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Investigation and evaluation of Effects of Tillage System on physical properties of soil

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Abstract

Tillage operations in dry soil conditions have increasingly been used in Ethiopia in recent years. However, using inappropriate tillage systems for agricultural activities affects soil physical properties like; bulk density, particle density, void ratio, porosity, and penetration resistance. The improper selection of tillage systems for dry soil conditions directly or indirectly affects the grain yield. Therefore, the present study evaluated the effect of different tillage techniques; on the soil's physical property parameters. The experiments were conducted at Kulumsa Agricultural Research Center (KARC); the design of the experiment was planned by using Randomized Completely Block Design (RCBD). The tillage was performed by using Conventional tillage (CT), Minimum tillage (MT), and No-tillage (NT) randomly for three blocks with three replications. The data analysis was carried out by using SPSS statistical analysis software. The results of this study revealed that the effect of tillage systems was significant on soil bulk density, particle density, soil penetration resistance, and non-significant on soil void ratio and porosity at $P \leq 0.05$ level of significance. The value of soil bulk density was higher in CT (1.3 cm-3) than NT (1.21 cm-3) in 2022 before tillage and after harvesting respectively. The value of soil particle density was higher in CT (1.41 cm-3) before tillage in 2021 and less in NT (1.36 cm-3). MT (13.43 %) had the maximum value of Soil porosity before tillage than MT (1.95%) after harvesting in the 2022 year of crop production. Soil void ratio was also higher in CT (0.11) in 2021-year crop production before tillage than MT (0.07) after harvesting in 2022. The soil penetration resistance was higher in NT (0.46 kN) than CT (0.21 kN) after harvesting in 2022 crop production.

Keywords: Soil physical properties, Tillage systems, Soil bulk density, Soil particle density.

I. Introduction

Tillage is the mechanical manipulation of soil for better seedbed preparation. It is well known that inappropriate tillage systems affect the soil's physical properties. When soil physical property is affected by tillage systems the crop yield will also affected. Some tillage systems may have a positive effect on the soil's physical properties, but some other tillage may negatively affect the soil and lead to less grain yield. Implementing effective and sustainable agriculture requires a deeper understanding of the impacts of conservation tillage practices on soil physical properties (Li *et al.*, 2019). Utmost, in most of the countries, conservation tillage has been shown to contribute to preserving soil properties. However, to promote this practice in new areas, it is necessary to generate information about its results in local environmental conditions (Ordoñez-Morales *et al.*, 2019).

In another way, No-tillage systems may affect soil properties depending on the soil condition, climatic conditions and the time factor during its implementation. In heavy no-tilled soils, a surface compacted layer is commonly found. Such a layer can affect root growth and soil water infiltration (Martínez *et al.*, 2008). However, it is reported by many researchers that the knowledge of the long-term impacts of no-tillage systems on soil properties is insufficient. It is essential to know which soil quality indicators are the most sensitive to management practices in each particular environment (Sokolowski et al., 2020). The movement and distribution of the soil water and nitrogen are significantly influenced by tillage management. However, the dynamics of soil water and nitrogen due to changes in tillage and surface residue cover can be difficult to characterize due to limitations in field experimentation (Ding et al., 2020). The comparative analysis of the effect of different tillage systems on silty loam soil physical properties was conducted in Northwest Slavonia from 1997-2000. The results showed that there were no significant differences among soil bulk density, total porosity, water holding capacity, air capacity, and soil moisture content. Due to the tillage effects of conventional practices, reduced, minimum tillage systems (Husnjak et al., 2002). The studies conducted in Morocco to identify the impact of the tillage system on soil physical properties showed that the NT system improved soil stability, bulk density, water content, and organic matter (El Mekkaoui *et al*., 2023, Kolhe *et al* 2024). Additionally, the study conducted in Bangladesh (Bangladesh Agricultural Research Institute) for four consecutive years from 2008 to 2012 to observe the effect of four tillage practices: zero tillage, minimum tillage, conventional tillage, and deep tillage on soil physical properties and crop yield under wheat-Mungbean-T aman cropping system. In this regard, the zero tillage showed the highest bulk density, particle density, increased porosity, and filed capacity. All tillage effects showed similar yields after four years of cropping cycles (Alam et al., 2014, Chali et al 2024).

To alleviate problems of environmental damage, improvements of soil health, and growth of plant and grain yield Conservation Agriculture is essential. Minimum and No-tillage practices have the benefits of enhancing soil health, and environmental and eco-friendly (Busari et al., 2015). The objective of this study was to investigate and evaluate the effect of different tillage techniques; like CT, MT, and NT on the soil physical property parameters like Bulk density, particle density, Total porosity, Void ratio, and penetration resistance of the soil.

2. Materials and Method

2.1 Materials

Different hand tools like; shovels, soil augers, hammers, and plastic bags were used for the soil sample preparation. Moreover; for the laboratory testing, the soil samples preparation followed: technical balance, pH meter, plastic bag, glass rod, paper towel, reagents, gloves, and dispenser were used. Also; for the field tillage experiments Massey Ferguson 6480 Tractor (75 -130 kW), Lemken Europal 5 Mould board plow, Lemken Saphir 7 Seed Drilling Machine, Lemken Kristall 9 Cultivator implements, etc were used. For the data analysis statistical software SPSS was used, to find the level of significance, for three tillage operations.

2.2 Study location and Experimental procedure

The study was carried out from June 2021- 22 to Nov 2021-22 during the crop planting season at Kulumsa Agricultural Research Center, Oromia regional state, Arsi zone, 167 km from Addis Ababa (Ethiopia) as shown in figure 1. Kulumsa is located at latitude/longitude 8º2' N and 39º10’E an Altitude of 2200 M a.s.l, it has 10ºC and 22 ºC min/max temperature, and mean annual rainfall is 788 ml. It's Agro ecological zone is from cool highland to semi-arid and dominated by clay soil. The soil samples were collected from nine plots at a depth of 15 cm using a soil auger systematic sampling technique. The samples for laboratory analysis were prepared and labeled separately for easy identification. Before analysis, the collected soil samples were air dried, and ground with a mortar and pestle to remove the large particles, the ground soil was screened by using a 2 mm sieve and stored at room temperature. The overall sample collection and preparation methodology is depicted in Figure 2 (a, b).

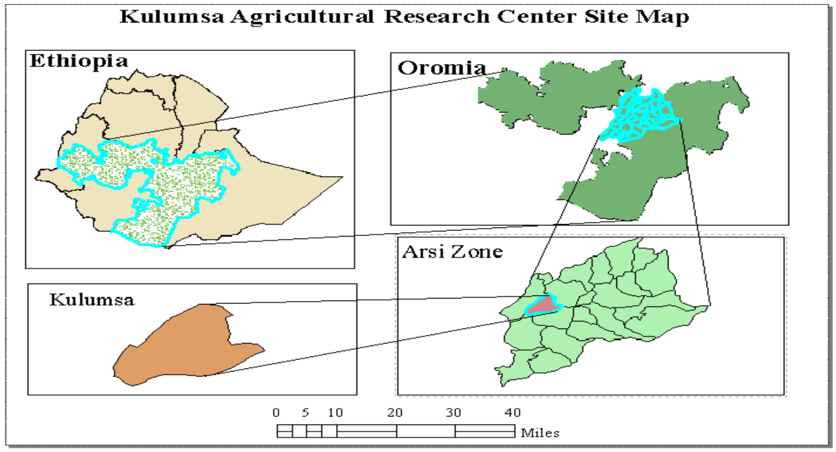
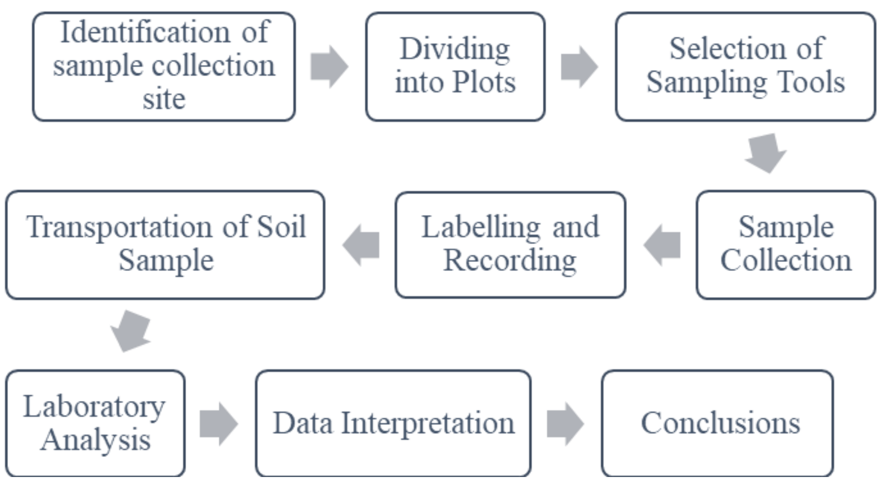


Figure 1: Experimental field site map

(a): Soil collection and Sample Preparation



(b): Soil Sample preparation and laboratory analysis Methodology

Figure. 2 (a, b). Soil sample preparation methods

2.2 Design of Field Experiment

A designed experiment is a test or series of tests in which purposeful changes are made to the input variables of a process so that we can observe and identify the corresponding changes in the output response. The output product has one or more observable characteristics or responses.

Some of the process variables x_1, x_2, x_3 (CT, MT, and NT) are controllable and some process variables z_1, z_2, z_3 (Fertilizer, Seed rate, and Pesticide) are controllable. And the uncontrollable variables; humidity, temperature, and rainfall are considered. From the combined effect of all these variables Controllable and non-controllable on the main tillage process the tillage output Y noted in the form of soil physical property parameters like; bulk density, particle density, void ratio, porosity, and soil structure (BD, PD, VR, P, ST). The overall experimental design is shown in Figure 3 as below;

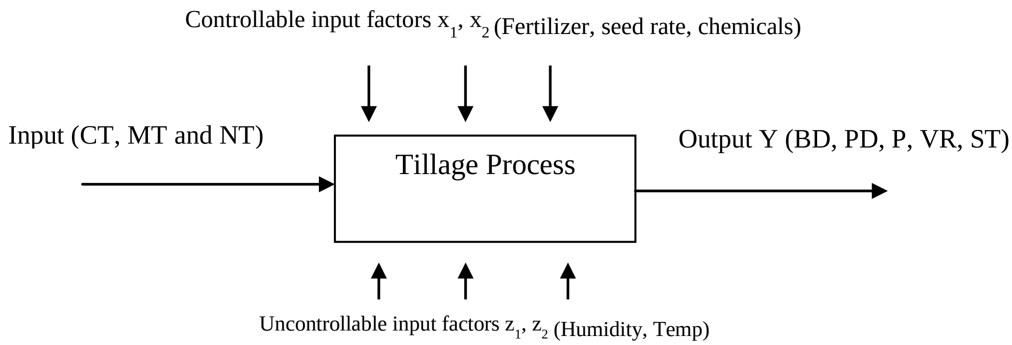


Fig. 3 The Overall Method of Experimental Design

The purpose of experimental design is to determine which variables are most influential on the response Y. And determine where to set influential variable (x) values so that Y is near the nominal value. Also, to set influential variable (x) values so that Y is small and determine where to set influential variable (x) values so that the effects of uncontrollable variables Z are minimized.

A completely randomized block design (CRBD) of three different tillage treatments conventional tillage (Ploughing and planting), Minimum tillage (Cultivator and planting), and No Tillage (direct planting/seed drilling) with three replications was used as shown in Figure 4 below. To carry out a field experiment 50 x 50 M^2 area of land experimental site position was used. The area of land was divided into nine plots, 15x20 M^2 for Conventional Tillage (CT), Minimum Tillage (MT) and No-Tillage (NT), three for each, the CRBD design of experiment for the overall tillage operation as shown in Figure 4.

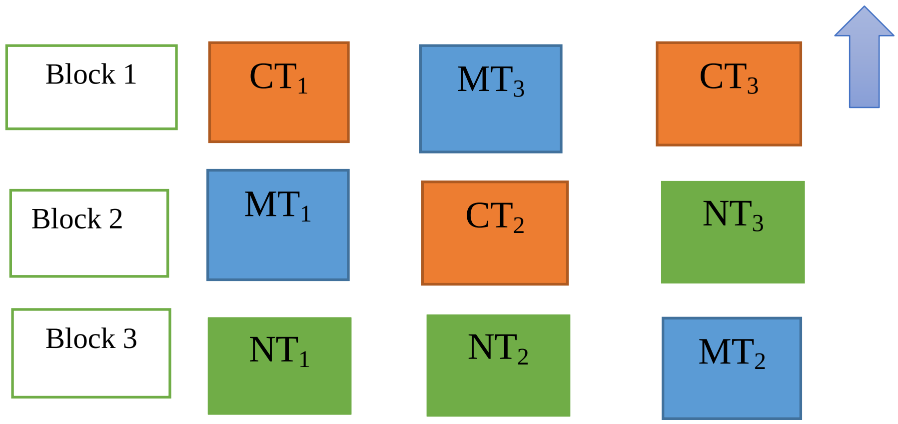


Figure 4: A completely randomized block Experimental Design

The effect of conventional tillage includes a combination of ploughing and planting, also; Minimum tillage includes cultivator and planting. And no tillage includes only planting. Finally, the effect of all tillage systems on soil physical property parameters was calculated by using the ANOVA table as dictated in table. Soil textural classes are classified based on the Guidelines for Soil description of FAO (Amerling et al., 2006).

2.3 Determination of Soil Physical Properties

2.3.1 Determination of Soil Bulk Density

Soil bulk density measures the density and tightness of soil samples, determined by measuring dry soil mass per unit volume. The bulk density was determined by measuring the weight of the wet soil and then dried by inserting it in the oven for 24 hours at 105℃ (Głab and Kulig, 2008).

$$\text{Soil Bulk Density} = soil\ total\left(\frac{g}{cm^3}\right) \quad [1]$$

2.3.2 Determination of Soil Particle Density

Soil particle density (Dp) is an important soil property for calculating soil porosity expressions (Schjønning et al., 2017b). To measure the soil particle density, the following materials and procedures were used. Namely; Pycnometer, oven-dried sieved soil, distilled water, a small funnel, and balance accurate to 0.1g, oven mitts, thermometer, (or 100 mL volumetric flask).

To measure soil particle density, distilled water was placed in a squirt bottle, the time was recorded since soil drying and storage, and the mass of an empty flask without its cap was measured. 25g of dried, sieved soil to a flask using a funnel was transferred, and the mass of the flask containing the soil was measured. 50ml of distilled water washed and to the soil. The mixture was brought to a gentle boil, then let it cool for 24 hours. After 24 hours, the flask was filled with distilled water and the mixture was weighed and recorded.

$$\text{Particle Density} = \text{soil total} \left(\frac{g}{cm^3}\right) \qquad [2]$$

2.3.3 Determination of Total Porosity

The total porosity of the soil samples was determined by analyzing the soil particle density and dry bulk density (Głab & Kulig, 2008).

$$\text{Porosity} = 1 - \left(\frac{DB}{DP}\right) * 100\%$$

[3]

Where DB: is Soil Bulk density

DP: Is soil Particle density

2.3.4 Determination of Soil Void Ratio

Defined as the ratio of total pore space to the total volume of individual solid particles (Upadhyaya, 2005).

$$e = \frac{Vo}{Vs}$$

[4]

Where V_0 is the total volume of voids and Vs is the total volume of solid particles.

2.3.5 Determination of Soil Penetration Resistance

Penetration resistance of soil is usually measured with a penetrometer. Penetrometer resistance is widely measured because it provides an easy and rapid method of assessing soil strength *(Dexter et al., 2007*). Soil penetration resistance is very crucial to do analyses of Soil compaction, aeration, root penetration, and soil profile which influence plant growth (*ML Jat et al; 2023*). Cone penetrometers are used widely for soil strength measurement and tillage decisions (S Gorucu *et al; 2006*). To measure the soil resistance hand operated Eijkelkamp Cone penetrometer with a 60° angle was used. Data was recorded by pushing the penetrometer by exerting force on the device to the soil. The soil resistance data was collected from nine plots at 15 cm depth. The resistance was measured at the cone red from the pressure gauge, which indicated it with a red pointer. The actual resistance to penetration resistance (KN/cm^2) of the soil was determined by diving the reading value by the surface of the cone from the device directly to a place where the pointer indicated.

2.3.6 Determination of Soil Texture

The hydrometer method was used to determine soil texture by using the following apparatus: Graduated cylinder 1000 ml, Soil dispersing stirrer: A high-speed electric stirrer with a cup receptacle, Hydrometer with Bouyoucos scale in g/L (ASTM), Stopwatch, Beaker 1L capacity, Thermometer -10 to 1000C, Plunger. It involves weighing 40g of soil into 600ml beakers, adding 5% Calgon solution, and 25 ml water. The beaker was covered with a watch glass and left for overnight. The soil is then stirred for 5 minutes, mixed with distilled water, and poured into a hydrometric jar. The hydrometer is read after 45 seconds. The jars were kept undisturbed for 3 hours and took the second reading (Beretta et al., 2014, Gindo et al 2023).

3 Results and Discussion

3.1 Results

The experimental test results of various tillage systems like CT, MT, and NT for soil physical property parameters are depicted in Tables 1 and 2 below. Also, the combined and year-wise effect of mean value of different tillage systems is depicted in Tables 3 and 4. Furthermore; the ANOA calculations for identifying the significance effect of various tillage systems on soil physical property parameters is presented in Tables 5 and 6.

Table 1: Analytical Results of field experiment of tillage system on soil physical property parameters before tillage and after harvesting in 2021 GC

Year of Crop Production	Tillage systems	Rep	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Total Porosity (%)	Void Ratio	Soil Penetration Resistance, KN
2021BT	CT	CT1	1.29	1.44	10.52	0.12	0.2
		CT2	1.23	1.44	11.65	0.13	0.22
		CT3	1.31	1.41	7.46	0.08	0.2
		Mean	1.28	1.43	9.88	0.11	0.21
	MT	MT1	1.34	1.51	11.27	0.13	0.26

		MT2	1.21	1.27	5.14	0.06	0.34
		MT3	1.26	1.33	5.23	0.059	0.28
		Mean	1.27	1.37	7.21	0.08	0.29
	NT	NT1	1.2	1.36	11.27	0.13	0.4
		NT2	1.22	1.4	8.99	0.1	0.42
		NT3	1.3	1.36	4.36	0.05	0.4
		Mean	1.24	1.37	8.21	0.09	0.41
2021AH	CT	CT1	1.27	1.34	5.13	0.051	0.25
		CT2	1.18	1.33	10.89	0.12	0.23
		CT3	1.34	1.43	6.68	0.07	0.3
		Mean	1.26	1.37	7.57	0.08	0.26
	MT	MT1	1.38	1.54	10.52	0.12	0.21
		MT2	1.25	1.32	5.23	0.06	0.24
		MT3	1.24	1.3	4.36	0.05	0.29
		Mean	1.29	1.39	6.7	0.08	0.25
	NT	NT1	1.21	1.33	8.99	0.1	0.41
		NT2	1.2	1.34	10.52	0.12	0.43
		NT3	1.34	1.43	6.3	0.07	0.46
		Mean	1.25	1.37	8.6	0.09	0.43

Table 2: Analytical values of field experiments of tillage system on soil physical property parameters before tillage and after harvesting in 2022 GC.

Year of Crop Production	Tillage systems	Rep	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Total Porosity (%)	Void Ratio	Soil Penetration Resistance, KN
2022BT	CT	CT1	1.3	1.38	5.9	0.06	0.22
		CT2	1.29	1.43	9.75	0.11	0.25
		CT3	1.32	1.44	7.85	0.08	0.24
		Mean	1.3	1.42	7.8	0.08	0.24
	MT	MT1	1.18	1.34	11.27	0.12	0.24
		MT2	1.23	1.29	5.12	0.05	0.31
		MT3	1.22	1.287	4.75	0.051	0.25
		Mean	1.21	1.31	7.05	0.07	0.27
	NT	NT1	1.21	1.32	8.18	0.09	0.48
		NT2	1.18	1.3	8.61	0.096	0.42
		NT3	1.28	1.36	5.23	0.06	0.43
		Mean	1.22	1.33	7.34	0.08	0.44
2022AH	CT	CT1	1.14	1.22	6.3	0.07	0.23
		CT2	1.23	1.4	11.65	0.13	0.21
		CT3	1.28	1.4	8.23	0.09	0.24
		Mean	1.22	1.34	8.73	0.097	0.23
	MT	MT1	1.33	1.45	7.85	0.08	0.3
		MT2	1.18	1.3	8.61	0.09	0.26
		MT3	1.19	1.27	5.9	0.06	0.24

		Mean	1.23	1.34	7.45	0.08	0.27
	NT	NT1	1.16	1.26	7.85	0.08	0.5
		NT2	1.11	1.23	9.75	0.11	0.41
		NT3	1.3	1.46	6.68	0.07	0.48
		Mean	1.19	1.32	8.09	0.09	0.46

Table 3: The combined two years mean value of the tillage system's effect on soil physical property parameters.

Tillage Systems	Count	Soil Parameter				
		SBD (g cm^{-3})	SPD (g cm^{-3})	TP (%)	SVR	SPR, KN
CT	12	1.26±0.06a	1.39±0.06a	8.50±2.32a	0.09±0.03a	0.23±0.03a
MT	12	1.25±0.07a	1.35±0.09a	7.10±2.67a	0.08±0.03a	0.27±0.04b
NT	12	1.23±0.07a	1.35±0.07a	8.06±2.09a	0.09±0.02a	0.44±0.03c

Table 4: Year wise comparison of tillage system on soil physical property parameter.

Year of Crop Production	N	Soil Parameter				
		SBD (g cm^{-3})	SPD (g cm^{-3})	TP (%)	SVR	SPR, KN
2021BT	9	1.26±0.05	1.39±0.07	8.43±2.95	0.10±0.03	0.30±0.09
2021AH	9	1.27±0.07	1.37±0.08	7.62±2.61	0.08±0.03	0.31±0.09
2022BT	9	1.25±0.05	1.35±0.06	7.41±2.29	0.08±0.03	0.32±0.1
2022AH	9	1.21±0.08	1.33±0.1	8.09±1.8	0.09±0.02	0.32±0.1

Table 5: Illustration of ANOVA table on the effect of tillage systems on soil parameters

Soil Parameter		Sum of Squares	df	Mean Square	F	Sig.
SBD (g cm^{-3})	Between Groups	0.009	2	0.005	1.151	0.329
	Within Groups	0.135	33	0.004		
	Total	0.145	35			
SPD (g cm^{-3})	Between Groups	0.013	2	0.007	1.117	0.339
	Within Groups	0.192	33	0.006		
	Total	0.205	35			
TP (%)	Between Groups	12.238	2	6.119	1.088	0.349
	Within Groups	185.592	33	5.624		
	Total	197.830	35			
SVR	Between Groups	0.002	2	0.001	1.003	0.378
	Within Groups	0.025	33	0.001		

	Total	0.027	35			
SPR, KN	Between Groups	0.285	2	0.143	130.513	0.000
	Within Groups	0.036	33	0.001		
	Total	0.321	35			

Table 6: Year wise Illustration of the ANOVA table for the impact of tillage systems on soil parameters.

Soil Parameter	Tillage system	Sum of Squares	df	Mean Square	F	Sig.
SBD (g cm^{-3})	Between Groups	0.016	3	0.005	1.343	0.278
	Within Groups	0.129	32	0.004		
	Total	0.145	35			
SPD (g cm^{-3})	Between Groups	0.018	3	0.006	1.033	0.391
	Within Groups	0.187	32	0.006		
	Total	0.205	35			
TP (%)	Between Groups	5.747	3	1.916	0.319	0.811
	Within Groups	192.083	32	6.003		
	Total	197.830	35			
SVR	Between Groups	0.001	3	0.000	0.488	0.693
	Within Groups	0.026	32	0.001		
	Total	0.027	35			
SPR, KN	Between Groups	0.001	3	0.000	0.047	0.986
	Within Groups	0.320	32	0.010		
	Total	0.321	35			

3.2. Discussions

Tables 1, 2, and Figure 5 presented the maximum mean values of bulk density, 1.28 g cm^{-3} and 1.3 g cm^{-3} for conventional tillage in 2021 and 2022, respectively. The maximum mean values of bulk density, 1.29 g cm^{-3} and 1.23 g cm^{-3} was also noted in minimum tillage in 2021 and 2022 after harvesting, respectively. The minimum values of bulk density, 1.24 g cm^{-3}, 1.25 g cm^{-3}, 1.22 g cm^{-3} and 1.19 g cm^{-3} were observed in No-Tillage 2021/22 before and after harvesting.

Tables 1, 2, and Figure 6 showed the maximum mean value of particle density, 1.43 g cm^{-3} and 1.42 g cm^{-3} for conventional tillage in 2021 and 2022 before tillage, respectively. The maximum value of particle density, 1.39 g cm^{-3} was also observed in 2021 after harvesting. The maximum value of similar soil particle density, 1.34 g cm^{-3} was also noted in conventional and minimum tillage in 2022 after harvesting. The minimum value of particle density, 1.31 g cm^{-3} for minimum tillage in 2022 before tillage and 1.32 g cm^{-3} for No-tillage in 2022 after harvesting, were noted.

The minimum value of similar particle density, 1.37 g cm^{-3} for minimum and No-tillage in 2021 before tillage, 1.37 g cm^{-3} for conventional and No-tillage in 2021 after harvesting, was also observed.

Tables 1, 2, and Figure 7 revealed the maximum mean values of total porosity of 9.88 %, 7.8 %, and 8.73 % in conventional tillage in 2021 before tillage and 2022 before tillage and after harvesting. The maximum value of total porosity, 8.6 %, also noted in No-tillage system. The minimum value of total porosity of 7.21 %, 6.7 % and 7.45 % were observed for minimum tillage in 2021 before tillage, and after harvesting, 2022 after harvesting. The minimum value of total porosity, 7.05 %, was also noted in No-tillage in 2022 before tillage.

Tables 1, 2, and Figure 8 showed the maximum mean value of the void ratio of 0.11 and 0.097 for conventional tillage in 2021 before tillage and 2022 after harvesting, respectively. The maximum value of the void ratio, 0.09 for No-tillage was observed in 2021 after harvesting. A similar maximum value of the void ratio, 0.08 for conventional and No-tillage was noted in 2022 before tillage. The table also revealed the minimum mean value of void ratio, 0.08, 0.07, and 0.08 for minimum tillage during 2021 and 2022 before tillage and 2022 after harvesting, respectively. Similar minimum values of void ratio, 0.08 noted for conventional and minimum tillage in 2021 after harvesting.

Tables 1, 2, and Figure 9 depicted the maximum mean value of soil penetration resistance: 0.41 kN, 0.43 kN, 0.44 kN, and 0.46 kN for No-tillage in 2021/22 before tillage and after harvesting, respectively. The minimum values of soil penetration resistance of 0.21 kN, 0.24 kN, and 0.23 kN also observed for conventional tillage in 2021 before tillage, 2022 before tillage, and after harvesting, respectively. The minimum value of soil penetration resistance, 0.25 kN for minimum tillage, was noted in 2021 after harvesting.

Table 3 and Table 4 show no significant differences in soil physical property parameters due to different tillage systems, except for soil penetration resistance. Two-year field experiments showed no significant soil change, suggesting more years are needed to understand the impact of tillage systems.

The ANOVA table in Table 5 showed slight differences in mean square and sum of square values compared to and between groups and within groups, but significant changes were observed in Soil Penetration Resistance.

The ANOVA table in figure 6 showed the significant change due to year. In this regard except for slight change between and with the group no change found due to tillage systems on soil physical property.

In general, even though the minimum and maximum value of soil bulk density was observed in a recommended range, the effect of No-tillage was better on soil bulk density. <1.3 g cm^{-3}: good, 1.3 to 1.55 g cm^{-3} fair and > 1.8 g cm^{-3} extremely bad value of soil bulk density. This indicated less value of soil bulk density better for soil aeration, root penetration and development, water movement, and nutrient availability(Mukhopadhyay *et al.*, 2019).

The value of soil particle density was lower than expected standard values in all tillage systems. This maybe happened due to soil organic matter for which the recommended value of maximum particle density lies between 1.0 g cm^{-3} and 1.3 g cm^{-3}. The other recommended value lies between 2.65 and 2.7 g cm^{-3} for mineral soils(Schjønning et al., 2017a).

No-tillage systems are commonly used for residue retention and increase soil bulk density by 2.3% (Li et al., 2020). However, studies in Nigeria, China, and Poland have shown insignificant changes in soil bulk density and penetration resistance (Osunbitan et al; 2005, Kolhe 2009). Conventional tillage is mainly affected by CT, increasing capillary porosity (Tangyuan et al., 2009). In Poland, CT has the highest soil porosity than NT systems (Lipiec et al., 2006). NT has higher soil penetration resistance than MT and CT tillage systems 27.8 % (Li et al., 2020).

The standard total porosity is classified as < 2 % very low, 2 % to 5 % low, 5 % to 15 % medium, 15 %-40 % high, and > 40 % very high. The result obtained for total porosity from field experiments for different tillage systems lies between 7.05 % and 9.88 %. The total porosity of the experimental field was medium (Amerling et al., 2006, Kolhe 2009). In general, the medium total porosity needs more improvement for crop growth.

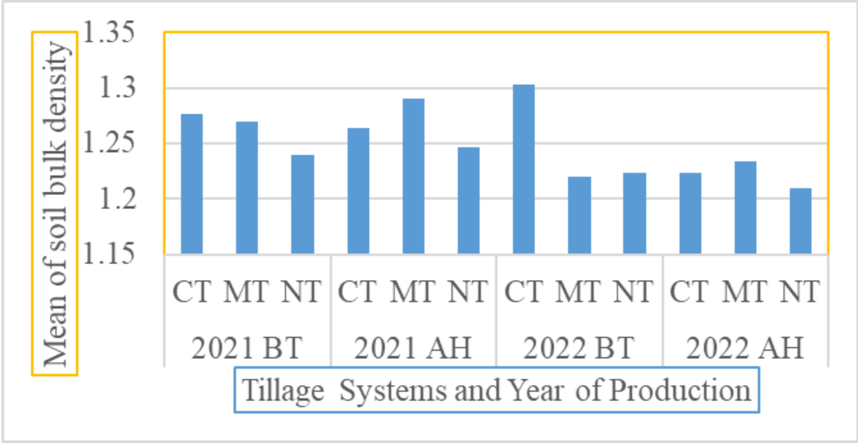


Figure 5: Mean effect of tillage systems on soil particle density

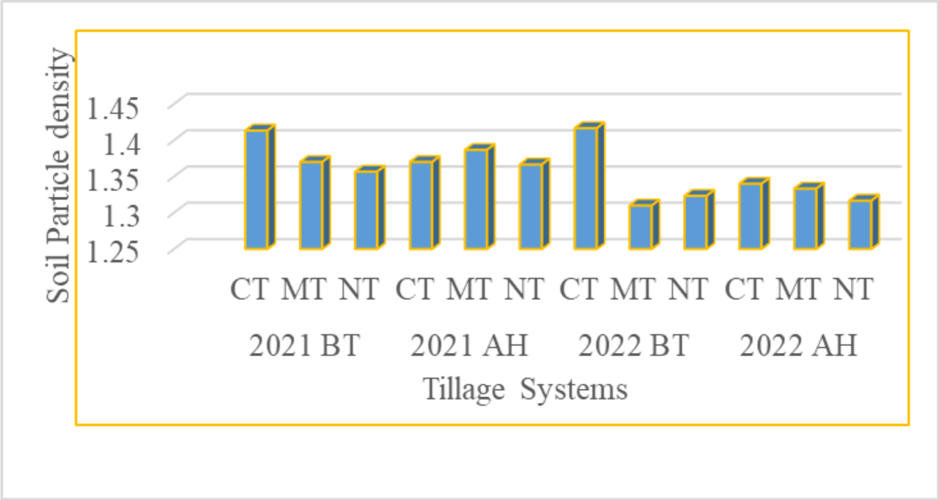


Figure 6: mean effect of tillage systems on soil particle density

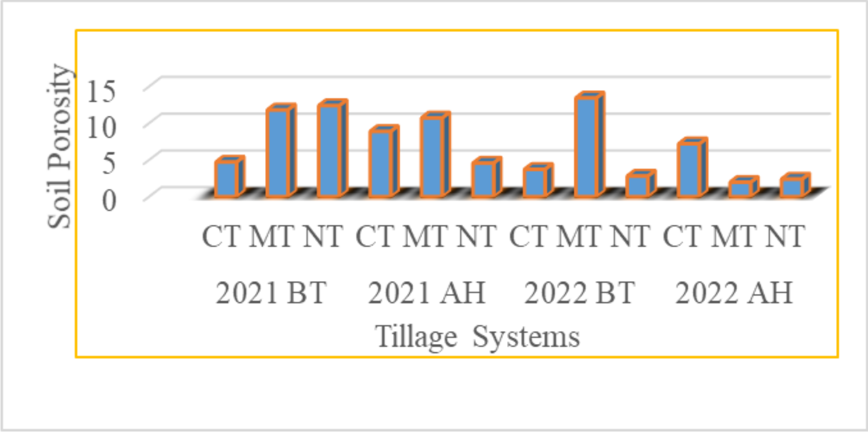


Figure 7: Mean effect of tillage systems on total porosity

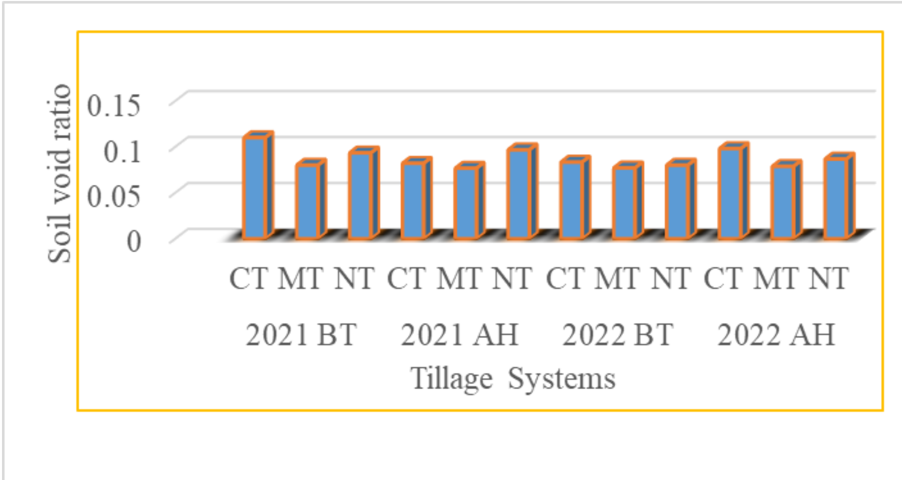


Figure 8: mean effect of tillage systems on void ratio

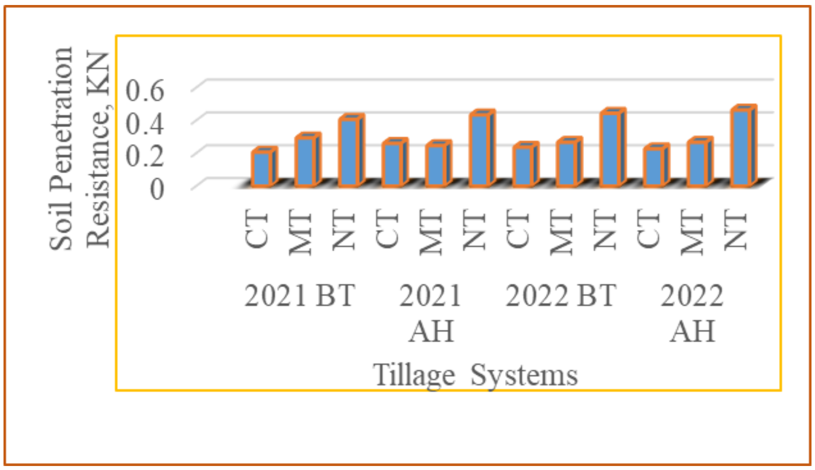


Figure 9: mean effect of tillage systems on soil penetration resistance

Table 7 and Figure 10 showed the highest percentage of sandy soil in CT (55.25%) than both NT (54.98 %) and MT (54.97 %) respectively. Following the sand soil the highest value of clay soil was observed also in CT (27.69%) than MT (26.89 %). The lowest silt soil percentage was also observed in CT (16.85 %) than in NT (18.04%). Figure 11 identification of soil texture at field experiment. In this regard, the soil textural classes of the field were sandy clay loam soil.

Table 7: Effect of Tillage Systems on Soil Texture

Tillage System	**Soil Texture**		
	%Clay	%Silt	%Sand
CT	27.6981	16.8581	55.2538
MT	26.8981	17.9881	54.9763

NT	26.9981	18.0381	54.9888
Mean	27.1981	17.6281	55.0729

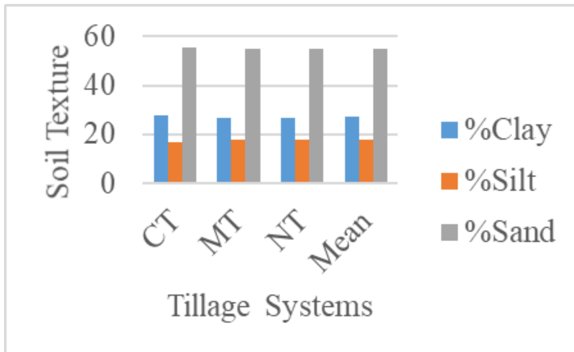


Figure 10: Mean effect of tillage systems on soil textures

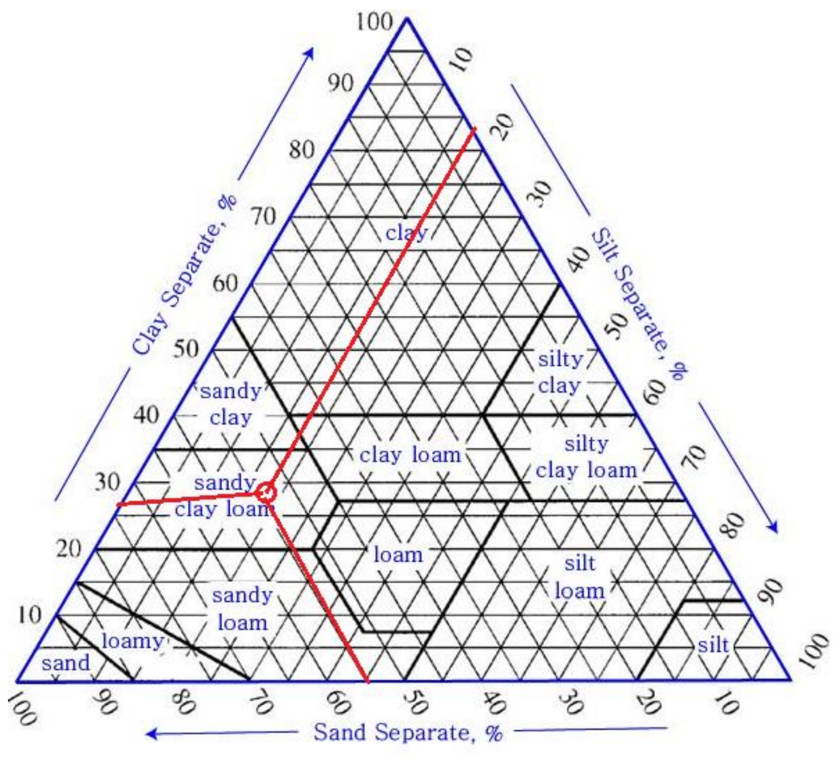


Figure 11: Triangles of Soil Textural Classes at KARC

The soil textural classes were a combination of clay, silt, and sand. The mean value of sand, was 55.07 %, clay, 27.19 %, and silt, 17.62 % respectively. The study result showed that Sand soil had the highest mean value of 55.07 %. In general, the soil texture was dominated by sandy clay loam soil in the place where the study was conducted. Table 7 and Figure 11 also showed that at 0.05 level of significance, no significant difference was observed in soil texture due to different tillage systems. Even though the soil texture takes long time to change, the tillage system negatively affects the soil quality. Since tillage disrupts the soil structure it is exposed to erosion and causes changes the soil physical property parameters.

Conclusions

The following conclusions were drawn from the field experimental results

- After Two years, different tillage practices showed that they influenced soil physical properties along with the improvement of fababean production. Minimum and No Tillage with biomass and residue incorporation conserved moisture in the soil profile and improved other soil properties, reduced the bulk density, soil particle density and porosity
- All tillage practices showed statistically similar yield after Two years of cropping cycles. Therefore, zero tillage (minimum soil disturbance) with 20% residue retention was found to be suitable to improve soil conditions and to achieve optimum yield under fababean cropping system for sandy clay loam soil.
- The average value of soil bulk density was higher in conventional and minimum tillage in the first season before tillage, and the bulk density noted higher for minimum tillage after harvesting.
- The higher average value soil particle density and soil porosity were observed for Conventional Tillage in both seasons of grain production before tillage and after harvesting. Also, the significant effect of tillage systems on soil particle density and non-significant effect for soil porosity was noted before tillage on grain production was noted.
- The soil penetration resistance was affected by tillage systems and significant differences among tillage treatments was observed.
- The soil texture was dominated by sandy clay loam soil; therefore, no significant difference was observed in soil texture for different tillage systems.

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