

Impact of Soil Amendments and Tillage Kind on Soil Physical Properties under Supplemental Sprinkler Irrigation and Dry Farming

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Abstract

The experiment was carried out on the farm of the College of Agriculture Engineering Science University of Duhok in the Kurdistan region of Iraq during the fall 2024–2025 growing season. Using a randomized complete block design (R.C.B.D.), the experiment was conducted in a split-split plot system with 36 experimental units that combined two tillage types (conventional and zero tillage) and three amendments (local, artificial, and control). Additionally, two irrigation levels—dry farming and supplemental irrigation—are used for replicates in order to examine how soil amendment, tillage, and irrigation affect the physical characteristics of the soil. The findings showed that the kind of tillage had a substantial impact on soil aggregate stability following cultivation, with zero tillage improving AS in comparison to conventional tillage. The interaction of Soil Amendment × Tillage Kind had a significant impact on soil bulk density, suggesting that the method of tillage affected how effective the amendments were. While conventional tillage yielded higher Bulk density values (1.62–1.69 g/cm³), wheat straw and Polyter coupled with zero tillage produced lower values (1.12–1.32 g/cm³). Additionally, analysis of variance revealed that whereas Tillage kind greatly decreased compaction under zero tillage, Soil Amendment by itself had no discernible impact on Bulk Density. Under zero tillage, Tillage Kind dramatically raised Field Capacity and the Soil Amendment × Tillage kind interaction improved water retention as well. Likewise, compared to conventional tillage, the wilting point was noticeably greater with zero tillage. Although the impacts of Soil amendment and Irrigation System were negligible. Zero tillage after cultivation had a favorable impact on the mean weight diameter of aggregates, validating its function in enhancing soil aggregation. All of these findings demonstrate that soil structure, aggregation, and water retention were consistently enhanced by zero tillage, whereas soil amendments had little effect on their own but had a favorable interaction with reduced tillage techniques. The goal of the study is to ascertain whether using local soil amendments for soil management is beneficial.

Keywords: soil management, soil amendment, physical properties of soil, Dry farming, Tillage Irrigation.

1. Introduction

The current world population will increase to 9.4 billion by 2050. Of the 8.2 billion people on the planet, 3 billion will live in arid and semiarid regions, resulting in security with minimal environmental risks due to a severe lack of renewable fresh water resources, high risks of soil degradation from a variety of degradation processes, farmers with little resources and inadequate institutional assistance. At the landscape level, the production loss can be anything from zero (or even a positive effect) to complete crop failure. Soil management methods must not only increase productivity per unit area and per unit time, but also address urgent environmental challenges .the rehabilitation of damaged lands and ecosystems, conversion of marginal lands to other suitable land uses, and agricultural intensification on prime agricultural land. (Lal, 2000)The reduction in per capita arable land area and renewable freshwater resources, the rise in soil and environmental degradation risks, and the possibility of decreased input use efficiency due to anticipated climate change make the task of doubling global food grain production by 2030 even more difficult. Therefore, it is more important than ever to define the procedures, guidelines, and laws that control the sustainable management of soil resources. By increasing soil resilience and boosting ecosystem services of the limited and delicate soil resource, the objective is to reduce the risks of soil degradation As illustrated by (Lal, 2009)

Haghighi et al (2010) reported that the characteristics of soil can be greatly impacted by changes in land usage. To ascertain the effects of land use changes on soil organic matter (SOM) and soil physical properties, such as soil aggregate stability, saturated hydraulic conductivity, infiltration rate, available water content,

total porosity, and bulk density (BD), Significant variations across land uses were also seen in total porosity, mean-weight diameter of aggregates, saturated hydraulic conductivity, accessible water content, and predicted final infiltration rate

Lal, R. (2000). Presented that among the major objectives of soil physical management in the tropics are raising agronomic productivity and enhancing environmental quality and enhanced database and a deeper comprehension of the dynamics of soil physical characteristics and processes are resolving a number of views that were brought about by a lack of scientific data and a misinterpretation of the fundamental processes. Providing food security, halting soil deterioration and repairing damaged soils, and enhancing environmental quality are the three main concerns facing the tropics in the twenty-first century. By determining and ranking the research needs in soil physical management.

Branca et al, (2013) indicated that to feed a growing population, agricultural production in developing nations must be raised. According to earlier research, sustainable land management might boost food production without causing damage to water and soil resources. Organic fertilization, little soil disturbance, terraces, water harvesting and conservation, agroforestry, and residue assimilation are examples of improved agronomic methods. Co-benefits from these activities may include decreased greenhouse gas emissions and improved soil and biomass carbon storage.

Arable soils' capacity to fulfill their various roles and promote sustainable development is hampered by the world's rising demand for food, fiber, and bio-based goods. Sustainable soil management in high-production settings ensures that biodiversity and ecosystem services are supported by soil functions, that natural and financial resources are used

effectively, that farming is lucrative, and that production circumstances meet moral and health requirements. (Helming et al., 2018).

Ros et al., (2022) demonstrated that both the significance of accurate soil quality evaluation and the critical role that healthy soil plays in attaining sustainable food production and environmental goals are becoming more widely acknowledged.

Together, the soil functions show the complex multidimensionality of soil quality while being sufficiently autonomous. The framework can make it easier to create sustainable soil management plans by connecting field-level initiatives with regional goals.

Delhak, (2022) showed that approximately one-third of the earth's surface is made up of arid and semiarid regions. Significant drought in other parts of the world and increased land degradation in these areas are caused by climate change.

Excessive soil depletion is caused by soil erosion and the improper or insufficient utilization of renewable natural resources. The issue has been made worse by harsh environmental circumstances, such as the recurrent droughts. The production of food is impacted by desertification and land degradation in developing nations, which make up the world's dry and semi desert regions.

Restoring deteriorated soil with an alternative soil stabilization technology, preventing and minimizing soil deterioration, and fighting desertification. Therefore, the study aimed to improve soil physical properties naturally by using such an available and easiest local material, and evaluation of the soil behavior under dry and irrigated conditions .conventional and conservation tillage process. Assessing the

role of soil amendment local(wheat straw)artificial (polyter)and control, and the combination between all above factors in arid and semiarid environment.in such environment like ours arid and semiarid region.

2. Materials and methods

2.1. Study Site and Experimental Setup:

The experiment was conducted at the land farm of College of Agriculture Engineering Science University of Duhok.in middle of December during the autumn season (2024). The experiment was laid out in a split-split plot design with the using of soil amendment in the main plot and irrigation and dry farming in the subplots and conservation and conventional. They were arranged in a (3 * 2* 2) factorial design (RCBD), which means the experiment consisted of three factors. Factor A- consisted of three soil amendment which are A1= local soil amendment (wheat straw) and A2= artificial soil amendment (Polyter) and A3=control (no soil amendment).factor B- two levels of tillage b1= conventional tillage and b2=zero tillage, factor C consist of two levels c1=dry farming for half of field and c2=supplemental irrigation for other half of field, with three replications (36 experimental units). first, soil sample were taken for physical analyses before land disturbance and parameter like (bulk density ,aggregate stability ,wilting point and field capacity) were estimated then land cleaned up from previous season residue then half right side plowed with moldboard plow then smoothed and leveled in 17/12/2024,then entire field were sowed and treated at same rate of seeds and amendment ,fertilizer applied based upon plant needs for growth, and irrigation was continuously done when needed until harvesting time at 26/5/2025 then after plant harvesting soil sample

were taken immediately from research location then all physical parameter like (bulk density) . Aggregate stability, field capacity and wilting point) were measured to determine the change in soil characteristic during this study and under different natural and artificial condition .before and after conducting the current research the following soil physical parameter were measured.

Table (1) .Some physical properties of the studied soil before planting.

Depth(0-20)	Unit	Soil properties
32.31	KPa	Field capacity
20.19	KPa	Wilting point
48.07	%	Soil Aggregate stability
0.397 (low stability)	Mm	Mean Weight Diameter, MWD
1.12	g cm ⁻³	Bulk density
Soil texture	-----	Clay loam

The current study began on evaluating different soil management processes on wheat growth and productivity in December 2024. The study area located in Sumel district at Duhok province in field of college of agricultural engineering science and the experiment area is located roughly 15 km west of Duhok Province in the Kurdistan

Region of Iraq. Area has the following geographic coordinates: which is located at latitude 36°51'38.437842" N and longitude 42°51'53.751171" E. with elevation approximately (475) meters above sea level (**Figure 1**)

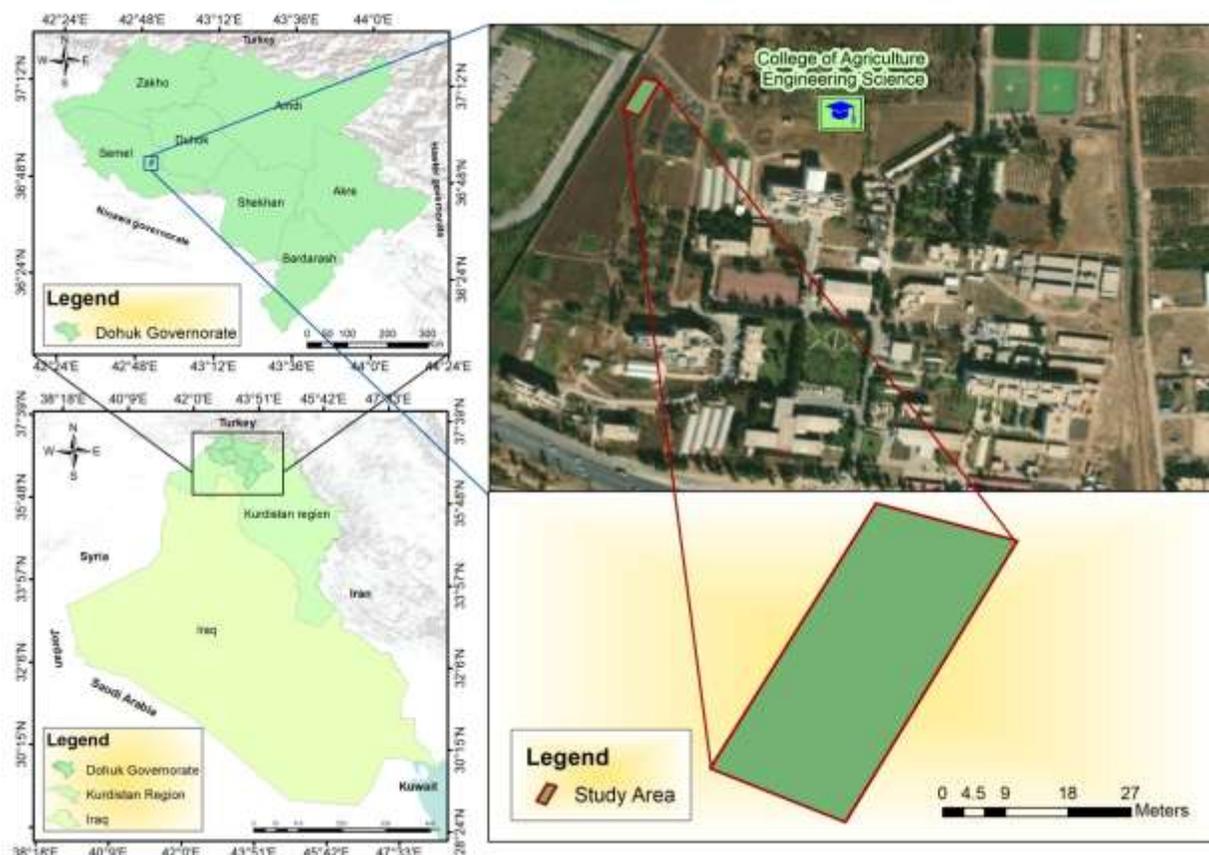


Figure (1): site of the field experiment

3. Studied indicators:

1. Soil indicators:

1.1 Aggregate stability refers to the ability of soil aggregates (clumps of soil particles) to resist disintegration when exposed to external forces such as water. This property is crucial for maintaining soil structure, reducing erosion, and enhancing water

infiltration and root growth. Here are the methods and formulas to measure and improve aggregate stability:

1.2. Mean Weight Diameter (MWD)

Soil aggregates are placed on a sieve and subjected to water. The amount of soil that remains on the sieve after a set period is measured to determine stability.

n

$MWD = \sum x w_i$ according to (E.W. Kemper and R.C. Rosenau, (1986)

1.3. Soil aggregate Stability (SAS) (%) according to (E.W. Kemper and R.C. Rosenau ,(1986)

1.4. Soil bulk density

Soil bulk density was measured by using core method according to (Blake and Hartge)(1986)

1.5. Field capacity and Wilting point

Field capacity and Wilting point was measured by (cooker pressure) and (pressure membrane) device according to (VEIHMEYER, F. J et al. 1949).

The compression between mean was carried out according to (LSD) range test ($p < 0.05$) and ($p < 0.01$) using a computerized program (Microsoft Excel) (Minitab software 16) (statistic 12) and (state blue)

4. Results and Discussion

4.1. Effect of Soil Amendments, Tillage Kind and Irrigation Status on soil

Physical properties.

Soil aggregate stability (AS) after cultivation was significantly influenced by tillage kind ($p < 0.05$). Zero tillage recorded the highest mean AS (114.8%), compared with conventional tillage (100.0%), a difference of ~14.8 units which exceeded the $LSD_{0.05}$ (1.413). This indicates that zero tillage was more effective in preserving soil structural stability compared with conventional tillage. Although wheat straw amendment had a numerically higher AS (74.5%) compared with polyter (69.2%) and the control (69.8%), these differences were not statistically significant ($p > 0.05$). Thus, the effect of soil amendments on aggregate stability was minimal compared with tillage kind.as illustrated in table (2).

Table (2) The Effect of the Soil Amendments .Tillage Kind and Irrigation Status on Soil Aggregate Stability (%), after Cultivating.

Treatments			Soil Aggregate Stability (%) after Cultivating				
Soil amendments	Tillage kind	Irrigation Status	R 1	R 2	R 3		
Control	1	1	32.88	29.39	33.97		
		2	26.39	32.15	29.12		
	2	1	24.46	31.74	35.47		
		2	48.48	40.27	30.23		
Polyter	1	1	33.08	37.74	36.59		
		2	30.87	29.82	34.83		
	2	1	45.13	36.57	39.16		
		2	42.34	33.88	40.9		
Wheat straw	1	1	29.18	32.28	31.07		
		2	45.57	38.26	36.91		
	2	1	29.96	38.64	48.57		
		2	44.37	40.71	38.13		
Test	Means						
LSD	SA	TK	SA*TK	IS	SA*IS	TK*IS	SA*TK*IS
	69.824	100.017	77.167	103.289	78.527	102.593	41.473
	69.213	114.835	62.481	110.227	69.440	105.507	35.693
	74.479		68.453		60.133	106.717	25.427
			69.973		69.973	112.215	37.054
			70.197		74.788		33.747
			78.761		78.503		34.707
							32.187
							37.787
							36.743
							33.453
						37.001	
						41.760	
5%	N .S	1.413	N .S	N .S	N .S	N .S	N .S
1%		2.140					

4 .2. Impact of the Soil Amendments .Tillage Kind and Irrigation Status on Soil bulk density.

The results presented in Table (3) show that soil bulk density was influenced by the interaction of soil amendments tillage kind

with values ranging from 1.12 to 1.69 g/cm³. These values fall within the general range for agricultural soils, where lower bulk density reflects better soil structure and porosity, while higher values indicate compaction. The interaction between soil amendment \times tillage (SA \times TK) was also significant at the 5% probability level (LSD = 0.111). This indicates that the influence of soil amendments on bulk density was dependent on the type of tillage applied. For example, wheat straw combined with zero tillage produced some of the lowest values

(1.12–1.32 g/cm³), whereas the same amendment under conventional tillage resulted in higher bulk density values (1.62–1.65 g/cm³). Similarly, Polyter showed better performance. The analysis of variance (ANOVA) for soil bulk density (Table 3) indicated that the differences among soil amendments (SA) were not statistically significant ($p > 0.05$). This means that the application of Polyter or wheat straw alone did not cause measurable changes in bulk density compared with the control.

Table (3) The Effect of the Soil Amendments .Tillage Kind and Irrigation Status on Soil Bulk Density (g/cm³).

Treatments			Soil Bulk Density(g/cm ³)				
Soil amendments	Tillage Type	Irrigation Status	R 1	R 2	R 3		
			Control	1	1	1.29	1.27
	2	1.69		1.32	1.4		
2	1	1.26		1.22	1.41		
	2	1.44		1.51	1.22		
Polyter	1	1	1.31	1.33	1.25		
		2	1.52	1.56	1.61		
	2	1	1.4	1.39	1.33		
		2	1.51	1.61	1.56		
Wheat straw	1	1	1.62	1.38	1.43		
		2	1.12	1.5	1.61		
	2	1	1.53	1.64	1.32		
		2	1.62	1.65	1.49		
Test	Means						
	SA	TK	SA*TK	IS	SA*IS	TK*IS	SA*TK*IS
	2.772	4.302	2.857	4.163	2.777	4.153	1.387

LSD	2.897	4.352	2.687	4.490	2.767	4.250	1.470
	2.985		2.860		2.860	4.410	1.297
			2.933		2.933	4.493	1.390
			2.887		3.057		1.297
			3.083		3.063		1.563
							1.373
							1.560
							1.477
							1.410
							1.497
						1.587	
5%	N .S	0.064	0.111	N .S	N .S	N .S	N .S
1%			0.169				

4.3. The Effect of the Soil Amendments. Tillage Kind and Irrigation Status on Soil moisture at field capacity and soil properties .the results in Table (4) show that

soil amendments, tillage type, and irrigation status had varying effects on soil moisture at field capacity (FC%). The statistical analysis revealed the Following :

Table (4) The Effect of the Soil Amendments .Tillage Kind and Irrigation Status on Soil Moisture at Field Capacity (%).

Treatments			Soil Moisture at Field Capacity (%)				
Soil amendments	Tillage Kind	Irrigation Status	R 1	R 2	R 3		
Control	1	1	31.32	30.18	32.3		
		2	30.11	31.2	30.9		
	2	1	30.2	29.18	29.89		
		2	27.14	26.11	30.18		
Polyter	1	1	31.22	31.16	31.04		
		2	26.45	31.9	29.86		
	2	1	30.94	28.39	31.33		

		2	28.32	29.93	31.49		
Wheat straw	1	1	32.25	30.66	29.07		
		2	28.75	29.05	31.06		
	2	1	30.42	30.03	29.9		
		2	31.3	32.4	27.98		
Test	Means						
LSD	SA	TK	SA*TK	IS	SA*IS	TK*IS	SA*TK*IS
	59.785	91.413	62.003	91.580	59.077	91.760	31.267
	60.338	89.188	57.567	89.022	61.877	88.353	30.737
	60.478		60.543		59.160	90.793	29.757
			60.133		60.133	90.297	27.810
			60.280		60.030		31.140
			60.677		61.220		29.403
							30.220
							29.913
							30.660
							29.620
							30.117
						30.560	
5%	N .S	1.079	1.869	N .S	N .S	N .S	N .S
1%							

Soil amendments did not show a significant effect on soil moisture at field capacity (ns at both 5% and 1% probability levels). However, numerically, wheat straw and polyter tended to maintain slightly higher soil moisture compared to the

control. For example, under wheat straw with conventional tillage and supplementary irrigation, FC values reached 32.25–30.66%, while the lowest values (26.45–28.75%) were generally

Table (5) The Effect of the Soil Amendments .Tillage Kind and Irrigation Status on Soil Moisture at Wilting point (%)

Treatments			Soil Moisture at Wilting Point (%)				
Soil amendment	Tillage Type	Irrigation Status	R 1	R 2	R 3		
Control	1	1	19.24	18.11	20.18		
		2	21.25	20.09	18.35		
	2	1	19.43	20.27	18.41		
		2	20.99	20.02	19.63		
Polyter	1	1	17.76	18.58	19.3		
		2	21.07	20.32	19.66		
	2	1	19.84	19.28	20.26		
		2	22.76	20.15	19.38		
Wheat straw	1	1	20.54	18.13	17.72		
		2	19.41	18.15	20.49		
	2	1	21.32	19.2	21.02		
		2	20.81	22.95	21.17		
Test	Means						
LSD	SA	TK	SA*TK	IS	SA*IS	TK*IS	SA*TK*IS
	39.328	58.058	39.073	58.098	39.390	58.443	19.177
	39.727	61.148	39.583	61.108	38.443	59.110	19.897
	40.152		38.897		39.720	59.353	19.370
			40.557		40.557	61.507	20.213
			38.147		41.277		18.547
			42.157		40.440		20.350
							19.793
							20.763
							18.797
							19.350
							20.513

							21.643
5%	N.S	0.462	0.800	N.S	N.S	N.S	N.S
1%		0.743					

4.5. The Effect of the Soil Amendments .Tillage Kind and Irrigation Status on

Mean Weight Diameter, MWD

Table (6), shows that MWD of soil aggregate stability after cultivation was significantly affected by tillage kind and soil amendment within instruction with tillage

kind at ($p < 0.05$) . by using zero tillage after land cultivation MWD of soil were significantly affected .the highest and lowest rate were (0.849 and 0.699)mm for zero tillage and conventional tillage respectively ,this refer to the high effect of zero tillage on soil MWD Regarding to treatment combination between soil amendment and tillage kind by using .

Table (6) The Effect of the Soil Amendments .Tillage Kind and Irrigation Status on Mean Weight Diameter (MWD).

Treatments			Mean Weight Diameter (MWD).				
Soil amendments	Tillage Kind	Irrigation Status	R 1	R 2	R 3		
Control	1	1	0.134	0.128	0.346		
		2	0.211	0.152	0.349		
	2	1	0.260	0.309	0.475		
		2	0.308	0.102	0.139		
Polyter	1	1	0.335	0.141	0.146		
		2	0.253	0.186	0.253		
	2	1	0.379	0.235	0.406		
		2	0.530	0.330	0.278		
Wheat straw	1	1	0.251	0.223	0.322		
		2	0.383	0.236	0.147		
	2	1	0.144	0.175	0.166		
		2	0.232	0.340	0.289		
Test	Means						
	SA	TK	SA*TK	IS	SA*IS	TK*IS	SA*TK*IS
	0.485	0.699	0.4396	0.762	0.386	0.788	0.203

LSD	0.579	0.849	0.530	0.786	0.444	0.621	0.237
	0.485		0.4382		0.579	0.984	0.348
			0.7193		0.719	0.704	0.183
			0.5205		0.541		0.207
			0.4486		0.552		0.231
							0.340
							0.379
							0.265
							0.255
							0.162
						0.287	
5%	N .S	0.054	0.094	N .S	N .S	N .S	N .S
1%		0.082	0.143				

5. Discussion

The findings showed that the kind of tillage had a major impact on the stability of soil aggregates during cultivation, with zero tillage retaining noticeably higher AS than conventional tillage table (2). This demonstrates how damaging mechanical soil disturbance in conventional tillage is, as it breaks down organic matter binding agents, disturbs soil aggregates, and leaves soil vulnerable to erosion. On the other hand, zero tillage reduces disturbance, enabling microbial activity, organic matter, and root residues to function as organic cementing agents that maintain aggregate stability.(Hajabbasi et all) (2007).

Although the changes were not statistically significant, soil amendments (polyter and wheat straw) produced some numerical improvements in AS when compared to the control, with wheat straw exhibiting the greatest mean (74.5%). This implies that short-term amendment treatment might not be enough to reverse the

structural harm caused by tillage, particularly in semi-arid environments where aggregate binding and decomposition occur more slowly. However, since organic residues enhance soil cohesiveness and microbial binding agents, the steady trend of greater AS with organic amendments like wheat straw suggests possible cumulative benefits if applied over time .These findings agree with earlier studies showing that reduced tillage combined with organic amendments enhances aggregate stability more effectively than either practice alone.(Yu et al ,(2017)

Thus, tillage techniques are mostly responsible for the study's preservation of aggregate stability, with amendments providing additional but less noticeable effects. The bulk density values of the soil fell within the typical range for agricultural soils, ranging from 1.12 to 1.69 g/cm³. But there were obvious disparities in treatment. Table (3) shows that there was a substantial interaction between soil amendments and tillage (SA × TK), suggesting that tillage

techniques had a considerable impact on how amendments affected BD. Wheat straw and polyter typically yielded lower BD values (as low as 1.12 g/cm²) under zero tillage, suggesting increased porosity and root penetration. On the other hand, the identical modifications resulted in increased BD (up to 1.65 g/cm²) under conventional tillage. This is probably due to the fact that repeated plowing

Negates the advantages of additional organic matter by destroying aggregate structure, accelerating compaction upon drying, and decreasing pore continuity .

Overall, zero tillage continuously showed noticeably reduced BD, demonstrating its beneficial impact on maintaining soil structure and porosity. These outcomes are in line with research showing that conventional tillage frequently results in a compacted plow pan, whereas decreased tillage less in soil compaction. .(Romaneckas et al, 2009)(

Table (4) shows that tillage type also had a substantial impact on field capacity, with zero tillage continuously sustaining higher soil moisture levels than conventional tillage. This is explained by zero tillage systems' improved pore continuity preservation and decreased evaporation beneath surface residue cover. The strong SA × TK interaction demonstrated that water retention was influenced by both tillage and soil amendments. Zero-tillage wheat straw was especially successful, yielding greater FC values (up to about 32%). Wheat straw's mulching action probably improved penetration while lowering surface evaporation.

Water-holding was quantitatively enhanced by Polyter, a synthetic soil conditioner; however this improvement was not statistically significant .Therefore, whereas amendments by themselves were

unable to substantially change FC, their combined effect with minimal tillage improved soil moisture retention. These findings provide credence to the notion that combined conservation strategies—zero tillage plus organic amendments—are more effective than individual treatments. (Singh, et al (2014).(Batra, S. D.).(2014).

Table 5 shows that tillage type had a substantial impact on wilting point, with zero tillage having a greater WP (20.38%) than conventional tillage (19.35%). The roughly 1% rise indicates that soils retain a little bit more water that is firmly bonded to soil particles when there is no tillage. Although plants with greater WP have less water available to them, this tendency is typically linked to better soil organic matter and finer pore structure, which increase water retention Wheat straw had the highest numerical values, while soil amendments had no discernible effect on WP. This suggests that the persistent wilting characteristics of the soil are not much altered in the near term by the addition of residue or synthetic amendments. However, The slight numerical increases point to a slow improvement in the production of microspores and soil organic binding .which may become more pronounced with long-term application.(Brandt, S. A.)(1992)

Table (6) shows that the type of tillage and the interaction of soil amendments had a substantial impact on mean weight diameter, a direct indicator of soil aggregate quality. Zero tillage clearly has an advantage in preserving aggregate size distribution, as seen by higher MWD values (0.849 mm) as compared to conventional tillage (0.699 mm). In comparison to the control, the MWD values of polyter and wheat straw, two soil amendments, were greater under zero tillage (up to 0.530 mm). This demonstrates how conditioners and organic

matter help to improve soil aggregates when disturbance is kept to a minimum

However, conventional tillage eliminated a large portion of the potential advantage, as evidenced by reduced MWD when residue application and frequent plowing were coupled.(Zhanget al (2017). These results align with the AS findings (Section 3,1), which demonstrate that zero tillage, especially when paired with organic inputs, maintains larger and more stable aggregate essential for erosion resistance, aeration, and infiltration.

Tillage type was consistently found to be the most significant determinant across all evaluated soil physical parameters (AS, BD, FC, WP, and MWD), with zero tillage outperforming conventional tillage in terms of aggregate stability, moisture retention, and soil structure preservation. Zero tillage elevated the wilting point marginally,

6. Conclusions:

The experiment demonstrated that tillage type was the major factor affecting soil physical Properties, and soil amendments had a small role in the short term applications. Zero tillage consistently better soil physical quality than the conventional tillage. As evidenced by the greater aggregate stability (AS), a higher mean weight diameter (MWD), lower bulk density (BD) and the retention of more soil moisture at field capacity (FC). While NT also caused a higher WP, the overall balance favored improved .soil composition and water accessibility. When taken into consideration alone, the impacts of soil amendments (Polyter and wheat straw) were not statistically significant. But when combined

decreased bulk density, increased field capacity, improved aggregate size distribution, and boosted aggregate stability.

Additional benefits from soil amendments (polyter and wheat straw) were generally present, but they were more noticeable when zero tillage was used in place of traditional tillage. Because physical qualities react more slowly to short-term water management than to tillage and additives, irrigation status had negligible or non-significant effects. These findings demonstrate that long-term soil conservation techniques outperform just short-term supplements .Zero tillage reduces soil disturbance, maintains pore continuity, and enables organic residues to exert cumulative effects, thereby improving resilience under both dry land and supplementary irrigation systems.

with zero tillage, they tended to enhance soil aggregation and moisture retention more than when conventional tillage was used. The impacts of irrigation status on the physical characteristics of the soil were either negligible or limited, indicating that management techniques (tillage plus amendment) are more important for structural soil improvements than temporary changes in the water supply .The results show that implementing zero tillage techniques, particularly in conjunction with organic residues like wheat straw, offers a sustainable means of boosting water retention, decreasing compaction, and improving structure in both dry farming and supplemental irrigation scenarios.

7. Recommendations:

The following suggestions are put forth in light of the research's findings:

1. Make zero tillage your main conservation strategy to retain soil aggregation, lower compaction, This is especially crucial in semi-arid areas like Northern Iraq.
2. Encourage the application of organic fertilizers, such as wheat straw. While short-term impacts were small, the steady pattern suggests cumulative benefits over time.
3. Use zero tillage to include amendments instead of traditional tillage. Under zero tillage, the advantages of straw or Polyter were most noticeable, while conventional tillage largely countered these benefit.
4. Promote additional irrigation techniques that go hand in hand with soil protection measures .
5. Long-term adoption and observation. Long-term implementation of residue management and zero tillage should be encouraged as a sustainable, approach for wheat-based cropping systems since many soil physical changes take time to manifest.

.8References:

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