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A review: Machine relationship with the tractor and its effect on the productivity and compaction of agricultural soil

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Abstract

The influence of process speed (PS) and tillage depth (TD) , on growth of corn (Zea mays L) yield, for Maha cultivar, were tested at two ranges of PS of 2.483 and 4.011 km.hr^{-1}, and three ranges of TD of 15,20 and 25cm. The experiments were conducted in a factorial experiment under complete randomized design with three replications. The results showed that the PS of 2.483 km.hr^{-1} was significantly better than the PS of 4.011km.hr^{-1} in all studied conditions. The , slippage ratio (SR) and the machine efficiency (ME), the physical soil characteristics represented by the soil density and porosity (SBD and TSP), and the plant characteristics represented the roots dry weight, PVI and the crop productivity (CP), except adjective of the fuel consumption (fC),which gave the best results with the second speed 4.011 km.hr^{-1}treatment of TD of 15cm was significantly superior to the levels of 20 and 25 cm in all studied conditions.

Keyword: maize, Maha cultivar, process speed (PS), tillage depth (TD), and physical soil characteristics.

I. INTRODUCTION

Agricultural machinery is the spine to any agricultural process. That development in the agricultural mechanization field, is a guide to increasing the agricultural area and lowering the agricultural production costs, by achieving the highest leadership at the lowest cost for the farmer (Al Sharifi, 2009), (Jebur, 2015) and (Alsharifi et al, 2009), adopting modern scientific methods using agricultural machines reflected this in a high economic return and achieving the highest profit for the farmer with the least effort, as all agricultural operations such as plowing, fertilization and irrigation are accomplished using the machine and in the fastest time (Jebur, 2013), (Alsharifi et al 2020a) and (Alaamer et al, 2022), the compacted earth layer often hinders the evolution and expansion of roots and may decrease the final output (Aikins et al, 2006), (Jassim. and Alsharifi, 2007) and (Alsharifi et al, 2019).

(Abdipur et al. 2012) and (Hussein and Nayyef, 2019). In some soil textures, which tend to have high clay ratios, where the agricultural machinery movement forms intensively, forming a solid layer close to the soil surface, and thus prevents

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the passage of water to the soil sectors, and this affects plant growth and yellowing. Study of (Rashidi, and Keshavarzpour, 2007), (Alsharifi, et al 2020). (Alaamer, et al 2021a), shows that the soil stirring process with a moldboard plow led to the solid soil loosening, its apparent density decreases, its porosity increases, and it provides suitable soil for plant growth, (Obeng-Antwi et al. 2022), (Shtewy, et al 2020a). The stirred soil allows the air to move quickly (Alsharifi, et al 2002), the large pores increase in soils with using two types plows (moldboard and disc) and thus increases the growth and elongation of the roots(Jebur and AL-Halfy 2022).

The tillage depth stability, the speed of the machine work, with increase in soil moisture lead to an increase in the slip ratio when used the moldboard plow, in a clay soil (Al-Sharifi et al, 2020b), (Alsharifi et al 2020c). Tillage depth is one of the important and influencing factors in the slippage ratio, as the swell in the plowing depth is accompanied by a swell in the slippage ratio and fuel consumption, as well as an increase in the traction force, and the reason for this is the increase in the practical speed for the tractor (Rashidi and Keshavarzpour 2007), (Alaamer and Alsharifi 2020), practical speed of the agricultural machine is the main influence on the practical productivity when the practical speed increases, the actual productivity increases (Alam et al, 2014), (Shtewy et al, 2020c), in addition, that the increase in the workable speed led to the field efficiency increased (Alsharifi and Ameen. 2018), increasing the passage of agricultural equipment inside the field increases the density values and decreases the porosity ratios, and this negatively affects the water infiltration movement in the soil, as it reduces the salts leaching and thus affects plant growth (Abdipur et al, 2012).

Pointed out (Alsharifi, 2022), (Hamzah and Alsharifi 2020), that the tamping operations resulting from the work of agricultural equipment cause an increase in bulk density as a result of the movement of soil particles on each other and the solution of some particles, and then the inter-distances in the soil decrease, which increases the mass of the soil relative to its fixed size, study of (Jebur, 2018), shows that when the tillage depth is increased, it is accompanied by an increase in the practical speed, which results in soil compaction, a collapse in its density, a decrease in its porosity, and thus the plant exposure to deterioration and a decrease in the total yield. Agricultural machines, especially plows, have a close relationship with the soil and its chemical and physical characteristics. Therefore, choosing the appropriate machine type is of great importance in determining the tillage quality, improving its properties, and then increasing crop productivity (Alsharifi et al, 2021a), (Ghali et al, 2020). Despite the many benefits of tillage, choosing the wrong machine will lead to negative results, it is reflected in the tillage characteristics, such as compacting the soil and increasing its density, and thus decreasing the productivity of the crop to be cultivated (Iqbal et al, 2021),. mentioned (Shtewy and Al-Sharifi 2020a), that the design factors of the machine are affected by several factors, including the resistance to drag, the tractor forward speed, the weight on the wheels, the height of the pulling arm, the type and moisture of the soil, the tire pressure, the size and shape of the tire.

Concluded (Bukhari et al, 1990), that by increasing the tractor practical speed and decreasing the soil moisture, it led to an increase in the slippage percentage, the bulk density of the soil and its porosity, as well as the resistance of the soil to penetration, while the fuel consumption ratios, field efficiency and the soil total porosity decreased. The main factor affecting the tractor fuel consumption rates, it is the soil moisture content and agricultural machinery type (Alsharifi. and Alaamer 2022), (Bukhari, et al, 1988), dealing with soils, with high moisture levels leads to the destruction of aggregates

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and soil compaction, and the low values porosity, and the unsuitable conditions creation for plant growth (Alaamer, et al 2022), [Al-Jezaaria et al. (2002)], the machine low efficiency depends on the operator skill, the field nature , and the machine type used (Raper 2002),

Mentioned (Alaamer et al (2022b), (Alsharifi et al. 2021c), that the raise in the sucking of water and nutrients may be reflected in the raise in plant growth as a result of the increase in the weight and growth of the roots, and thus a raise crop productivity, with good tillage operations emanating from the appropriate depth and work speed. Choosing the appropriate machine to perfect the wanted work depends on its weight, the machine low weight achieved the highest positive results for all technical characteristics represented by the slip ratio, fuel required, machine efficiency and traction force (Hu W. et al 2012), (Hussain et al,1999). Reducing the chances of cohesion between the wheels and the ground, this is limited to low speeds and depths, this reduces soil compaction and thus achieves high results for plant growth, due to the wide roots spread in the soil to suit the appropriate depth (Amini S. and Asoodar 2015), (Roldan et al, 2005). The ground or field speed of the tillage vehicle is one of the important factors, and the justification that affects its productivity in quantity and quality, although the recommended speeds at the present time are still in the range decreased, the ambition is to reach greater speeds. (Chen and Yang 2020), (Aziz et al, 2020). The yield of yellow corn is affected by the characteristics and field conditions, such as soil strength and timing perform agricultural operations in addition to soil hardness and plant residues from the previous season. (Sheehy et al, 2015).

The nutritional value of plant root growth is affected by physical changes in properties, the soil has an serious role in improving the crop quality and increasing the output ratio with continuity. The passage of agricultural equipment plays an important role in the maize plants growth (Sheehy et al, 2015), (Alsharifi et al 2021d) use of non-traditional and appropriate tillage processes reduces surface infestation and increases crop rates the tip, which causes soil moisture to be preserved, many references indicated that tillage techniques in the lower limits have the ability to catch water to a greater extent than in traditional soil tillage technologies (Alsharifi et al 2021d), (Çelik 2011). The objective of the article was to evaluate the agricultural machine performance on soil productivity and compaction, at different practical speeds and different ranges depths.

II. MATERIALS AND RESEARCH METHODS

The experiment was carried out in 2021, using an agricultural tractor MF285s type and a soil-moving machine, moldboard plow with a working width of 1.20m and a weight of 320 kg, manufactured by the General Establishment for mechanical industries - Babylon, under the influence of a process speed (PS) of 0.484 and 4.011 km.hr^{-1} and tillage depths (TD) of 15, 20 and 25cm. (Al-Sharifi, 2009b) and (Mazzoncini, et al 2011).The technical characteristics of the tillage machine and the tractor, were studied, represented by the fuel consumption, slippage ratio and the machine efficiency , the physical soil characteristics represented by the soil density and porosity, and the plant characteristics represented by the roots dry weight, PVI and the total yield, were calculated for each test.

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2.1. Technical characteristics of the mechanized unit (tractor + plow)

2.1.1. Fuel Consumption (FC)

All results were obtained according to Eq; 1. (Al Sharifi, 2009), (Alaamer and Alsharifi, 2020)

$$Q_F = \frac{F_A \times 10000}{W_P \times L \times 1000} \quad (1)$$

Where : Q_F. The amount of fuel consumed L.ha^{-1}, F_A. Spent fuel for the pilot unit (30m), W_P. Working width for the tillage machine cm, L. Treatment length (30m).

2.1.2. Slippage ratio (SR)

All results were obtained according to Eq; 2. (Alsharifi and Ameen 2018)

$$S = \frac{V_P - V_T}{V_T} \times 100 \quad (2)$$

Where; S. Slippage ratio %, V_P. Speed km.hr^{-1} , V_T. theoretical speed km.hr^{-1}

2.1.3.Machine efficiency (MF)

According to Eq 3. The results were estimated, by adopting the previously used calculation method [Al-Sharifi et al 2020b), (Hamzah and Alsharifi 2020)

$$M_E = \frac{E_{FC}}{T_{FC}} \times 100 \quad (3)$$

2.2.Soil physical properties

Soil texture was determined in the field in which the experiments, were executed as shown in the Table.1 below ;

Table 1. Physical and chemical soil analysis

Depth	**Texture %**			
0-25 (cm)	Clay	Silt	Sand	
	49	20	31	Silt Clay loam
	SBD (Mg m^{-3})	TSP (%)	SPR (Kpa)	
	1.28	51.69	1653.23	
	1.31	50.56	1786.78	
	1.30	50.94	1578.12	
VA	1.32	50.18	1572.7	

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0-25	Soil chemical properties			
	E.C (Ds.cm^{3})	HP		
	1.43	6.67		
	Soluble cation meq.I^{-1}			
	Na	K	Ca+Mg	
	11.42	12.45	56.82	
	O.C (%)	CEC (Meq.100g^{-1})	CaCo3 (%)	O.M (%)
	0.44	33.91	4	0.53

2.2.1.Soil moisture ;

Its determined by adopting the Eq.4, observe Fig. 1, [9], [29].

$$W = \frac{W_{WS}}{W_{DS}} \times 100 \quad (4)$$

Where; W. Soil moisture %, W_{WS} . Is the wet soil weight, W_{DS}. Is the dry soil weight.

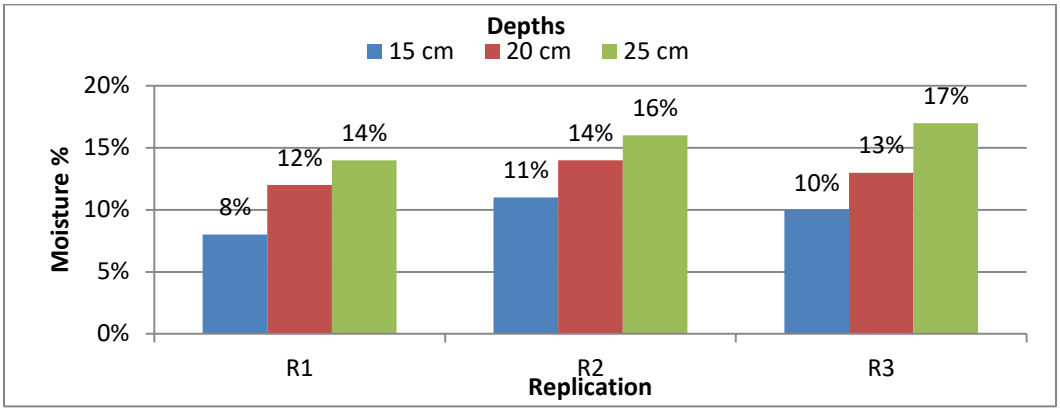

Fig .1.Soil moisture ratios

2.2.2.Soil bulk density (SBD)

Eq 5. Soil density values determination (Alsharifi et al, 2009)

$$SBD = \frac{W_{DS}}{T_{SV}} \quad (5)$$

Where: SBD; Soil density (Mg.m^{-3}), W_{DS}. Is the dry soil weight .(Mg) , T_{SV} Total soil volume. (M^{-3}).

2.2.3. Total soil porosity (TSP)

It was calculated according to the Eq 6. (A.Jassim and Alsharifi, 2007).

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$T_{SP} = \frac{SBD}{P_S} \times 100$ (6)

Where: total soil porosity (%), SBD : dry bulk density (Mg.m$_{-3}$), *PS* : partial density (Mg.m^{-3}).

Soil properties were determined which include density (SBD) + porosity(TSP), after one month (1Mon), two months (2Mon) and the growing season end (GSE).

2.3.Corn crop characteristics

2.3.1. Root dry weight (RDW)

It was calculated by uprooting 10 plants random, with three replications for each experimental unit, and washing them with water to get rid of dust adhering to the roots, then drying them in the oven and weighing them with a sensitive balance. (Alaamer et al, 2021a)

2.3.2. Plant vigor index (PVI)

Was calculated by the following, Eq.8.

$PVI = \frac{P_L \times G_P}{100}$ (7)

Where; PVI; plant vigor index cm, PL; plant length cm, GP; Germination ratio.

2.3.3. Crop productivity (CP)

Crop productivity was calculated by (Hamzah and Alsharifi 2020).

Data were collected for all the traits studied in this experimented, and analyzed using RCBD design, and minor difference LSD=0.05, according to the GenStat program (Oehlert, 2010).

III. RESULTS AND DISCUSSION

3.1.Fuel consumption (FC)

The results in the statistical analysis Table .1 shown that there is a very significant effect of the PS factor and TD on the FC values. The FC has been shown in at varied conditions for PS types and different TD. The best results of 8.589L.ha^{-1}, was obtained among the combination of PS 4.011km.hr^{-1}and 15 cm TD.

Table 1. Impact of process speed(PS) and tillage depth(TD) on FC .

Speed Km.hr^{-1}	Depths cm			Mean of PS
	15	20	25	
2.483	10.087	11.246	12.388	11.240
4.011	8.589	9.018	10.226	9.278
Mean of TD	9.338	10.132	11.307	
LSD=0.05	PS	TD	TD*PS	

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	0.178	0.206	0.319	

The FC is shown in Table. 1, at varied conditions for PS and different TD. As it appears from the results of the statistical analysis, there is a highly significant effect of the TD on the FC,(Fig.1), there are significant differences, as the treatment of the TD -15 cm on record the lowest values of 9.338 L.ha^{-1}, while the treatment of TD -25 cm gave the highest values of 11.307 L.ha^{-1}. The superior FC values of the TD- 25cm compared to the TD-15 cm, are due use of perfect absorption power of the machine with depth decreased (Alsharifi et al, 2009).

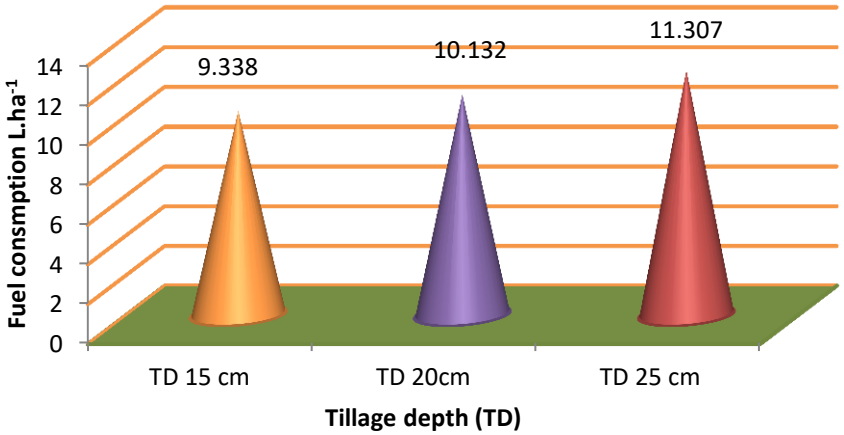

Fig 1. Effect of TD on FC

The FC is shown in Table. 1, at varied conditions for PS . As it appears from the results of the statistical analysis, there is a highly significant effect of the PS on the FC,(Fig. 2). There are substantial differences between all treatments. The PS -2.483 km.hr^{-1} recorded the highest value as 11.240 L.ha^{-1}, while the PS -4.011km.hr^{-1} recorded the lowest value as 9.278 L.ha^{-1}, respectively. The reason for the high FC when low speed it's the high shear stress applied to the weapon during the completion of the work (Alsharifi et al, 2020).

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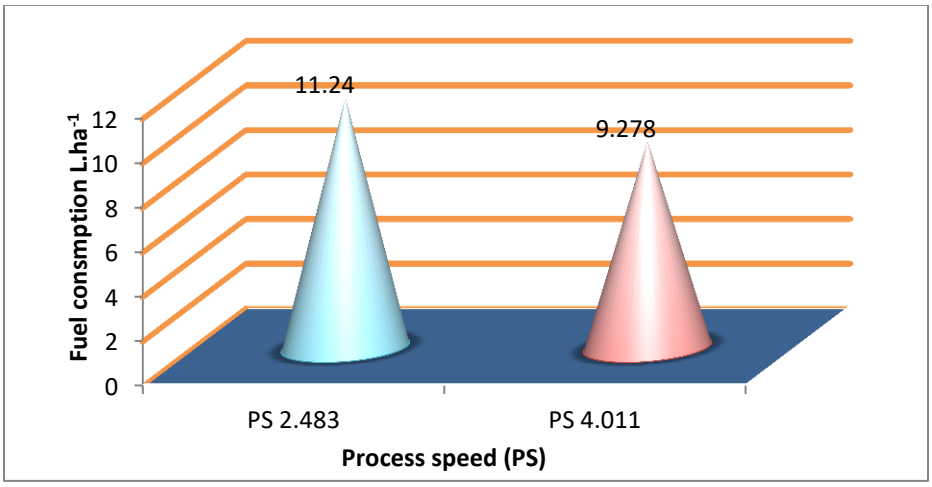

Fig 2. Effect of PS on FC

3.2.Slippage ratio (SR)

The results in the statistical analysis Table .1 shown that there is a highly significant effect of the PS factor and TD on the SR ratios. The SR has been shown in at varied conditions for PS types and different TD. The best results of 9.815%, was obtained among the combination of PS -2.483 km.hr^{-1}and TD -15 cm.

Table 2. Impact of process speed(PS) and tillage depth (TD) on SR .

Speed Km.hr^{-1}	Depths cm			Mean of PS
	15	20	25	
2.483	9.815	10.683	11.204	10.567
4.011	10.717	11.529	13.422	11.890
Mean of TD	10.266	11.106	12.313	
LSD=0.05	PS	TD	TD*PS	
	0.209	0.311	0.462	

The SR is shown in Table. 2, at varied conditions for PS . As it appears from the results of the statistical analysis, there is a highly significant effect of the PS on the SR,(Fig. 3). There are substantial differences between all treatments. The PS - 2.483 km.hr^{-1} recorded the lowest ratio as 10.567%, while the PS - 4.011km.hr^{-1} recorded the highest ratio as 11.890%, respectively. The reason for the high RS when high speed it's reduced the cohesion between the tractor wheels and the ground (Alaamer and Alsharifi 2020).

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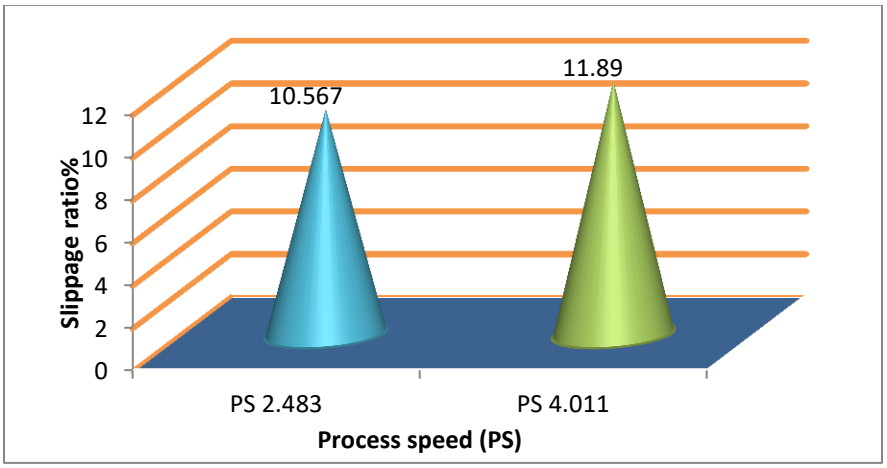

Fig 3. Effect of PS on SR

The SR is shown in table. 2, there is a very significant effect of TD on the SR, (Fig. 4), there are significant differences, as the treatment of the TD-15 cm on record the lowest ratio of 10.266% , while the treatment of TD - 25 cm gave the highest ratio of 12.313%. The superior SR ratios of the TD -25 cm compared to the TD -15 cm, it's a result of the stress exerted on the machine when increasing the tillage depth (Mohamed and Al –Shamary 2022)

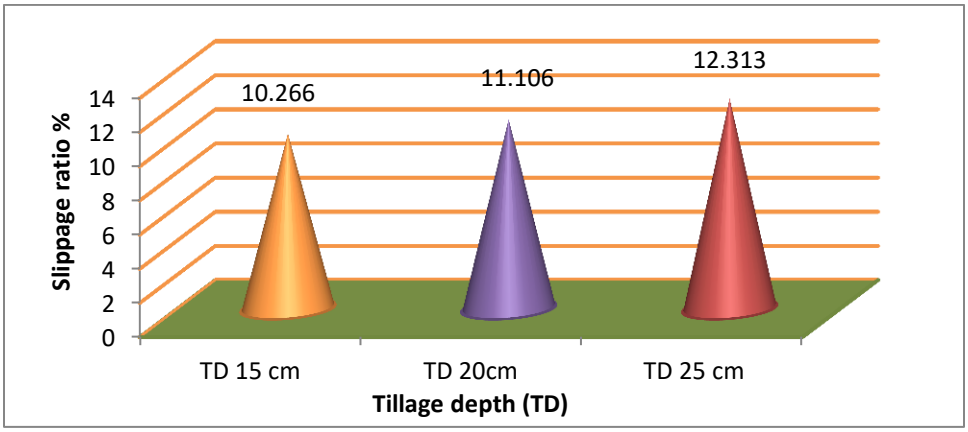

Fig 4. Effect of TD on SR

3.3. Machine efficiency (MF)

The results in the statistical analysis Table .3 shown that there is a very significant effect of the PS factor and TD on the ME ratios. The ME has been shown in at varied conditions for PS types of and different TD. The best results of 79.416%, was obtained among the combination of PS -2.483 km.hr^{-1}and TD- 15 cm.

Table 3. Impact of process speed(PS) and tillage depth(TD) on MF .

Speed Km.hr^{-1}	Depths cm			Mean of PS
	15	20	25	
2.483	79.416	69.242	65.513	71.390

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4.011	75.910	64.119	62.708	67.580
Mean of TD	77.663	66.681	64.110	
LSD=0.05	PS	TD	TD*PS	
	2.247	2.466	3.081	

The influence of PS, on the ME are showed in Fig .5. It is particular that the PS -2.483km.h^{-1} was significantly better than the 4.011km.hr^{-1}. The results acquired 71.390 and 67.580% respectively. The reason for the decrease in machine efficiency with the PS of 4.011km.hr^{-1} is the increase in the slippage ratio. (Mankhi. and Jebur. 2022).

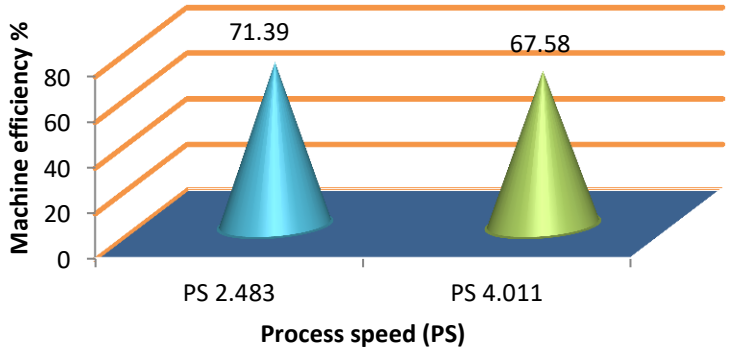

Fig 5. Effect of PS on SR

Showed in Fig.6. As increasing the TD leads to an decrease the ME, the results were 77.663, 66.681 and 64.110%, respectively. The reason for the increase in machine efficiency ratios is a clear evidence of a decrease in the slippage ratio. (Jebur, and AL-Halfi 2022).

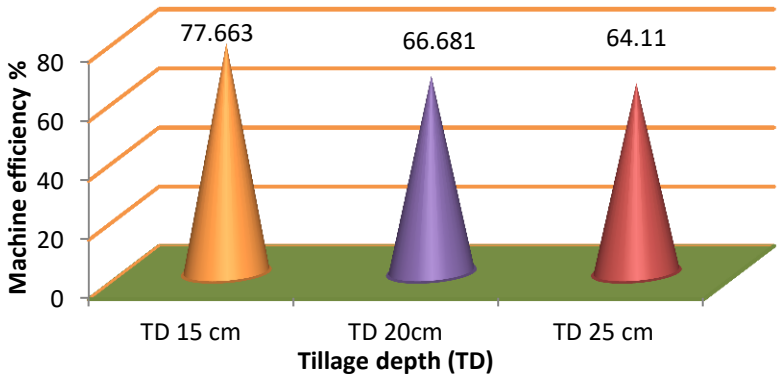

Fig 6. Effect of TD on ME

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3.4.Soil density and porosity

The results in the statistical analysis table .4 shown that there is a very significant effect of the PS factor and TD on the soil density and porosity. The SBD and TSP, has been shown in at varied conditions for PS types and different TD. The best results of 1.28Mg.cm^{-2} and 51.69% respectively, was obtained among the combination of PS- 2.483 km.hr^{-1}and TD - 15 cm.

Table 4. Impact of process speed(PS) and tillage depth(TD) on SBD and TSP .

PS	TD cm	SBD			TSP		
		1Mon	2Mon	GSE	1Mon	2Mon	GSE
2.483	15	1.24	1.28	1.29	53.21	51.69	51.32
	20	1.26	1.30	1.31	52.45	50.94	50.56
	25	1.28	1.31	1.32	51.69	50.56	50.18
4.011	15	1.28	1.31	1.33	51.69	50.56	49.81
	20	1.30	1.32	1.34	50.94	50.18	49.43
	25	1.32	1.34	1.36	50.18	49.43	48.67
PS	2.483	1.26	1.29	1.31	52.45	51.32	50.56
	4.011	1.30	1.32	1.34	50.94	50.18	49.43
TD	15	1.26	1.30	1.31	52.45	50.94	50.56
	20	1.28	1.31	1.33	51.69	50.56	49.81
	25	1.30	1.33	1.34	50.94	49.81	49.43
LSD=0.05	PS	0.02	0.03	0.04	0.123	0.433	0.512
	TD	0.03	0.04	0.06	0.124	0.520	0.611
	PS*TD	0.06	0.07	0.08	0.128	0.652	0.823

From Fig. 7. The better values of 1.26, 1.29 1.32Mg.cm^{-3} and 52.45, 51.32 and 50.56% at PS-2.483 km.hr^{-1}. While high ratios of 1.30, 1.32 and 1.34Mg.cm^{-3}and 50.94, 50.18 and 49.43% at PS- 4.011km.hr^{-1}. Increasing the practical speed of the mechanical unit (tractor + machine) leads to crushing and fragmenting the soil and creating small particles that fill the pores, reduce their volume, increase their density and decrease their porosity, (Jebur, 2018).

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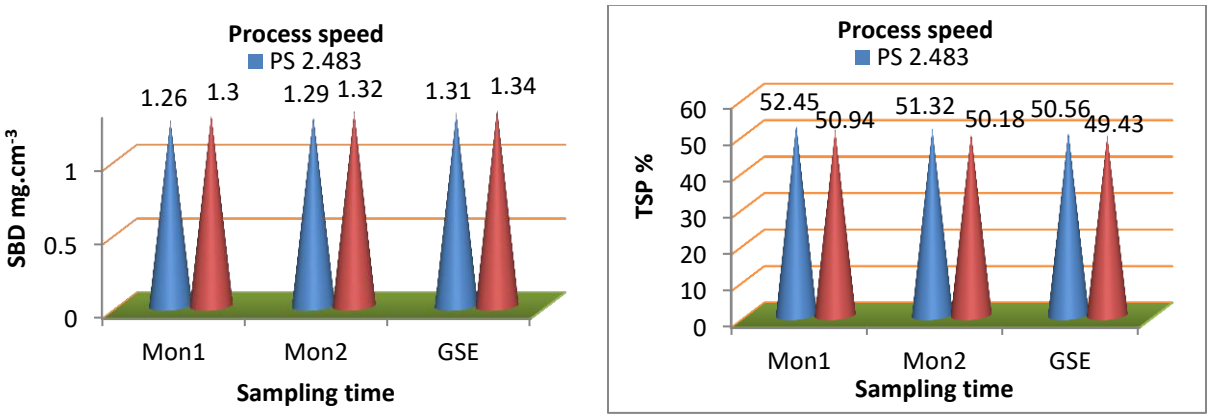
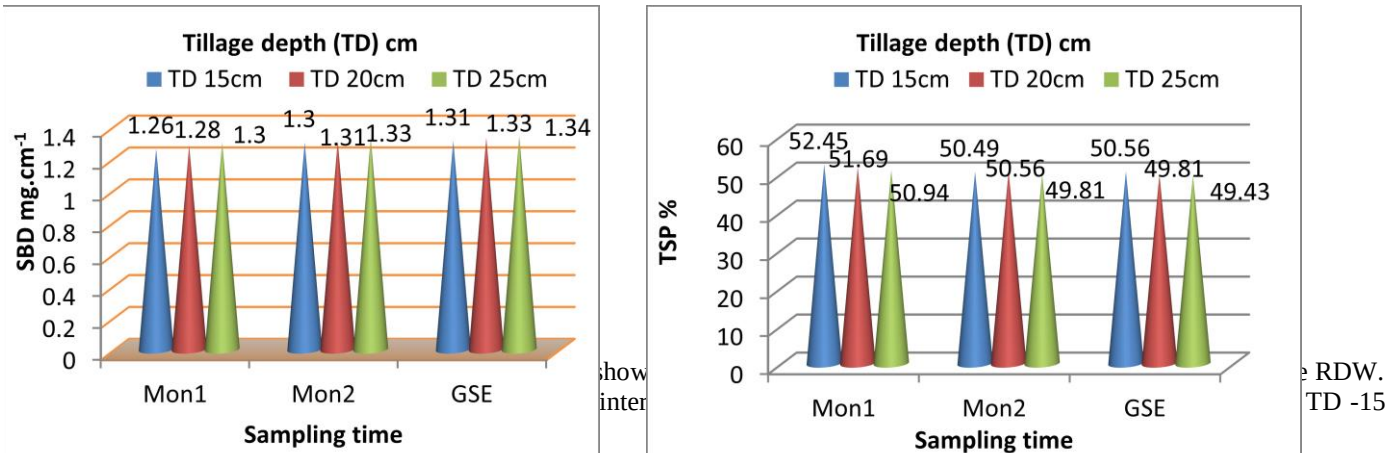


Fig 7. Effect of PS on SBD and TSP

Showed in Fig 8. As increased the TD 15cm result to an increase SBD, 1.26,1.30 and1.31Mg.cm-3, this is reflected in its increased porosity, the proportions were as follows 52.45, 50.94 and 50.56% respectively, while increased TD of 25 cm leads to an increased SBD and the results were 1.30, 1.33 and 1.34Mg.cm-3. this is reflected in its increased porosity, the proportions were as follows 50.94, 49.81 and 49.43% respectively. The reason for the increase in TSP ratios is a clear evidence of a decrease in the SBD ratio (Hamad et al, 2021).



show … RDW. inter … TD -15

Fig 8. Effect of TD on SBD and TSP

Table 5. Impact of process speed(PS) and tillage depth (TD) on RDW .

Speed Km.hr^{-1}	Depths cm			Mean of PS
	15	20	25	
2.483	60.86	56.03	54.98	57.29

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4.011	57.59	53.18	51.92	54.23
Mean of TD	59.22	54.61	53.43	
LSD=0.05	PS	TD	TD*PS	
	0.441	0.591	0.652	

Increasing the tillage depth leads to a decrease in RDW, and the obtained values were 59.22, 54.61 and 53.43 g respectively, Fig 9. The reason for this is the squeeze resulting from the weapon when it penetrates the soil, which impedes the spread and roots growth in the soil, and this is reflected in the root dry weight decrease (Alaamer. et al 2022) and (Hachim, and Jebur 2022).

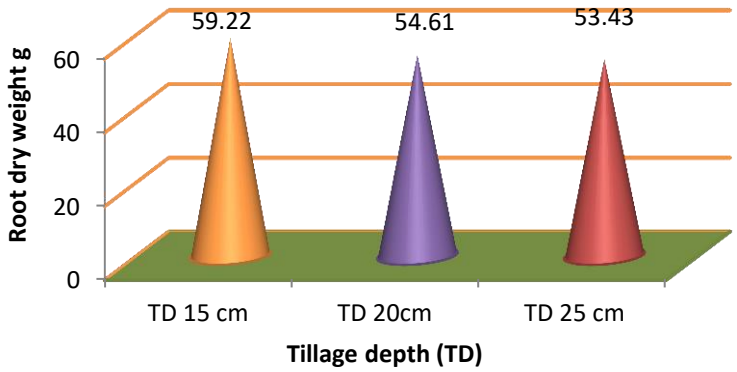

Fig 9. Effect of TD on RDW

Increasing the process speeds leads to a decrease in RDW, and the obtained values were 57.29 and 54.23 g, respectively, Fig 10. That speed increased led to the squeeze resulting by the weapon when it penetrates the soil, which impedes the spread and roots growth in the soil, and this is reflected in the root dry weight decrease (Hussain. and Ismail 2020)

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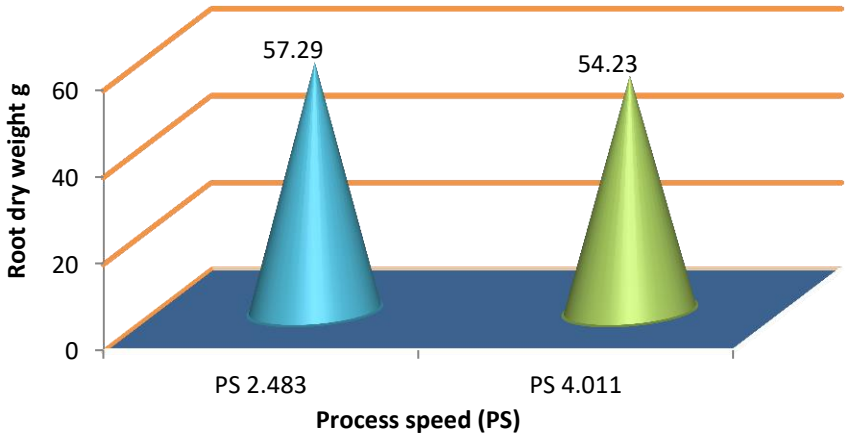

Fig 10. Effect of PS on RDW

3.6.Plant vigor index (PVI)

The results in the statistical analysis Table .6, shown that a very significant effect of the PS factor and TD on the PVI. Best results of 65.93 cm was obtained, when interferences among the combination of PS -2.483 km.hr^{-1}and TD -15 cm.

Table 6. Impact of process speed(PS) and tillage depth (TD) on PVI .

Speed Km.hr^{-1}	Depths cm			Mean of PS
	15	20	25	
2.483	65.93	61.17	59.89	62.33
4.011	62.55	58.53	55.46	58.85
Mean of TD	64.24	59.85	57.67	
LSD=0.05	PS	TD	TD*PS	
	0.532	0.604	0.791	

Fig .11. The results showed a significant effect of the process speed , and it was superior to the first speed, 2.483 km.hr^{-1}, as it recorded the highest rate PVI 62.33 cm, compared to the second speed, 4,011 km.hr^{-1}, which recorded the lowest rate 58.85 cm. The reason for this is that the first practical speed works to provide a wide area that helps the roots spread inside the soil as a result of the availability of moisture and good elements that contribute to improving the crop characteristics (Al-Temimi. and Al-Hilfy. 2022).

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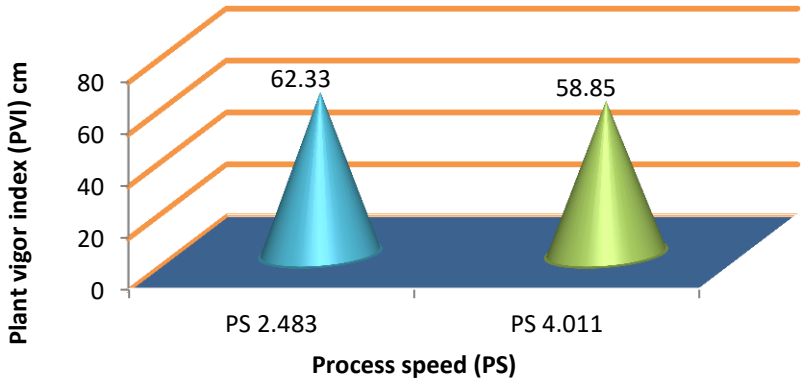

Fig 11. Effect of PS on PVI

Increasing the TD leads to a decrease in PVI, and the obtained values were 64.24, 59.85 and 57.67 cm respectively, Fig 12. Increasing the tillage depth leads to an increase soil compaction and a decrease in the water leak rates in the soil, and this was reflected negatively in a decrease in the PVI values (Amer, et al 2021).

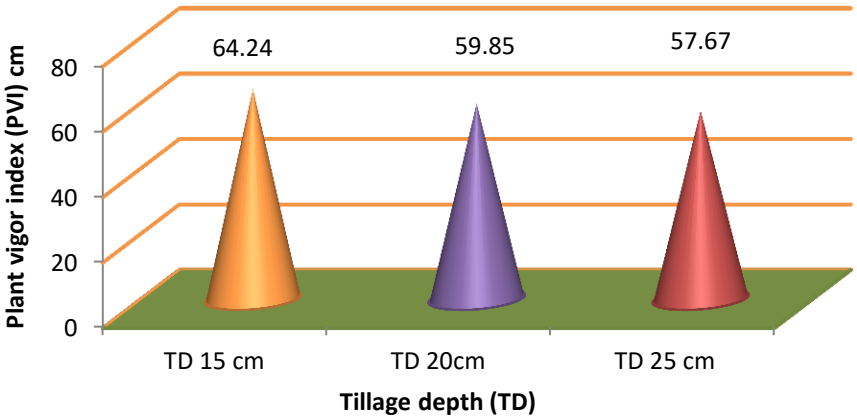

Fig 12. Effect of TD on PVI

3.7.Crop productivity (CP)

The results in the statistical analysis Table .7, shown that there is a highly significant effect of the PS factor and TD on the CP. The best results of 5.015 t.ha^{-1} cm was obtained, when interferences among the combination of PS -2.483 km.hr^{-1}and TD -15 cm.

Table 7. Impact of process speed(PS) and tillage depth (TD) on CP .

Speed Km.hr^{-1}	Depths cm			Mean of PS
	15	20	25	

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2.483	5.015	4.604	3.663	4.427
4.011	4.034	3.711	3.001	3.582
Mean of TD	4.524	4.157	3.332	
LSD=0.05	PS	TD	TD*PS	
	0.038	0.046	0.078	

Shown in Fig 13. The TD of 15cm indicated the highest CP of 4.524t.ha^{-1}, against 3.332 t.ha^{-1} at TD of 25cm. The soil compaction increased, is resulted from the tillage deepening, and this in turn affected the soil properties represented by density and porosity during the growing season, which led to hindered root growth and crop productivity decreased[8], (Çelik, 2011) and (Al-Dulaimi and Al-Amri. 2020).

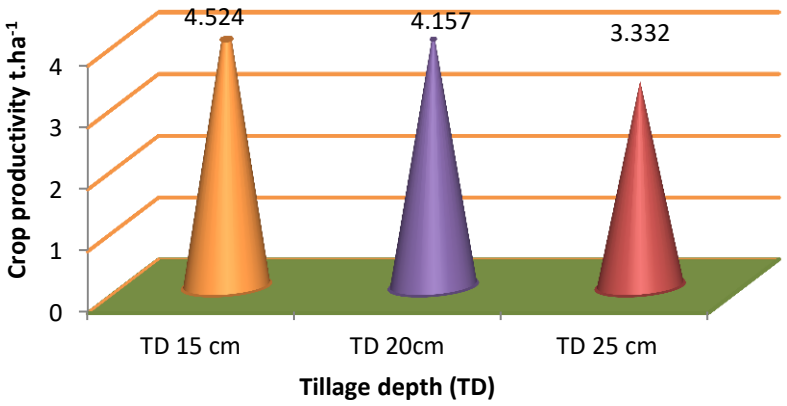

Fig 13. Effect of TD on CP

The SP at 2.483 km.hr^{-1} showed the highest CP of 4.427t.ha^{-1}, while the lowest CP of 3.582 t.ha^{-1} was for 4.011km.hr^{-1} SP. Fig 14. Increase in the practical speed of the plowing machine leads to the soil particles breaking up and filling the pores, and thus affected the growth characteristics of the corn crop and decreased its productivity (Almaliki et al, 2019).

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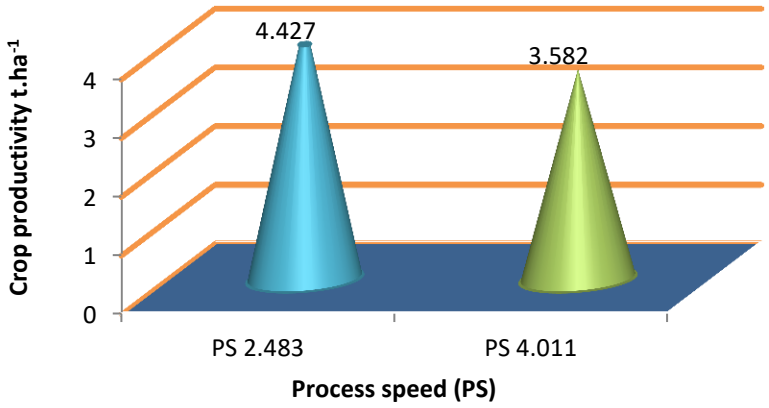

Fig 14. Effect of SP on CP

IV. CONCLUSION

There were considerable differences among the treatment of tillage depth (TD) at a level of 15 cm it gave the preferable results compared to the two treatments 20 and 25 cm and this is good economically. The PS of 2.483 km.hr-1 was significantly better than the PS of 4.011km.hr-1 in all studied conditions.

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