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Effect of Leveling and Tillage Equipment on Soil Bulk Density and Yield of Maize

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Abstract

A field experiment was carried out to evaluate the effect of leveling and tillage equipment on the soil bulk density and the growth and production of maize. Three landscaping types of equipment, namely laser, pelvic, and grader equipment, and three tillage equipment, namely moldboard plow, chisel plow, and no-till farming system. Soil bulk density, practical productivity, plant height, weight of 100 seeds, number of seeds per ear, and the yield of maize were measured. The results can be summarized as follows: The interaction between the pelvic leveling equipment and the no-till farming system was superior in obtaining the lowest soil bulk density, while the interaction between the laser leveling equipment and chisel plow was superior in obtaining the highest plant height, the highest weight of 100 seeds stood 36.70 g, the highest number Seeds per ear stood 371.30 seeds per ear and the highest yield of the plant stood 6.36 tons ha-1 compared to the other interventions.

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Introduction

Agricultural mechanization is one of the basic components of agriculture because it provides the possibility to control the various factors affecting productivity and thus increase production in quantity and quality, in addition to its clear role in the speed of completion of agricultural operations and then increasing the areas planted with different crops through reducing costs and reducing working hours (Jasim *et al.*, 2017).

Leveling and amending the soil surface leads to improving the productivity and efficiency of irrigation, whether it is from traditional or modern methods, by conducting the laser leveling process, as it saves 15-30% of water, also increases water use efficiency, improves crop productivity and reduces irrigation time, (Das and Chalodia 2018; Winkler *et al.*, 2018). On the other hand, the multiplicity of soil types, different climatic conditions, and different crops have created many types of equipment for soil preparation (Jasim and Saadoon, 2020). and different types of tillage equipment, the types of plows (moldboard and discs), are among the most common and oldest used in the world, and are preferred to be used in cold climatic conditions and the soil is not exposed to any A type of erosion because of its ability to overturn the soil section, bury plant residues and improve soil conditions (Smith *et al.*, 2005; Jasim, 2018).

Several heavy equipment's equipment are used for soil landing and leveling such as bulldozers, shovels, graders, and scrapers and light equipment such as pelvic, field plane, and plane implements. Many researchers pointed out that using heavy equipment such as graders, shovels, bulldozers, and scrapers in soil leveling and landing caused severe soil compaction, soil hardpan, and sometimes soil crust. Soil bulk density is affected when soil operations are managed using agricultural machines and leads to compaction; this negatively affects the physical properties of the soil and thus impedes plant growth and prevents the spread of roots to the surface layer (Hu, *et al.,* 2012). Jasim and Al-Shujairi (2011) indicated that the leveling equipment has a clear effect on the soil bulk density as a result of the increase in the load imposed by the leveling equipment on the upper soil layers, which causes an increase in soil compaction and thus an increase in the soil bulk density. The adopted tillage system affected the bulk density values, as Hamada recorded the significant superiority of the modulated tillage system compared to the chisel plow (Al-Zubaidi, 2004; Jasim *et al.,* 2000; Lu, *et al.,* 2020).

Yellow corn (*Zea mays* L.) comes after wheat and rice in importance in terms of cultivated area and yield, as it is grown on a large scale worldwide. It is one of the most important grain crops in agriculture universal, is used as food for humans and animal feed, it is considered to be a fodder crop that presides over the universal fodder list because it's preferable in comparison with the other grains due to its high productivity. It's a primary substance in the feeding of poultry and cattle, and it is also used in other many food industries as raw material (Ali *et al.,* 2019; Ali *et al.,* 2020). This study was conducted to identify the effect of some leveling and tillage equipment on the soil bulk density and the growth and yield of maize.

Material and methods

A field experiment was carried out in Maysan Governorate, south of the capital of Iraq, Baghdad 340 km on 15 July 2020 located on the latitude (68.5020) and longitude (35.3939) for the autumn agricultural season in silt loam soil. Samples were taken from the field soil, from a depth of 0 - 30 cm, from different locations, to determine some physical and chemical properties (Table 1).

Table 1. Some Physical and Chemical Properties of the Field Soil

Soil penetration resistance (kg cm^{-2})	Dry Soil Moisture content (%)	Soil Porosity (%)	Bulk Density (μg m^{-3})	Soil texture	Soil separators (g kg^{-1})			EC 1:1 (ds.m^{-1})	PH
					clay	silt	sand		
1.25	20 - 18	54	1.21	Silt Loam	315	478	207	2.5	7.5

Three landscaping types of equipment, namely laser, pelvic, and grader equipment, and three tillage equipment, namely moldboard, chisel, and no-till farming system, were used in this study. Soil bulk density, equipment actual productivity, plant height, weight of 100 seeds, number of seeds per ear, and the yield of maize were measured in this experiment. A nested design under the complete randomized block design (CRBD) was used with three replications, and the least significant difference test under 0.05 probability ($LSD_{=0.05}$) was used to compare the averages of the treatments. A Messy Ferguson 5465 tractor (142 Hp, France made, six cylinders with 5.5 tons weight) was used in the experiment.

Table 2. Some indicators for equipment used in the experiment

Equipment Type	Indicators					
	Type	**Year and Model**	**Operation Width (m)**	**Weight (kg)**	**No. of Shares and shanks**	**Country Made**
Chisel	175 Plow	1985 157	2.5	305	11	Iraq
Mold board	plow	1985	1.05	294	3	Iraq
Disk Harrows	Tandem Double Action	2006	3	1400	26	Turkey
Pelvic	Landing	2010	3	250	1	Turkey
Laser scraper	3006 Laser	2018	3	4300	1	Italy
Grader	Grader 12 Cylinders	1988	3	5000	1	Sweden

The maize crop, the synthetic local variety, was planted on 18 August 2021. The experimental units were fertilized with dab fertilizer (0%, 18%, and 18%) during the planting processes, and nitrogen fertilizer (46% nitrogen) was placed in two batches a week after planting and a month later, as directed by the Ministry of Agriculture.

The field was razed manually several times to get rid of the weeds, and a panel irrigation system was used where watering was done whenever needed.

Mays stalk borer insect was preventively controlled with granular diazinon (10% substance) at an amount of 1.25 $kg.dunum^{-1}$ was fed at the growing top of the plant and in two batches, the first after 20 days of germination and the second after 15 days of the first batch, according to what was suggested by Alali (1980).

The slipping process was carried out manually by scattering the excess plants keeping the best plants from the plants in each of the planting lines and obtaining the optimum number of plants while maintaining the stability of the distances between adjacent plants in one line.

Performance and Parameters

1. Soil Bulk density ($\mu g\ m^{-3}$)

It was estimated by core sampling method by taking soil samples using these cylinders and drying them in an electric oven at a temperature of 105 °C for 24 hours and calculated from the following equation: Black *et al.* (1965).

$$f_b = Ms / Vt$$

Where:

f_b = Soil bulk density

Ms = Kiln dried soil sample mass (g).

Vt = The total volume of the soil with its natural structure(cm^3).

2. Practical productivity (ha. h^{-1})

The practical productivity was calculated using the following equation and according to the method suggested by Kepner (1972).

$$Pp = 0.1 * Bp * Vp * ft$$

Where:

Pp: Practical productivity (hectares/hour).

Bp: Actual working width of the plow (m).

Vp: Operational speed (km/h).

Tf: Coefficient useful time is 70%.

3. Plant height (cm)

The height of the plant was measured after the completion of flowering and for ten plants taken randomly from the two middle lines of each replicate, starting from the surface of the soil to the base of the flag leaf of yellow corn (Al-Sahoki and Waheeb, 1990).

4. Yield productivity (tons. ha^{-1})

Plant yield was measured by choosing ten plants randomly taken from the two middle lines and for each replicate. The number of seeds per ear was calculated and the weight of 100 seeds for the ten randomly selected plants was taken and the average was taken for each experimental panel. The production was calculated by multiplying the rate of yield per plant g * Plant density and weight adjustment based on the humidity of 15.5% for all weight-related traits and according to the equation (Al-Sahoki and Waheeb, 1990).

Results and discussion

1. Soil bulk density (μg m^{-3})

Table 3 shows the effect of leveling equipment and tillage equipment on the soil bulk density, as the laser leveling equipment and the tablet leveling equipment recorded the following values, which amounted to 1.34 μg m^{-3} and 1.29 μg m^{-3}, respectively, and they are significantly less than the graded screed, which recorded the highest value of the bulk density, which was 1.5 μg m^{-3}. The reason for the increase in the bulk density when using the insert may be due to an increase in the weight and pressure of the knife. These results are consistent with the results obtained by Jasim *et al.* (2000); and Humphreys *et al.* (2010).

It is also clear from Table 3 that the tillage equipment has a significant effect on increasing the soil bulk density. Both the treatment of the tillage system using chisel plow and the no-till farming system recorded the following values 1.37 and 1.36 μg m^{-3}, respectively, to achieve the least significant difference compared to using the plow, which achieved the highest value for the soil bulk density, which was 1.40 μg m^{-3}, and these results are in agreement with the results obtained by Al Shukrji (2004) and Lu *et al.* (2020).

As for the interaction between the leveling equipment and the tillage equipment, it had a significant effect on the soil bulk density, as it recorded the highest value due to the interference of the graded leveling equipment with the tillage system using the plow, and it amounted to 1.53 μg m^{-3}. These results came as a result of the role played by the plow in turning and throwing the soil, which increases its fragmentation, and then the possibility of filling the voids in a larger proportion, which leads to a higher weight of the unit of the material concerning the fixed volume and, in the end, an increase in the soil bulk density these results are in agreement with the results obtained by Al-Sayyah (2016); Lu *et al.* (2020).

The interaction between the leveling equipment using the plate leveling equipment and the no-till farming system gave the lowest value for the soil bulk density which was 1.27 μg m^{-3}.

Table 3. Effect of leveling equipment and tillage equipment on the bulk density (μg m^{-3})

Leveling Equipment	Tillage Equipment			Average leveling Equipment
	Moldboard plow	Chisel plow	No- tillage	
Laser	1.37	1.33	1.32	1.34
Grader	1.53	1.49	1.48	1.50
pelvic	1.31	1.28	1.27	1.29
$\boldsymbol{L.S.D_{0.05}}$	0.0293			0.029
Average of Tillage Equipment	1.40	1.37	1.36	
$\boldsymbol{L.S.D =_{0.05}}$	0.0059			

2. Practical productivity (ha. h^{-1})

Table 4 shows the effect of leveling equipment and tillage equipment on the actual productivity of the equipment, as the leveling equipment outperformed the listed by obtaining the highest value of productivity, amounting to 0.672 ha. h^{-1}, compared to other leveling equipment, and this may be due to an increase in the width of the knife. These results are consistent with the results obtained It is cited by Jasim *et al.* (2000); Humphreys *et al.* (2010).

It is also clear from the table that the tillage equipment has a significant effect on actual productivity. The treatment of the tillage system using the chisel plow outperformed the treatment of the tillage using the plow, as the chisel plow got 0.367 ha. h^{-1}and this may be due to an increase in the working width of the chisel plow. The results are with the results obtained by Al-Shakraji (2004); and Al-Zubaidi (2004).

Table 4. Effect of leveling equipment and tillage equipment on the actual productivity of the equipment (ha. h^{-1})

leveling and Tillage Equipment	Practical productivity (ha h^{-1})
Laser Scraper	0.66
Grader	0.67
pelvic	0.53
$\boldsymbol{L.S.D =_{0.05}}$	0.089
Tillage Equipment	Practical productivity (ha h^{-1})
Moldboard Plow	0.167
Chisel Plow	0.367
$\boldsymbol{L.S.D =_{0.05}}$	0.073

3. Plant height (cm)

Table 5 shows the effect of leveling equipment and tillage equipment on plant height, as the Lysia leveling equipment excelled in obtaining the highest value of plant height, which amounted to 181.4 cm, compared to other leveling equipment. These results are in agreement with the results obtained by Jasim *et al.* (2000).
It was also clear from the table that the tillage equipment had a significant effect on the plant height. The treatment of tillage using the chisel plow outperformed the other treatments, as it obtained 178.33 cm for the plant height. Al-Shakraji (2004); and Al-Zubaidi (2004) obtained it.

The interaction between the laser leveling equipment and the tillage system using the chisel plow outperformed the rest of the interactions in obtaining the highest plant height of 187.00 cm.

Table 5. Effect of leveling equipment and tillage equipment on plant height (cm)

Leveling Equipment	Tillage Equipment			Average leveling Equipment
	Moldboard Plow	Chisel Plow	No-tillage	
laser	177.00	187.00	180.30	181.40
Grader	155.00	171.00	162.30	162.80
pelvic	166.10	177.00	171.30	171.50
$L.S.D_{0.05}$	5.68			2.98
Average of Tillage Equipment	166.00	178.33	171.30	
$LS.D =_{0.05}$	3.70			

4. Weight of 100 seeds

Table 6 shows the effect of leveling equipment and tillage equipment on the weight of 100 seeds, as the Laser leveling equipment outperformed by obtaining the highest value of the weight of 100 seeds, which amounted to 35.54 g compared to other leveling equipment. Spread equally and these results agree with the results obtained by Jasim *et al.* (2000).

The table also shows that the tillage equipment has a significant effect on the weight of 100 seeds. The tillage equipment using the chisel plow outperformed the other systems, as the tillage equipment using the chisel got 33.44 g for the weight of 100 seeds. These results are in line with the results obtained by Al-Shakraji (2004); and Al-Zubaidi (2004).

The interaction between the laser leveling equipment and the tillage system using the chisel plow outperformed the rest of the interactions in obtaining the highest weight for 100 seeds, which amounted to 36.7 g.

Table 6. Effect of leveling equipment and tillage equipment on the weight of 100 seeds (g)

Leveling Equipment	Tillage Equipment			Average Leveling Equipment
	Moldboard Plow	Chisel Plow	No- tillage	
laser	34.66	36.70	35.28	35.54
Grader	28.24	30.32	29.42	29.34
pelvic	31.74	33.30	32.22	32.42
$L.S.D_{0.05}$	1.885			1.202
Average of Tillage Equipment	31.54	33.44	32.32	
$L.S.D =_{0.05}$	1.156			

5. Number of seeds per ear

Table 7 shows the effect of leveling equipment and tillage equipment on the number of seeds per pod, as the Lysia leveling equipment outperformed by obtaining the highest value of the number of seeds per pod, which amounted to 353.8 seeds per pod, compared to other leveling equipment, and this may be the reason for a better leveling procedure Reducing the pressure on the soil from other equipment so that the irrigation was spread evenly and the negative effect was less. These results agree with the results obtained by Jasim *et al.* (2000).

The table also shows that the tillage equipment significantly affects the number of seeds per pod. The tillage equipment using the chisel plow outperformed the other systems, as it got 329.7 seeds per pod. This may be to reduce the negative impact of tillage further and reduce soil compaction. These results are in line with the results obtained by Al-Shakraji (2004); and Al-Zubaidi (2004).

The interaction between the laser leveling equipment and the chisel plow tillage system outperformed the rest of the interactions in obtaining the highest number of seeds per ear, which amounted to 371.

Table 7. Effect of leveling equipment and tillage equipment on the number of seeds per ear (seed ear^{-1})

Leveling Equipment	Tillage Equipment			Average leveling Equipment
	Moldboard Plow	Chisel Plow	No- tillage	
laser	0.338	3.371	0.352	8.353
Grader	3.261	7.286	3.273	8.273
pelvic	0.295	0.331	3.307	1.311
$L.S.D_{0.05}$	11.32			7.69
Average of Tillage Equipment	1.298	7.329	9.310	
$L.S.D_{=0.05}$	6.74			

6. Yield productivity (tons ha^{-1})

Table 8 shows the effect of leveling equipment and tillage equipment on the yield of yellow corn, as the laser leveling equipment outperformed by obtaining the highest value of the yield of yellow corn, which amounted to 5.06 tons ha^{-1} compared to other leveling equipment, and the reason may be to reduce pressure on the soil from other equipment and improve Plant growth and these results agree with the results obtained by Jasim *et al.* (2000).

The table also shows that the tillage equipment has a significant effect on the yield of yellow corn. The tillage system using a chisel plow outperformed the other systems, as it obtained the highest yield value of yellow corn, which amounted to 5.64 tons ha^{-1}. This may be the reason for this to reduce the negative impact of tillage with the plow Al-Mutrahi and to reduce soil compaction, as well as plant height and improving its growth and these results are consistent with the results obtained by Al-Shakrji (2004); Al-Zubaidi (2004).

The interaction between the laser leveling equipment and the tillage system using the chisel plow outperformed the rest of the interactions in obtaining the highest value of the yellow corn yield of 6.36 tons ha-1.

Table 8. Effect of leveling equipment and tillage equipment on maize yield (ton ha^{-1})

Leveling Equipment	Tillage equipment			Average Leveling Equipment
	moldboard	Chisel	No tillage	
laser scraper	3.47	6.36	5.34	5.06
Grader	2.63	4.83	3.28	3.58
pelvic	3.18	5.72	4.24	4.38
$L.S.D_{0.05}$	2.27			1.02
Average of Tillage Equipment	3.09	5.64	4.29	
$L.S.D_{0.05}$	2.14			

Conclusions

Through the above results, we conclude the pelvic leveling equipment excelled in obtaining the lowest value of the soil bulk density, and the laser leveling treatment excelled in obtaining the highest height of the plant, the highest weight of 100 seeds, the highest number of seeds in the ear, and the highest yield of yellow corn.

And the superiority of the no-till agricultural system obtained the lowest soil bulk density, while the tillage system using the chisel plow outperformed in obtaining the highest plant height, the highest weight of 100 seeds, the highest number of seeds per ear, the yield of yellow corn, and the highest field actual productivity of the equipment.

The interaction between the pelvic leveling equipment and the no-till planting system was superior in obtaining the lowest soil bulk density. In contrast, the interaction between the laser leveling equipment and chisel plow was superior in obtaining the highest plant height, the highest weight of 100 seeds, the highest number of seeds per ear, and the highest yield of the plant.

Using laser and pelvic leveling equipment, a chisel plow, and a no-till system was recommended, as well as not using heavy equipment in leveling and landing agricultural fields.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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