Research Article

The Impact of Various Equipment, Processing Speeds and Plant Residues on Some Mechanical, Physical Traits of The Soil and The Productivity of Yellow Corn

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Abstract | A field study was carried out to assess how different equipment operating speeds and plant residues affect certain soil mechanical and physical characteristics, as well as yellow maize output. The experiment included three distinct types of ploughs including a three- bottom reversible mouldboard plough, a three-bottom disc plough, and the chisel plough (the first factor), on unattended soil that containing plant residues (the second factor), at three running speeds (3, 5, and 7 km.h^{-1}) (the third factor). Following a completely randomized block design with three replications, practical productivity, field efficiency, fuel consumption, bulk density, and plant yield were studied. The findings revealed that field type, tillage implement, and operating speed had a clear influence on most mechanical and physical soil parameters. The field that is containing plant residues recorded the highest practical productivity of 5.82 ha.h^{-1}, the highest field efficiency of 56.45%, the lowest fuel consumption of 32.02 li.h^{-1}, and the highest plant production of 4.21 t.h^{-1}. The unattended field recorded the highest bulk density of 1.57 Mg.m^{-3}. The disc plough recorded the highest practical productivity of 7.26 ha.h^{-1}, the highest field efficiency of 63.67%, the lowest fuel consumption of 34.18 li.h^{-1}, and the highest plant productivity of 5.58 t.h^{-1}. Taken together, the three-way interactions showed a significant impact on all the studied traits in this research.

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Introduction

Tillage is considered an essential phase in preparing the soil for subsequent agricultural operations. It breaks up and softens the soil, resulting in a suitable seedbed. Additionally, tillage increases the surface area of the soil that is exposed to direct sunlight hence improves soil aeration by creating soil aggregates that facilitate air movement, which in turn improves the soil's physical traits (Amer, 2024).

The performance of Ploughing is shaped by several elements most especially the machine's operating speed and soil type. In compacted or dense soils, reduced operating speeds are recommended to ensure best ploughing quality. Tillage is considered an effective technique of weed control (Al-Banna, 1990). On the other hand (Bachanam *et al.*, 1993) indicated that the soil bulk density increases in unattended land compared to the land that containing plant residues, such as wheat crop residues. In the same sense (Al-Talabani 2002) mentioned that increasing the machine's forward pace/speed leads to a raise in soil bulk density. She argued this by stating that speed contributes to increasing the thrust exerted by the ploughing equipment which results to more breaking up of soil clods. The gaps between the particles are filled with smaller particles after that, which decreases pore size and raises bulk density these findings..

As shown by Baver *et al.*, 1972, the total soil porosity is inversely related to bulk density, the higher the bulk density, the lower the porosity. This emphasises the importance of tillage practice as a factor in improving soil properties. They also indicated that porosity varies according to soil texture; clay soils have higher porosity but smaller pores, while sandy soils have lower porosity but larger pores (Hasan *et al.*, 2025).

When using the same tillage, it has been indicated that a direct relationship between soil penetration resistance and bulk density was observed (Dograma 1999). As for soil resistance for cutting and shaping showed that it is directly influenced by the depth and width of tillage, as these factors dedicate the amount of force required to penetrate and shape the soil. Aday *et al.*, 2004 have indicated that fuel consumption varies depending on the operating speeds used in the experiment. According to Al-Ani (2000) the slippage of the driving wheels of an agricultural tractor is an important performance indicator, thus reducing drive wheel slippage leads to boost machine productivity and decrease the time required to complete the agricultural operation, which in turn leads to a reduction in fuel consumption (Al-Ta'I, 1999).

Objective of the study

This study evaluates how different plough types and operating speeds influence tillage quality, field efficiency, and energy use.

Material and Method

The measurements and data collected during the experiment included the following:

Practical machine productivity (ha h^{-1})

The practical machine productivity was measured using the following equation according to the method proposed by Kepner *et al.* (1982).

- Pp = 0.1 × Bp × Vp × Ft
- **Pp:** practical productivity (ha h^{-1}).
- **Bp:** practical working width of the plough (m).
- **Vp:** practical speed (km. h^{-1}).
- **Ft:** the coefficient of time exploitation (0.7 as an average of plows) Directory of the General Company for Mechanical Industries, Alexandria.

Field efficiency (%)

The field efficiency was measured using the following equation according to the method proposed by Hunt (1980).

- Fe = Pp/Pt × 100
- Where:
- Fe: Field Efficiency (%).
- Pp: practical productivity (ha-1).
- Pt: theoretical productivity (ha-1).

Table 1: *The physical and the chemical properties of the field Amer & Swain, 2019.*

Total porosity (%)	(EC) Decimensm^{-1}	PH	soil texture	Soil separator gm kg^{-1}
49	4.01	7.39	Silty clay	Sand clay silt 100 175 600

Fuel consumption (li.ha^{-1})

The amount of consumed fuel was measured according to the method used by Al-Gerah *et al.* (1998).

$$Fc = Q \times 10000 / TL \times Wp \times 1000$$

- Where:
- Fc: The amount of fuel consumed (li.h-^{1})
- Q: The amount of fuel during transaction (millilitres)
- TL: Treatment length (m)
- Wp: Practical width of the plough (m)
- soil bulk density: Estimated using the core sample method.

Yellow corn production t.h^{-1}

Ten plants were randomly marked from the two median lines of each replicate. The average yield per g was then multiplied by plant density to determine yield. Al-Sahouki's (1990) equation was used to adjust weight based on 15.5% moisture for all weight-related features.

Results and Discussion

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

Data presented in Table 2 show that the practical machine productivity value was affected by field type, tillage implement type, and operating speed, as well as the two-way and three-way interactions between them. With the maximum practical machine productivity rate of 5.82 ha.h^{-1} and the lowest practical productivity rate of 4.92 ha.h^{-1} in unexploited fields, the results demonstrated a significant advantage for fields containing plant residues over uncultivated fields. This outcome is in consistent with the findings of Bachanam *et al.* (1993).

As for the influence of tillage implements, the data showed a significant advantage for the disc plough in comparison with the mouldboard plough and the chisel plough, recording the highest practical productivity rate of 7.26 ha.h^{-1}, followed by the mouldboard plough at 5.74 ha.h^{-1}and the chisel plough of 4.45 ha.h^{-1}. This variation in values is explained by the variations in the design features of each plough, which affect how each equipment behaves with the soil and the arrangement of particles after ploughing.

Additionally, the findings proofed that raising the operating pace/speed of ploughing from 3 to 5 and then to 7 km.h^{-1} led to a significant increase in terms of the machine's operating productivity and this can be argued in a way that greater speeds give the plough more momentum/thrust while it is running, which breaks up soil clods more finely. Consequently, the resulting fine particles fill the voids and pores, reducing pore size and increasing machine productivity. This result supports the findings of Amer and Swain, 2019. As for the three-way interaction among the field, the type of plough, and the operating speed, the results showed that the best combination was when using the reversible disc plough in the plant residue field and along with the third working speed of (7 km.h^{-1}), where the highest working productivity rate of 6.60 ha.h^{-1} was recorded. In contrast, the lowest working productivity rate was recorded in the unattained field when using the chisel plough at the first working speed of (3 km.h^{-1}), as it reached 3.97 ha.h^{-1}. The findings indicate unequivocally that the three-way interaction between the study factors has a clear significant effect on working productivity (Amer, 2017).

Table 2: *Impact of field Type, used Tillage Equipment and Operating Speed on the Machine's Practical Productivity (ha.h^{-1})*

Field type	Plough Type	Practical speed(km.h^{-1})			Average
		3	5	7	
Residue field	Chisel plough	3.35	4.75	5.24	4.45
	Reversible mouldboard	4.79	5.91	6.53	5.74
	Reversible disc plough	6.52	7.23	8.02	7.26
	Average	4.89	5.96	6.6	5.82
Unattained field	Chisel plough	2.32	3.31	4.91	3.51
	Reversible mouldboard	3.95	4.87	5.02	4.61
	Reversible disc plough	5.64	6.32	7.94	6.63
	Average	3.97	4.83	5.96	4.92
L.S.D		0.020 Practical Speed:			
0.05		0.016Plough Type:			
		0.009Field Type:			
		0.039Interaction:			

Field efficiency (%)

The impact of field type, tillage implement type, and operating speed on the field efficiency value, together with their two-way and three-way interactions, is apparent in Table 3. The findings showed a significant improvement for the field containing plant residues over the unattained field, recording the highest field efficiency ratio of 56.45%, while the lowest field efficiency ratio of 51.44% was observed in the unexploited field. This result is in line with what (Abdullah *et al.*, 2025) indicated. The disc plough had the highest field performance level of 63.67%, followed by the mouldboard plough of 56.00% and the chisel plough of 49.67%, according to data collected about the impact of tillage equipment. This variation in values is contributed to traction resistance and soil resistance; hence these results are in line with the results of those (Hasan *et al.*, 2023) and (Swain, et., al. 2022).

The findings also showed that increasing the running speed of the ploughing from 3 to 5 and then to (km.h $^{-1}$) led to a significant increase in the field efficiency of the implement, respectively. This is explained by the fact that if soil resistance, slippage, and losses do not rise substantially, thus increasing the operating speed raises the field efficiency values. concerning the three-way interaction among the field, the type of plough, and the working speed, the results showed that the best combination was when using the reversible disc plough in the plant residue field along with the third working speed of (7 km.h^{-1}), where the highest field efficiency ratio of 69% was recorded. In contrast, the unattained field had the poorest field efficiency ratio of (39%) when the chisel plough was used at the initial working speed of 3 km/h. The findings unequivocally show that field performance is significantly impacted by the three-way interaction amongst the research elements.

Table 3: *Impact of field type, plough type, and practical speed on field efficiency (%)*

Field Type	Plough Type	Practical speed(km.h^{-1})			Average
		3	5	7	
Residue field	Chisel plough	45	48	56	49.67
	Reversible mouldboard	49	57	62	56
	Reversible disc plough	58	64	69	63.67
	Average	50.67	56.33	62.33	56.45
Unattained field	Chisel plough	39	44	51	44.67
	Reversible mouldboard	43	52	59	51.33
	Reversible disc plough	52	59	64	58.33
	Average	44.67	51.67	58	51.44
L.S.D		0.23 Practical Speed:			
0.05		0.19 Plough Type:			
		0.21Field Type:			
		0.32Interaction:			

Fuel consumption (li.ha^{-1})

The impact of field type, tillage implement type, and running speed on fuel consumption, along with the two-way and three-way interactions among them, are shown in Table 4. It was revealed that the greatest value of fuel consumption of 33.14 li.h^{-1} and the lowest value of fuel consumption ratio of 32.02 li.h^{-1} in the field that is unattained, the findings display a significant improvement for the untreated field over the field that is containing plant remains (Amer, 2017).

Regarding the effect of ploughing implements, the findings showed a significant improvement in the favour of the disc plough in comparison with the mouldboard plough and the chisel plough, in recording the biggest value of fuel consumption rate of 34.18 li.h^{-1}, followed by the mouldboard plough in recording 31.89 li.h^{-1} and the chisel plough in recording 29.98 li.h^{-1}. the reason for this discrepancy in values is the variance in resistance that are experienced when working in the soil. Additionally, the findings showed that the consumed fuel increased significantly when the ploughing speed was raised from 3 to 5 and eventually to 7 km.h^{-1} and this can be justified in a way that higher speeds cause the soil to become more resistant to the implement's trafficking, thus require more power to separate moreover displace, this is supported by the findings of (Hasan *et al*., 2025). The best pairing according to the obtained results of the three-way interaction among the field, ploughing type, and plough speed, was recorded when using the disc plough in the field contaminated with the crop residue using the first ploughing speed of (3 km.h^{-1}), whereby the lowest consumed fuel ratio was noted of 30.58 li.h^{-1}.on the other hand, the highest consumed fuel ratio was obtained in the unattained field when using the disc plough at the third ploughing speed of (7 km.h^{-1}), recording 34.84 li.h^{-1}. These findings unequivocally point out that the three-way interaction among the study parameters scored a significant impact on fuel consumption.

Table 4: *Effect of field type, plough type used, and plough speed on fuel consumption (Li.h^{-1})*

Field type	Plough type	Practical speed(km.h^{-1})			Average
		3	5	7	
Residue field	Chisel plough	28.69	29.67	31.58	29.98
	Reversible mouldboard	30.41	31.59	33.68	31.89
	Reversible disc plough	32.64	34.49	35.41	34.18
	Average	30.58	31.92	33.56	32.02
Unattained field	Chisel plough	29.91	30.23	32.91	31.02
	Reversible mouldboard	31.95	32.92	34.68	33.18
	Reversible disc plough	33.84	34.89	36.93	35.22
	Average	31.9	32.68	34.84	33.14
L.S.D		0.21 Practical Speed:			
0.05		0.08 Plough Type:			
		0.013 Field Type:			
		0.027 Interaction :			

Bulk density (Pb)

The data presented in Figure 1 and Table 5 show that the impact of field type, ploughing implement type, and operating pace on the bulk density of the soil in addition to the two and three-way interactions among them, .So the findings asserts a significant favour for the unattained field over the field that is containing plant residues, recording the highest bulk density value of 1.57 $MG.m^{-3}$, while the lowest bulk density value of 1.42 $MG.m^{-3}$ was obtained in the previously ploughed field that is contaminated with wheat residues. This reduction in bulk density in the field that is comprising plant residues can be explained in a way: the organic residues' ability to raise the quantity and size of soil pores, which led to a decrease in the density of the soil. This result is consistent with what (Hasan *et al*., 2024) pointed out in his study. As for the impact of ploughing equipment, the results revealed that the mouldboard plough performed significantly better than the chisel and disc ploughs, recording the highest value of bulk density of 1.67 $MG.m^{-3}$, in comparison with 1.55 $MG.m^{-3}$and 1.50 $MG.m^{-3}$ for the chisel plough and disc plough respectively. So, these discrepancies in values are contributed to the differences in the design characteristics of each plough equipment, which affect how each implement interacts with the soil and the distribution of particles after tillage operation. Additionally, the results displayed a considerable increase in the soil bulk density when the practical ploughing speed was increased from 2 to 3 and finally to 4 $km.h^{-1}$. This is because higher speeds give the ploughing equipment greater thrust/momentum while it is functioning, which causes the soil clods to fragment more finely. As a result of that, the produced fine particles reduce pore size hence increase bulk density by filling the voids and pores. This result is supported by the findings of (Amer, 2019). On the other hand, the three-way interaction among the field, plough type, and working speed/pace. The results showed that the optimum pairing was achieved when using a mouldboard plough in the unattained field along with the third working speed of (7 $km.h^{-1}$), recording the highest bulk density of 1.62 $MG.m^{-3}$. On the other hand, the field filled with plant remains had the lowest bulk density of 1.37 $MG.m^{-3}$ when a chisel plough was used at the first practical speed of 3 $km.h^{-1}$ and these findings unequivocally show that soil bulk density is significantly impacted by the three-way interaction of the study parameters.

Yellow corn production tons.h^{-1}

Figure 2 and Table 6 illustrates the effect of field type, plough implement type, and operating speed, as well as the two-way and three-way interactions among them, on plant productivity. The findings showed a significant advantage for the field containing plant residues over the unattained field, recording the highest plant productivity rate of 56.45 $t.h^{-1}$, while the lowest plant productivity rate was 3.75 $t.h^{-1}$in the uncultivated field. This result is consistent with the findings of Amer and Muter, 2023.

As for of the impact of ploughing equipment, the data showed the significant preferences of the disc plough over the mouldboard plough and the chisel ploughing recording the highest plant productivity rate of 5.58 $t.h^{-1}$, followed by the mouldboard plough of 4.61 $t.h^{-1}$and the chisel plough of 2.45 $t.h^{-1}$ (Amer, et. al., 2025).

Also, the results displayed that increasing the ploughing speed from 3 to 5 and then to 7 $km.h^{-1}$ led to a significant raise in plant productivity. When

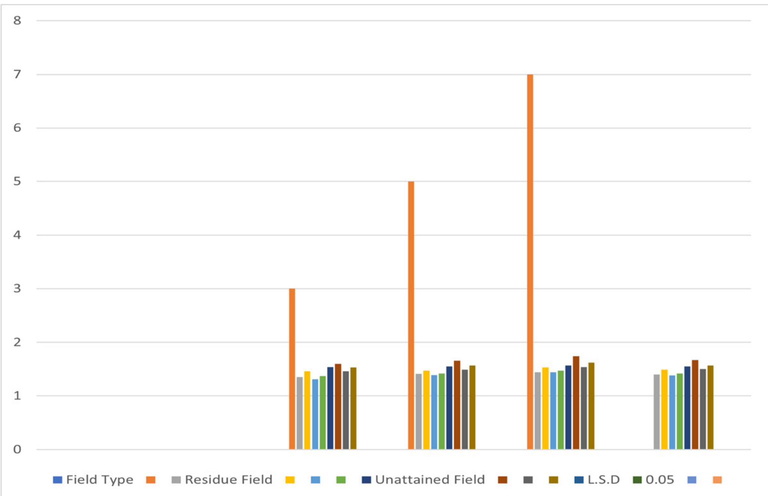

Figure 1: *Effect of field type, ploughing equipment used, and working speed on soil bulk density ($MG.m^{-3}$)*

looking at the three-way interaction among the field type, plough type, and ploughing speed, the results indicated that employing a reversible disc plough in the field with crop residue at the third ploughing speed of (7 km.h^{-1}) produced the best pairing, whereby the highest plant productivity rate of 5.69 t.h^{-1}was recorded.

Table 5: *Effect of field type, ploughing equipment used, and working speed on soil bulk density (MG.m^{-3})*

Field type	Plough type	Practical speed(km.h^{-1})			Average
		3	5	7	
Residue field	Chisel plough	1.35	1.41	1.44	1.4
	Reversible mouldboard	1.46	1.47	1.53	1.49
	Reversible disc plough	1.31	1.39	1.44	1.38
	Average	1.37	1.42	1.47	1.42
Unattained field	Chisel plough	1.54	1.55	1.57	1.55
	Reversible mouldboard	1.6	1.66	1.74	1.67
	Reversible disc plough	1.46	1.49	1.54	1.5
	Average	1.53	1.57	1.62	1.57
L.S.D		Practical Speed: 0.016			
0.05		Plough Type : 0.017			
		Field Type: 0.011			
		Interaction: 0.038			

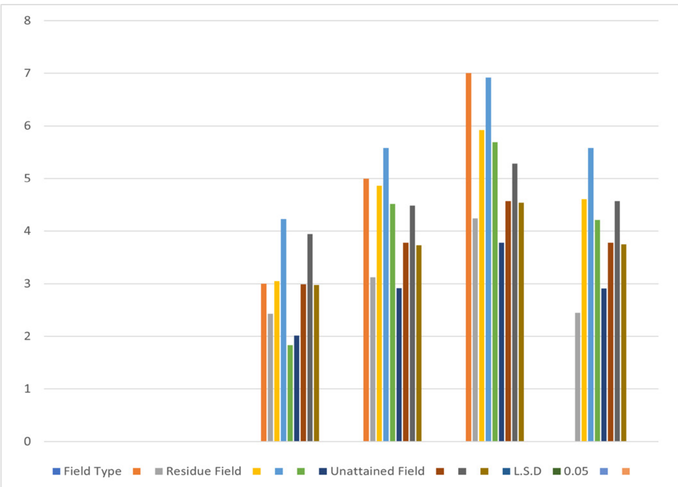

Figure 2: *Field type effect, used tillage equipment, and ploughing pace on plant productivity (t.h^{-1})*

On the other hand, the least plant productivity rate was recorded in the uncultivated field when using the chisel plough at the first ploughing pace/speed of (3 km.h^{-1}), scoring 2.98 t.h^{-1}. These findings unequivocally show that field efficiency is significantly influenced by the three-way interaction among the research parameters.

Table 6: *Field type effect, used tillage equipment, and ploughing pace on plant productivity (t.h^{-1})*

Field type	Plough type	Practical speed(km.h^{-1})			Average
		3	5	7	
Residue field	Chisel plough	2.43	3.12	4.24	2.45
	Reversible mouldboard	3.05	4.86	5.92	4.61
	Reversible disc plough	4.23	5.58	6.92	5.58
	Average	1.83	4.52	5.69	4.21
Unattained field	Chisel plough	2.02	2.92	3.78	2.91
	Reversible mouldboard	2.99	3.78	4.57	3.78
	Reversible disc plough	3.94	4.48	5.28	4.57
	Average	2.98	3.73	4.54	3.75
L.S.D		Practical Speed :0.23			
0.05		Plough Type: 0.19			
		Field Type: 0.21			
		Interaction : 0.32			

Conclusions

In this investigation, the field with plant residue produced the best outcome Using the reversible disc plough led to obtain the best results. The optimum findings were obtained applying the third speed of (7 km.h^{-1}).

Recommendations

We recommend utilizing the fields containing plant residues employing the reversible disc ploughs with the third speed/pace to score the best results. Additionally, we recommend that researchers conduct further tests using different ploughs and operating speeds.

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Novelty Statement

The study The Impact of Various Equipment, Processing

Speeds and Plant Residues on Some Mechanical, Physical Traits of The Soil and The Productivity of Yellow Corn, The experiment included three distinct types of ploughs including a three- bottom reversible mouldboard plough, a three-bottom disc plough, and the chisel plough (the first factor), on unattended soil that containing plant residues (the second factor), at three running speeds (3, 5, and 7 km.h-1) (the third factor). Following a completely randomized block design with three replications, practical productivity, field efficiency, fuel consumption, bulk density, and plant yield were studied. The findings revealed that field type, tillage implement, and operating speed had a clear influence on most mechanical and physical soil parameters.

Author's Contribution

Khalid zemam amer: Study concept methodology, data analysis, manuscript preparation, data validation and final editing.
Sara ali muter: Technical support and consulting.
All authors approved the final version of the manuscript and are responsible for the submitted material.

Generative AI and AI-assisted technology statement
The artificial intelligence analysis of all sections of this manuscript showed that none of the text plagiarized and was with a score of zero.

Conflict of interest
The authors have declkared no conflict of interest.

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