Effect of different Tillage Systems on some Physical Properties of soil and Barley Growth

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Abstract

A Field experiment was conducted in Girda Rasha, the Experimental Field of Agriculture College at ٢٠٠٩- ٢٠١٠ to evaluate the effect of different tillage systems on some Soil physical properties and growth of Barley. Five tillage systems were applied (no tillage, Harrow disc, Chisel plough, Rotary plough, Moldboard plough). Tillage methods significantly affected soil physical properties as increase in soil moisture content, soil porosity and decrease in soil bulk density and soil penetration resistance for ٠ – ١٥ cm and ١٥ – ٣٠ cm soil layer. The highest values of moisture content were at rotary tillage (٣,٧٤٧٪) and (٦,٠٦٠٪) and the lowest values were at no tillage (٢,٥٧٧٪) and (٣,٧٥٠٪) for (٠ -١٥ cm) and (١٥-٣٠cm) depth respectively. The highest values of soil bulk density were under Moldboard tillage of ١,٤٠٨ Mg. $m^{-٣}$ and ١,٦٤٨ $Mg.m^{-٣}$ which were more than no tillage plots, and the lowest values were under Chisel plough ١,٢٦٥ $Mg.m^{-٣}$ and Rotary plough of ١,٥٣٧ $Mg.m^{-٣}$ at ٠-١٥ cm and ١٥-٣٠ cm layer respectively. The highest values of soil porosity were under Chisel plough of ٥٢,٢٧٪ and at rotary plough of ٤٢٪ and the lowest values were under Moldboard plough of ٤٦,٨٥٪ and ٣٧,٨١٪ which were less than no tillage plots at ٠-١٥ cm and ١٥-٣٠ cm layers, respectively. The highest values of soil penetration resistance were under Moldboard plough ٤٦٣,٦٧ kpa and no tillage of ٦٧٥,٣ kpa and the lowest values were under Harrow Disc tillage of ١٩١,٠ kpa and ٢٥٧,٧ kpa at ٠-١٥ cm and ١٥-٣٠cm layers respectively.

The tillage methods significantly affected on the height of plant and Barley yield weight and non significant on dry mater weight and weight of ١٠٠٠ grains. The heighest value of high of plant was at rotary plough of ٨١,٦٧ cm and the lowest value was at no-tillage plot of ٦٨,٣٣ cm. The highest value of Barley yield weight was at Moldboard plough of ١,٧٦٠ $Mg.ha^{-١}$ and the lowest value was at no tillage of ٠,٧٤٣ Mg. $ha^{-١}$.

Practical speed and slippage percentage response significantly to all tillage treatments. The best forward speed was at Chisel and Rotary plough of ٣,٨٨ and ٣,٨٩ Km/hr, respectively. But the worse was for Harrow Disc plough which was ٣,٥٥ km/ hr. The best value of slip percentage were at Rotary and Chisel plough of ٥,٣٤٪ and ٥,٤٩٪, respectively, while the highest value were at Harrow Disc and Moldboard plough of ١٣,٧٪ and ١٢,٢٠٪, respectively.

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Introduction

Soil tilling, in general is one of the fundamental agro-technical operation in agriculture because of its influence on soil properties, environment and crop production. Tilling plays an important role in controlling weeds and managing crop residues, but the primary purpose of tilling is to change the soil structure (Raney and Zingg, ١٩٥٧). Primary tillage of soil is mainly used to cut and loose soil to depth of ١٥-٣٠ cm (Mckyes, ١٩٨٥).

In order to efficiently handle the demand in agricultural food production, soil physical properties must be managed adequately. The main aspect of soil physics for plant productivity is to preserve suitable proportions between solid, liquid and gaseous phase (Glinski and Lipiec, ١٩٩٠). Soil physical properties are extremely vital to plant growth. The influence of tillage implements on soil physical properties is significant. Buschiazzo, et al (١٩٩٨) determined that the soil physical properties changes resultant from soil tillage treatment could influence the yield level of grown crops. Aggregate size, moisture content, penetration resistance and bulk density are important soil physical properties.

Carman (١٩٩٧) observed that different methods produced yield, which appeared to relate to the soil conditions produced by tillage.

Taniguchi et al (١٩٩٩) reported that an increase in tillage operating speed resulted in more soil pulverization.

Bukhari et al. (١٩٨٩), reported that from the forward speed of the tractor the productivity of the agricultural implements can be controlled and increase in the practical speed of the tractor caused practical increase of the implement. The forward speed of the tractor regarded as an important and one effective factor of the implement work. Rapid and complete germination and emergence of wheat seeds improve the odds for obtaining good yields (Nasr and Selles, ١٩٩٥). Tillage practices affect mechanical characteristics of seed bed considerably and thus crop emergence (Mohanty and poinuli, ٢٠٠٤).

Gan et al. (١٩٩٢) reported that plants that emerge early contribute more to crop yield than those that emerge later. Thus, desirable crop yields are achieved by providing seeds with an environment that encourages early germination and emergence.

The aim of this work is to know the effects of different plowing systems on some physical properties of soil and its effect on growth and yield of barley, and also to select the most appropriate tillage system for silty clay loam soil of Girda-rasha which results in positive effect on physical properties of soil and plant growth.

Materials and methods

This experiment was conducted at Girda-rasha, the Experimental Fields of the College of Agriculture, University of Salahaddin, which is located at ٤ km distance to the south east of Erbil city (٣٦°١١́ N , ٤٤°٠١́ E , ٤٢٠m asl) in growing season of ٢٠٠٩ – ٢٠١٠. The soil properties of the experiment site are shown in Table (١). The experiment was laid out as RCBD with five different tillage systems with three replicates. The statistical test was done using Duncan multiple range test at ٥٪ level. The land was divided into three blocks each of ٤ * ٤٠ m, divided to plots٤*٤ m the plowing has been done by different plough equipment in each plot as shown below:

١. No tillage
٢. Moldboard plough ٢٥-٣٠ cm depth
٣. Rotary plough ١٠-١٢ cm depth
٤. Chisel plough ١٠-١٥ cm depth
٥. Disk Harrow ١٥-٢٠ cm depth

New Holland tractor was used with (١١٠ hp) to pull the ploughs in the field, after plowing the soil of mold board treatment was softened by secondary tillage and the actual practical speed of the plowing was determined by a stop watch to find the time for (٤٠ m) distance as shown in the equation below

$$\text{Speed (km hr}^{-1}) = \frac{\text{Distance (m)}}{\text{Time (sec)}} * ٣,٦$$

And also the slippage percentage was calculated by the following equation

$$\%\text{slippage} = \frac{\text{Speed without load} - \text{Speed with load}}{\text{Speed without load}} * ١٠٠$$

Soil samples were taken after plowing at ٢٨/١٠/٢٠٠٩ and after harvesting at ٣٠/٥/٢٠١٠ from each plot for the layer of ٠-١٥ cm and ١٥-٣٠ cm for soil physical properties measurement, at the same time the penetration resistant was measured in the above layers. The following physical properties where measured:

Bulk density by core method (Blake ,١٩٦٥)

١-Penetration resistance (kpa). Determined by cone pentrometer with length ١٣mm, diameter ٩mm and net weight of ٢,٥ pound (١,١٣٤ kg).

٢-Moisture content by using Halogen moisture analyzer.

٣-Porosity calculated from bulk density and particle density.

The plots were planted with local black barley by hand spread with an average of ١٢٠ kg/ha on ٣٠-١١-٢٠٠٩. Chemical fertilizers were applied with an average of ٢٠٠ kg Urea /ha , ١٢٠ kg triple super phosphate / ha and ١٢٠ kg.ha^{-1} potassium chloride. At the end of the season, plant height were measured in each experimental unit randomly then the crop was harvested in each plot of the experimental units separately on (٢٨/٥/٢٠١٠).

For barley crop the following measurement were taken:

١-Plant height by using a measuring tape at field, this was taken in different place of the treated unit and the average was taken.

٢-Crop dry weight for each treated unit by a sensitive balance.

٣-Weight of the grains yield for each treated unit by a sensitive balance.

٤-Weight of ١٠٠٠ grains of barley by a sensitive balance.

Table (١) Some selected physical and chemical properties of the study soil at Girda Rasha site.

Properties		Unit	Value
Particle size distribution analysis	Clay	$g.kg^{-1}$	٣٧٠
	Silt	$g.kg^{-1}$	٥٢٥
	Sand	$g.kg^{-1}$	١٠٥
	Texture	-	Silt clay loam
Bulk Density		$mg.m^{-3}$	١,٣٨٠
Water retention at	-٣٣	Kpa	٣١٤,٠
	-١٥٠٠	Kpa	١٦٩,٠
pH		-	٨,٠٠
ECe		$ds.m^{-1}$	٠,٥١
$CaCO_3$ content		$g.kg^{-1}$ %	٣٧٤.٣
Organic matter		$g.kg^{-1}$ %	٩.٩
Available Nitrogen		$mg.kg^{-1}$	١٢٥
Available Phosphorus		$mg.kg^{-1}$	١١,١٥*١٠^{٤}
Available Potassium		$mg.kg^{-1}$	٦٣,٧٥

Result and discussion

Physical properties of soil after tillage for (٠ – ١٥ cm) layer:

١- Bulk density (Mg m^{-3}):

Table(٢) shows that different tillage treatments significantly affected soil bulk density (Rashidi and Faraydon, ٢٠٠٨) except the Moldboard treatment compared with no Tillage plot, because of inverting the sub soil to the surface (Al banna, ١٩٩٠), The highest value was obtained under Moldboard treatment of ١,٤٠٨ Mg m^{-3} and the lowest value was under Chisel tillage ١,٢٦٥ Mg. m^{-3}.

٢- Soil Porosity (%):

Table (٢) shows that different tillage treatments significantly affected soil porosity at all treatments except the Moldboard tillage due to high bulk density, The highest value was found under Chisel tillage ٥٢,٢٧٪ and the lowest value was under Moldboard tillage which was of ٤٦,٨٦٪ accepted with (Rashidi and Faraydon, ٢٠٠٧).

٣- Soil Penetration resistance (kpa):

Table(٢) shows that a significant effect of Chisel and Harrow tillage treatments on soil penetration resistance but there were no significant effect of Moldboard and rotary tillage on it. The highest value was under Moldboard tillage of ٤٦٣,٦٧ kpa and the lowest value was under Harrow disc tillage of ١٩١,٠٠ kpa.

٤- Soil moisture content (%):

Table (٢) shows that the different tillage treatments significantly affected on soil moisture content compared with no tillage plot accepted with (Khurshid,et al,٢٠٠٦) the highest value was found under Rotary tillage of ٣,٧٤٧% that may be due to high micro-pores (Saha,٢٠٠٤), and the lowest value was for no tillage plot ٢,٥٧٧٪.

Physical properties of soil of ١٥ – ٣٠ cm layer:

Table (٢) The effect of different systems of tillage on some physical properties of Girda Rasha soil at ٠ – ١٥ cm depth.

Systems of tillage	Soil bulk density	Soil moisture content %	Soil porosity %	Penetration resistance kpa

No tillage	١,٣٥٦	٢,٥٧٧	٤٨,٨٣	٤٥٠,٣٣
Chisel plough	١,٢٦٥	٢,٧٦٠	٥٢,٢٧	٢٥٨,٣٣
Disc Harrow plough	١,٢٨٤ d	٣,٥٧٧ b	٥١,٥٤ b	١٩١,٠٠ c
Rotary	١,٣٤٩	٣,٧٤٧	٤٩,٠٨	٤٦١,٦٧
Moldboard plough	١,٤٠٨ a	٣,١٠٠ c	٤٦,٨٦ e	٤٦٣,٦٤ a

*The means having the same letters are not significant and the means having different letters are significant.

١- Bulk density (Mg/m^{٣}):

Table (٣) shows that the different tillage treatments affected significantly on bulk density at all treatments (positively at Harrow Disk tillage and Rotary tillage, but negatively at Moldboard tillage and Chisel tillage) due to the pressure of the plough equipment on subsoil at last two treatments .The highest value was obtained under Moldboard tillage of ١,٦٤٨ Mg m$^{-٣}$, and the lowest value was under Rotary tillage of ١,٥٣٧ Mg.m$^{-٣}$.

٢- Soil porosity (%):

Table (٣) shows that the Harrow disc and Rotary tillage affected significantly on soil porosity (Khurshid, et al. ٢٠٠٦) and Moldboard, Chisel tillage affected negatively due to high bulk density, the highest value was found under Rotary tillage of ٤٢٪ and the lowest value was under Mould board tillage of ٣٧,٨١٪.

٣- Soil penetration resistance (kpa):

Table (٣) shows that the tillage treatments affected significantly on soil penetration resistance at all treatments compare with no- tillage plot (Rashidi and Faraydon, ٢٠٠٨).The highest value was found for no-tillage plot of ٦٧٥,٣kpa and the lowest value was under Harrow disc of ٢٥٧,٧ kpa.

٤- Soil moisture content (%):

Table (٣) shows that tillage treatment affected significant at soil moisture content at all treatments compare with no-tillage plot (Rashidi and Fereydoun , ٢٠٠٨).The highest value was obtained under Harrow disc tillage of ٦,٠٦٪ and the lowest value was found under no tillage plot of ٣,٠٧٪.

Table (٣) The effect of different systems of tillage on some physical properties of Girda Rasha soil at ١٥ – ٣٠ cm depth.

Systems of tillage	Soil bulk density	Soil moisture content %	Soil porosity %	Penetration resistance kpa
No tillage	١,٦١٣	٣,٧٥	٣٩,١٢	٦٧٥,٣٠
Chisel plough	١,٦٤١	٣,٩٩	٣٨,٠٨	٣٣٢,٠٠
Disc Harrow plough	١,٥٨٨ d	٦,٠٦ a	٤٠,٠٧ b	٢٥٧,٧٠ e
Rotary	١,٥٣٧	٥,٠٢	٤٢,٠٠	٥٤٦,٠٠
Moldboard plough	١,٦٤٨ a	٥,٥٤ a	٣٧,٨١ e	٦٤٨,٠٠ b

*The means having the same letters are not significant and the means having different letters are significant.

Plant parameters:

١- Plant height (cm):

Table (٤) showing that different tillage treatments has been significantly affected height of plant compared with non-tillage plot due to produce a favorable environment for crop growth and nutrient use

(Khan et al, ٢٠٠١). The highest value was found under Rotary tillage of ٨١,٦٧ cm it may be due to high soil moisture content, and the lowest value at no tillage of ٦٨,٣٣ cm, but there was no significant difference between the tillage treatments.

٢- Dry mater weight ($Mg.ha^{-1}$):

Table (٤) shows that the different tillage systems increase the dry matte of the barley but they were not significant except in the Rotary tillage which had the highest value of ٧,١٦٧ Mg ha^{-1} it may be due to high soil moisture content, and the lowest value was under no tillage plot of ٤,٢٨٣ $Mg.ha^{-1}$ (Rashidi and Faraydon, ٢٠٠٨).

٣- Weight of (١٠٠٠) grains(g):

Table ٤ shows that the effect of different tillage treatments on weight of ١٠٠٠ grains found not significant increased. However the highest value was found under Rotary tillage of ٣٣,٨٧ g it may be due to high soil moisture content, and the lowest was for no tillage of ٣٢,٩٣ g (Khan et al, ٢٠٠١).

٤- Barley yield weight($Mg.ha^{-1}$):

Table (٤) shows a significant difference of tillage treatments on Barley yield weight compared with no-tillage plot. The highest value was found under mold board tillage of ١,٧٦ $Mg.ha^{-1}$ it may be due to high bulk density which cause more contact between plant roots and soil particles causing absorption of nutrients and water, and the lowest value was for no tillage plot of ٠,٧٤$Mg.ha^{-1}$ (Rashidi and Fereydon, ٢٠٠٨).

Table (٤) The effect of tillage systems on the plant parameters.

Systems of tillage	١٠٠٠ grain weight (g)	Grain yield (Mg/ha)	Biomass yield (Mg/ha)	Plant height (cm)
No tillage	٣٢,٩٣	٠,٧٤٣	٤,٢٨٣	٦٨,٣٣
Chisel plough	٣٣,٤٠	١,٣٣٧	٥,٢٦٦	٧٥,٦٧
Disc Harrow plough	٣٣,٢٠ a	١,٦٢٧ ab	٥,٦٦٧ ab	٧٧,٠٠ a
Rotary	٣٣,٨٧	١,٦٤٣	٧,١٦٧	٨١,٦٧
Moldboard plough	٣٣,٦٧ a	١,٧٦٠ a	٥,٦٦٧ ab	٧٨,٦٧ a

*The means having the same letters are not significant and the means having different letters are significant.

Tillage practice properties:

Table (٥) shows the effect of studied tillage treatments on practical forward speed and slip percentage of the vehicle. No practical speed and slip percentage observed in no tillage treatment while both of them responded significantly with the other treatments. The best forward speeds were ٣,٨٨ and ٣,٨٩ $Km.hr^{-1}$ for chisel tillage and rotary tillage respectively. But the less practical forward speed was ٣,٥٥ $Km.hr^{-1}$ at Harrow Disc treatment. This might be due to the increase of both plow width and tillage depth by the equipment which is increased the soil resistance to movement. Slip percentage was also affected by the studied treatments as the best values is the less one under Rotary and Chisel tillage were of ٥,٣٤٪ and ٥,٤٩ respectively. While the highest values were under Harrow disc and Moldboard tillage, the average was ١٣,٧٪ and ١٢,٢٠٪, respectively. The slip percentage increased due to the depth of the plow and the width of equipment (Bukhari et al, ١٩٨٩).

Table(٥) Tillage practice properties

Systems of tillage	Practical speed (km/hr)	Slippage percentage
No tillage	---	---
Chisel plough	٣,٨٨ a*	٥,٤٩ b

Disc Harrow plough	٣,٥٥	c	١٣,٠٧	a
Rotary plough	٣,٨٩	a	٥,٣٤	b
Moldboard plough	٣,٦٥	b	١٢,٢٠	a

*The means having the same letters are not significant and the means having different letters are significant.

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تأثير أنظمة الحراثة المختلفة في الصفات الفيزيائية للتربة ونمو نبات الشعير

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الخلاصة

أجريت هذه الدراسة في حقل كرده ره شه، ٤ كم جنوب شرق مدينة أربيل التابعة إلى كلية الزراعة خلال الموسم ٢٠٠٩-٢٠١٠ لأجل دراسة تأثير الحراثات المختلفة في بعض صفات الفيزيائية للتربة و نمو محصول الشعير. فقد أجريت خمس معاملات لمحاريث المختلفة وهي (بدون الحراثة، محراث حفار، محراث قرصي رأسي، محراث دوراني و محراث مطرحي قلاب) بتصميم (RCBD) و اختبار (Duncan) على مستوى ٥%. تم حراثة التربة وأخذت نماذج التربة من المعاملات للطبقتين ٠-١٥ و ١٥-٣٠ سم للتحاليل الفيزيائية وتم قياس مقاومة الاختراق في الحقل للطبقتين المذكورتين وإضافة الأسمدة الكيمياوية (٢٠٠ كغم يوريا. هكتار$^{-1}$ ، ١٢٠ كغم.هكتار$^{-1}$ سوبر فوسفات ت و ١٢٠ كغم. هكتار$^{-1}$ كلوريد البوتاسيوم) .تم زراعة الحقل بالشعير المحلي بتاريخ ٢٠٠٩\١١\٣٠. في نهاية موسم الزراعة و بتأريخ ٢٠١٠\٥\٢٨ تم قياس ارتفاع النبات وتم حصاد الشعير لأجراء القياسات. أجريت التحاليل الفيزيائية للتربة وهي (الكثافة الظاهرية، المسامية والمحتوى الرطوبي إضافة إلى مقاومة الاختراق). بالنسبة للنبات أجريت القياسات التالية (ارتفاع النبات، وزن المادة الجافة، الإنتاجية، وزن ١٠٠٠ حبة لمحصول الشعير). علماً انه قد قيست السرعة العملية و نسبة الانزلاق للمحاريث من الحقل مباشرةً خلال إجراء عمليات الحراثة.

حيث بينت نتائج التجربة أن تأثير الحراثة كان معنويا في الصفات الفيزيائية للتربة، مما أدى إلى زيادة المحتوى الرطوبي و المسامية كما أدى إلى انخفاض كل من الكثافة الظاهرية و مقاومة الاختراق في الطبقتين ٠-١٥ و١٥-٣٠سم. وكانت أعلى قيمة للمحتوى الرطوبي للتربة في معاملة المحراث ألدوراني ٣,٧٤٧% و ٦,٠٦٠% وأقل قيمة للمعاملة بدون حراثة ٢,٥٧٧% و ٣,٧٥٠% عند الأعماق ٠-١٥ و ١٥-٣٠ سم على التوالي، و أعل قيمة للكثافة الظاهرية كانت عند معاملة المحراث المطرحي ١,٤٠٨ و ١,٦٤٨ميكاكرام.م$^{-3}$ و التي كانتا أكبر من معاملة بدون الحراثة، و أقل قيمة كانت عند معاملة المحراث الحفار١,٢٦٥ ميكاكرام.م$^{-3}$ و محراث دوراني ١,٥٣٧ ميكاكرام.م$^{-3}$ عند أعماق ٠-١٥و ١٥-٣٠ سم على التوالي و بالنسبة للمسامية كانت أعلى قيمة عند معاملة المحراث الحفار ٥٢,٢٧% و محراث ألدوراني ٤٢% و أقل قيمة كانت عند معاملة محراث المطرحي القلاب ٤٥,٨٥% و٣٧,٨١% عند الأعماق ٠-١٥ و ١٥-٣٠ سم على التوالي.

أما مقاومة الاختراق فكانت أعلى قيمة لها عند المعاملات محراث المطرحي القلاب ٤٦٧,٣٧ كيلو باسكال وبدون الحراثة ٦٧٥,٣٠ كيلو باسكال و أقل قيمة عند المعاملات محراث القرصي الرأسي ١٩١,٠٠ كيلو باسكال و ٢٥٧,٧٠ كيلو باسكال عند أعماق ٠-١٥ سم و ١٥-٣٠ سم على التوالي. كذلك أثرت أنواع الحراثة معنويا على ارتفاع النبات و الإنتاج وغير معنوي على وزن الجاف و وزن١٠٠٠ حبة الشعير، وكانت أعلى قيمة لارتفاع النبات عند معاملة المحراث ألدوراني ٨١,٦٧ سم وأقل قيمة عند معاملة بدون الحراثة ٦٨,٣٣ سم ، و أعلى قيمة للإنتاج كانت عند محراث مطرحي القلاب ١,٧٦٠ ميكاكرام\هكتار و أقل قيمة عند معاملة بدون الحراثة ٠,٧٤٣ ميكاكرام\هكتار.

أما بالنسبة لسرعة العملية ونسبة الانزلاق فقد تأثرت بصورة معنوية بنظم الحراثة، و كانت أفضل قيمة للسرعة العملية للمحراث الحفار و الدوراني٣,٨٨ و ٣,٨٩ كم.ساعة$^{-1}$ ،على التوالي، أما أقل قيمة للسرعة العملية فكانت عند استعمال المحراث القرصي الرأسي ٣,٥٥ كم\ ساعة. أما بالنسبة لصفة نسبة الانزلاق فكانت أفضل قيمة و هي ألأقل عند معاملة المحراث ألدوراني و الحفار ٥,٣٤% و ٥,٤٩%، و كانت أعلى قيمة عند معاملة كل من المحراث القرصي الرأسي و المطرحي القلاب ١٣,٠٧% و ١٢,٢٠% و على التوالي.