [13]. For this calculation, taking 10 g of soil from the beaker and 20ml of distilled water. Mix the suspension with a glass rod and allow to reheat three times after 10 minutes. Reading was recorded in the suspension with combined electrodes by inserting pH meter in the suspension after half an hour. Soil samples were analyzed for the purpose of Electrical conductivity (ECe) (14). For this suspension of soil and water was prepared with the ratio of 1:5 soil and water. 25ml of deionized water and 5g of soil was inserted into a 50ml beaker. After that reading was recorded by putting Electrode of EC meter (DDS-12DW) in the suspension. With the help of digital thermometer soil temperature was measured. In each plot reading was recorded through digital thermometer.

2.4 Crop Data

From cultivation to harvesting Crop was grown. Various parameters which relates to crop production was analyzed. Plant emergence percentage was measure by counting number of emerged plants in m^{-2} by plant emergence percentage. Shoot biomass was measured by randomly From each plot harvesting of crop from one-meter square area was done. In the oven

the plant samples were kept, at 65⁰C for two days for the purpose of drying. Conversion of biomass to Kg m² by weighting the dried samples. Grain yield was measured by in each phase the weight of the grain was recorded after threshing and weighing by balance [14].

2.5 Data Analysis

Data were collected for different variables included in the analysis of variance (ANOVA) and the methods obtained were compared with the 5% value by small variance analysis [15].

3. RESULTS AND DISCUSSION

3.1 Total Soil Organic Carbon

TOC under different farming practices as shown in (Fig. 2). The overall data shows that there have been significant effects of different soil farming practices on total organic carbon during sowing and harvesting. However changes under the numerical system were observed. The highest rate of TOC rate (0.89%) was observed in zero cultivation during sowing followed by small plowing (TOC 0.76%) and conventional plowing (TOC 0.72%) respectively. The highest soil to TOC tune (0.90%) was recorded at zero tillage followed by minimum tillage (TOC 0.84%) and conventional tillage (TOC 0.77%) respectively after harvest.

The increase in TOC to zero tillage may be due to minor soil disturbances and limited activity of

soil carbon oxidation. The accumulation of different farming systems often contributes to SOC soil concentration. Strong farming practices increase the formation of organic matter (SOM) in the soil [16], a study of soil analysis, have caused a dramatic change in the TOC in zero-yielding farming. Desert areas are characterized by low SOC content containing low water content and nutrient retention, thus, low internal soil fertility [17]. Conservation tillage is widely documented as a way to reduce SOC losses [18] reported the results of a comprehensive long-term agricultural study and found that on average, the transition from conventional farming (CT) to no-tillage (NT) could take up to 60 g of carbon year⁻¹. Moldboard plowing, in CT systems, increases SOM decay and loss of C from ground to ecosystem like CO₂.

3.2 Mineral Associated Organic Carbon

The results concerning the mineral associated organic carbon under different tillage practices are demonstrated in (Fig. 3). The results showed a significant effect of different tillage practices on soil mineral organic carbon at time of sowing and harvesting. Numerical data changes were observed. Maximum MOC was recorded in minimum tillage at sowing time, (0.30%) followed by zero tillage (0.29%) and conventional tillage (0.24%) respectively. Maximum mean value of soil MOC was record in Zero tillage (0.27%) followed by minimum tillage (0.24%) and conventional tillage (0.25 %) after harvesting respectively.

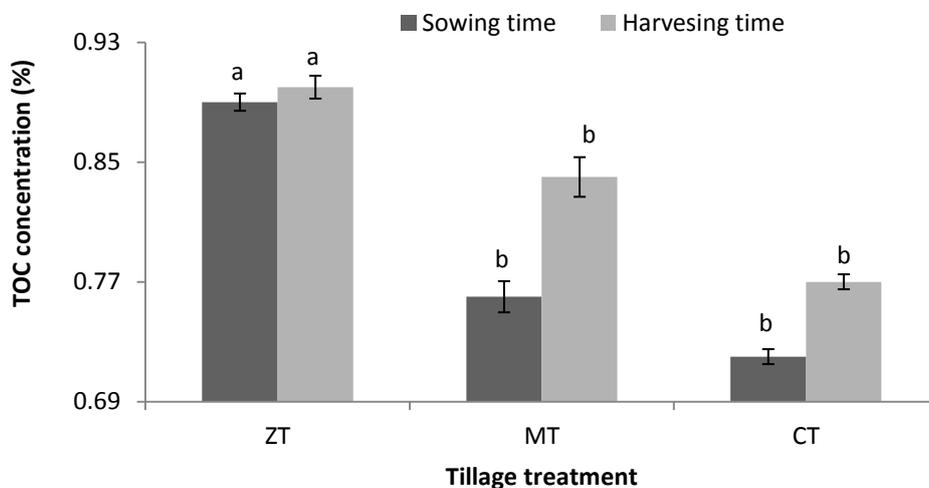


Fig. 2. Soil TOC concentration (%) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at P=0.01

The mineral associated organic carbon under conventional tillage systems without prevention of organic matters is related to the higher decomposition of organic carbon. The highest amount of carbon in mineral associated organic carbon is possibly due to different climatic factors i.e. high temperature relative humidity, unfavorable fluctuation to organic matter decomposition and transformation to MOC. Our research results were same to as [19] that data has non- significant effect of tillage on MOC. My research also found the same pattern of MOC which possibly is due to short duration of study as well as physical and chemical characteristics of soil organic matter and biological decomposition.

3.3 Particulate Organic Carbon

Particulate organic carbon (POC) under different tillage practices are depicted in (Fig. 4). The results show that there were significant effects of different tillage practices on Particulate Organic Carbon at time of sowing and harvesting. During the entire research work, numerical changes were observed as maximum mean value of soil POC was observed in zero tillage at the time of sowing (0.46%) followed by minimum tillage (0.46%) and conventional tillage (0.43%) respectively. Maximum mean value of soil POC was record in Zero tillage (0.45%) followed by Minimum tillage (0.40%) and conventional tillage (0.42 %) after harvesting respectively.

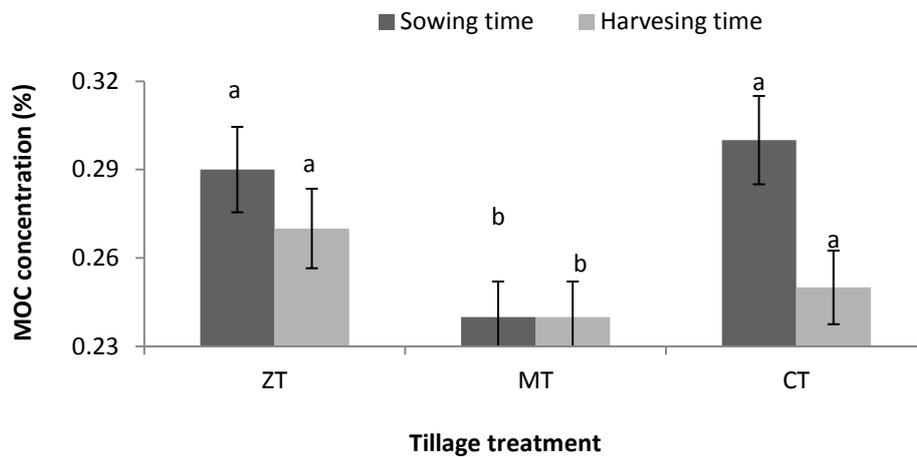


Fig. 3. Soil MOC concentration (%) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at $P=0.01$

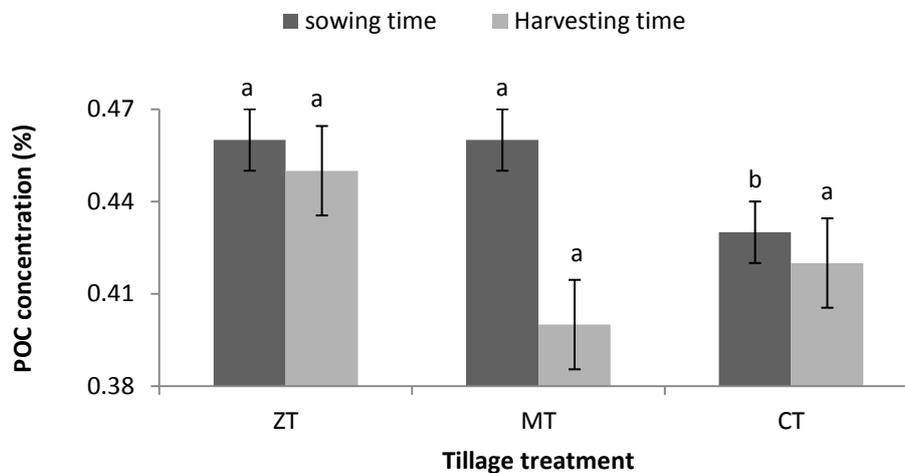


Fig. 4. Soil POC concentration (%) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at $P=0.01$

Due to the high inclination of advanced agricultural disturbances, POC is also an important indicator of the initial response of the SOC state under various mechanical processes [20]. The waste particles of natural carbon-related minerals have a diameter of more than 53 μm , and are involved under mineral residues in the form of organo-mineral complexes shape. This is similar to SOM in the complex level of stability and longevity within the soil [21]. Therefore, the size distribution of organic matter particles (SOM) can help to assess changes in land use, due to the sensitivity of these components to soil management [22].

3.4 Microbial Biomass Carbon

Soil microbial biomass carbon (SMBC) was widely affected by different tillage management practices (Fig. 5). The results showed that there was a significant effect on different tillage practices on soil (SMBC) at different time of sowing and harvesting as numerical changes were observed during the research work. Maximum mean value of soil microbial biomass carbon (SMBC) was observed in zero tillage at the time of sowing (0.57%) followed by minimum tillage (0.47%) and conventional tillage (0.43%) respectively. Maximum mean value of soil microbial biomass carbon (SMBC) was record at zero tillage (0.53%) followed by minimum tillage (0.52%) and conventional tillage (0.47 %) after harvesting respectively.

The definite increase in SMBC concentrations under ZT and MT farming systems may be due to a slight decline in biodiversity and the addition of organic matter such as crop residues which has led to the addition of an active SOC pool.

Soil microbial biomass and its function can have a profound effect on plant residues, which in turn can affect soil's ability to provide nutrients to plants through biodiversity. Organic carbon content in soil is a positive co-relation with soil microbial biomass carbon [23]. The large impact of SOC on SMBC indicates that SOC is the more determinant of SMBC in case of higher clay content. In case of water-soluble contents, natural carbon is leached into the soil that changes the quantity of SOC. Water-soluble natural carbon within the soil is then mixed with the carbon to construct microbial biomass with the aid of microbes 'nitrogen [24]. The inter relationship between SOC and SMBC demonstrates the imperative role of SOC for function of soil in terms of nutrient accessibility and development on structure of soil via the contribution of microbes [25].

The higher microbial biomass carbon SMBC under different tillage systems with retention of crop residues is related to improved total organic carbon compounds in soil. The main source for microbial community is crop residue. Soil microbial biomass carbon has recommended as sensitive indicator to the health of soil improvement as affected by different systems of tillage and crop residues [26]. Some other researcher explained that increasing concentration of carbon input and their low mineralization process is quit beneficial for increasing microbial biomass carbon SMBC under no-till systems. They further added that soil biological activities are enhanced by conservation of tillage practice. Workers in Pakistan such as [27], reported that increased cropping intensity and preservation of crop residues promotes soil microbial activity.

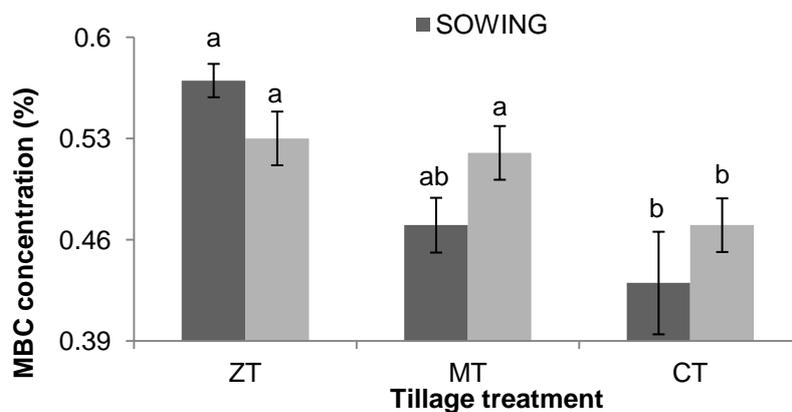


Fig. 5. Soil MBC concentration (%) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at P=0.01

3.5 Soil Moisture Contents

Wet soil samples were taken and dried in shade to study soil moisture contents. When the soil was completely dried up than these samples were re-weight. The soil moisture was first affected by different tillage management practices (Fig. 6). Results showed that there were significant effect of different tillage practices on the soil moisture contents although, numerical changes were observed. Mean value of soil moisture contents was observed maximum in crop field of zero tillage (16.15%) while in minimum tillage practice, soil moisture contents was found to be 15.87% and in conventional tillage soil moisture contents was 15.16% respectively.

The moisture contents were found higher in ZT as compared to MT and CT and this increased water contents in ZT may be due to higher organic matter contents that improve the water retention capacity of the soil and also due to the soil cover of the organic matter that works as mulch and hence reduces the evaporation of soil water. Similar results were attained from [28] who also reported increase in soil water contents under zero till system.

Moreover, for higher moisture contents, ploughing with moldboard in CT and MT plots had broken the surface compressed layer which resulted in higher storage of water. The retention of crop residues also enriched storage of water by reducing evaporation losses in ZT plot as covering the surface area of the experimental plot in question hence reducing evaporation

process. The result is in line with [29] who reported that zero tilled plots store higher moisture contents due to lower bulk density and more porosity than the other treatments. The addition of a water reserve below the surface horizons increases the depth of rooting and increases water availability for plants, which significantly improves their confrontation during periods of drought [30]. Guar roots are mostly found between 0-12 cm depths and the crop residue left on the soil surface not only increases organic matter contents of the soil, that serves as a plant nutrient, but also works as a mulch that reduces the loss of water in the upper area of soil through covering or so called mulching effects. This process also increases physical properties soil.

3.6 Emergence

The result dictated that there was a non-significant effect of different tillage practices on emergence percentage as depicted in (Fig. 7). Mean emergence percentage was observed in conventional tillage system (26%) as compared to minimum tillage (22%) and zero tillage (19%) respectively.

In this study, the emergence percentages were found to be affected in different tillage systems. Emergence percent conventional tillage (CT) was found to be highest as compared to others (ZT and MT). This highest increase in germination in the conventional tillage may be the result of greater appropriate soil situations for seedbed preparation. Similarly, same findings were also

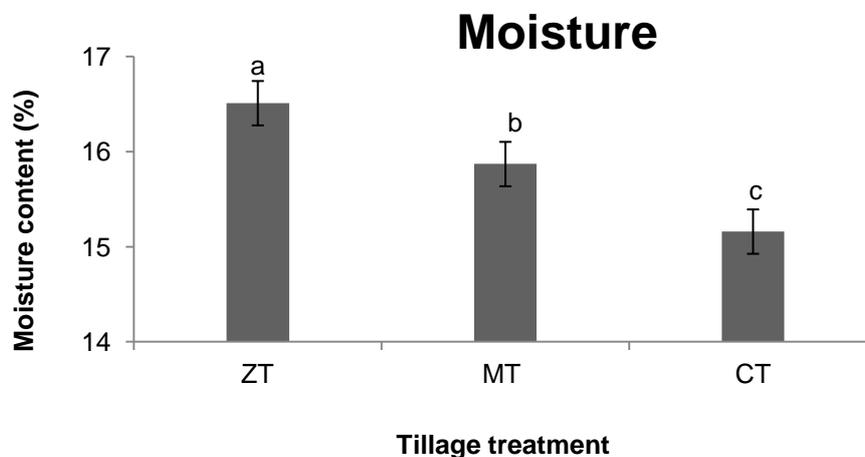


Fig. 6. Soil moisture contents (%) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at P=0.01

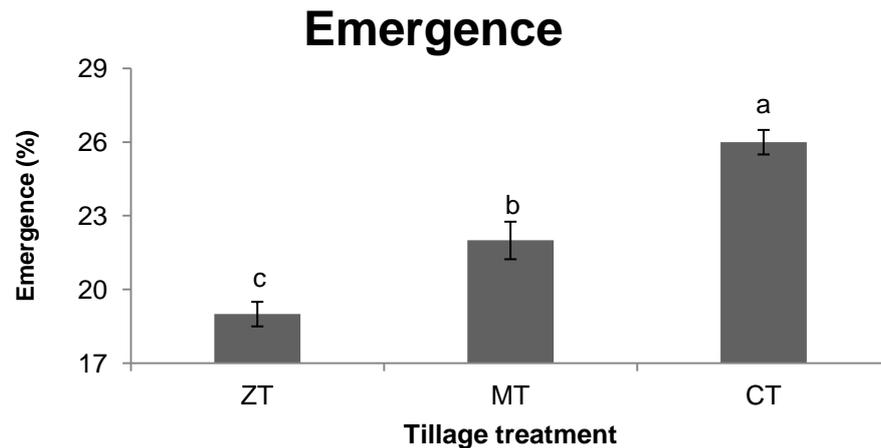


Fig. 7. Emergence (m^{-2}) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at $P=0.01$

observed by [31] who reported that high residual coverage increased crop yields in the rotary hoe conservation system and moldboard plow in muddy soils which led to better crop rotation and ultimately contributed to crop growth and overall crop yields. A better percentage of growth in smallholder and conventional farming may be associated with better moisture retention during the growing season. Reduced soil compaction provides a good crop of vegetation that occurs in conventional farming and is much smaller compared to zero tillage when bulk density was high and hence the germination was found to be lower than both the mentioned farming systems

(CT) and MT).The study is further supported by [32] whose research found a better seedling emergence because of desirable bulk density and proper water availability.

3.7 Biological yield

Biological yield is a major donor to total output of any crop and dependent upon crop administration, type of variety and many other factors such as Plant population, varieties, and their mutual relationship between varieties and plant population [33].

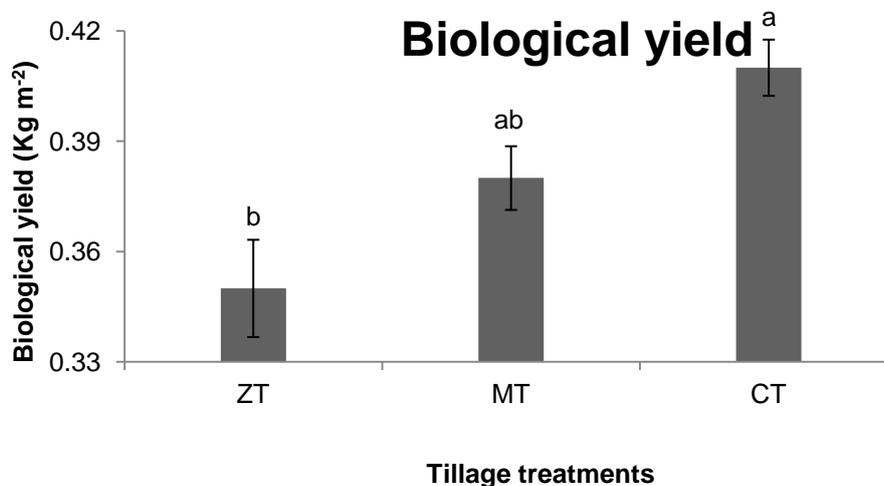


Fig. 8. Biological yield ($Kg m^{-2}$) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at $P=0.01$

The research crop biological yield (kg) was affected by various tillage practices as shown in (Fig. 8). Statistically the different tillage practices were found to have significant for test crop biological yield. Maximum mean value of Biological yield (0.41 kg m^{-2}) was observed in conventional tillage system followed by minimum tillage (0.38 kg m^{-2}) and zero tillage (0.35 kg m^{-2}) respectively.

Conventional tillage treatment (CT) usually results in soil conditions, while MT and ZT have resulted in lower biological yields due to soil compaction which in turn contributed to seed germination and deeper root penetration into the seed bed. The possible reason for high biological yield of conventional tillage treatment is probably attributed to the good soil conditions as soft/porous seedbed preparation, desirable soil aeration, extended infiltration charge, availability of vitamins and moisture etc.

3.8 Grain Yield

Different tillage practices affected the grain yield as shown in (Fig. 9). The results suggested that there was a significant effect on different tillage practices on the overall grain yield of the test crop (Kg m^{-2}). The study revealed a maximum grain yield (0.15 Kg m^{-2}) in conventional tillage system followed by minimum tillage (Grain yield 0.12 kg m^{-2}) and zero tillage (Grain yield 0.13 kg m^{-2}) respectively. The high yield of grain in conventional agriculture is probably due to the breaking of the solid pan which led to a deep penetration of guar roots to absorb moisture, air

and nutrients which resulted in high grain yields. The conventional tillage treatment (CT) yielded higher due to the condition of the seedbed as it was more porous than MT and ZT. The changes in data of grain yield for different cultural practices may be due to the compactness of the soil, seed germination percentage, and penetration of root deeper in the seedbed, providing better germination conditions for the test crop [34].

Conventional farming areas that cause high grain yields can be caused by the depletion of the underground pan with chisel plows that increase water flow and movement even if the humidity level is low during the dry season which promotes root growth and thus facilitates better crop development. In ZT areas, low grain yields were associated with lower yields due to improper germination and crop production conditions. Decreased yield in ZT areas may be related to delayed germination of the original crop. In ZT structures, the surface of the test field is compact which should affect plant germination and establishment which ultimately reduces yields. Same findings were reported by Sortino, O., [35]. Their study revealed that the crop yield is likewise reduced with late germination. Similar findings were observed by Meftahizade, H., et al., [36] who reported that the upper layer of soil constrains root development. The studies of other scientists Patil & Sheelavantar, [37] determined a higher grain yield of various plants under deep tillage practices in comparison to zero or minimum tillage [38].

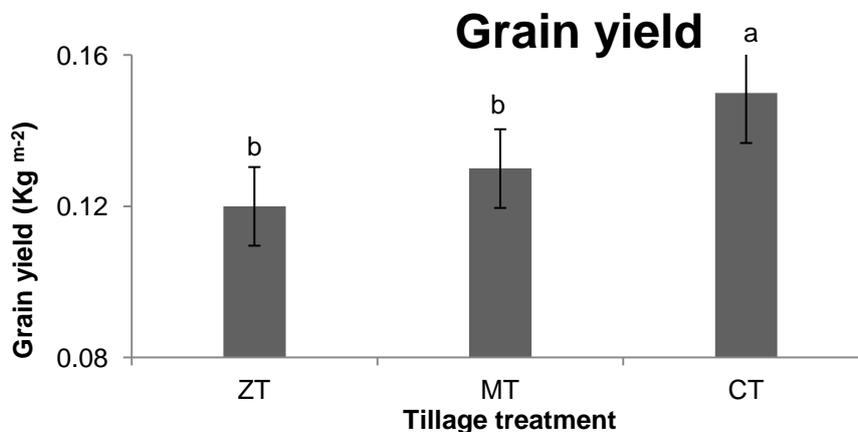


Fig. 9. Grain yield (kg m^{-2}) under different tillage practices during 2019-20 under guar crop in upland of Balochistan

The error bars show standard error. Means with different letters are significantly different with LSD at $P=0.01$

4. CONCLUSION

It is concluded that reduction of tillage practices with growing of crops in leguminous rotations have potential to improve organic matter contents in soil, enhance soil moisture contents and provide sufficient yields. It is further suggested to extend research trial at multiple locations under different soil and climatic conditions also to involve other disciplines of agriculture to alter crop sowing time, methods and varietal modification.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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