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EFFECT OF MECHANICAL PROPERTIES ON SOME GROWTH CHARACTERISTICS FOR MAIZE, SYN5018 VARIETY

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Abstract

The effect of the angle of plow penetration of soil and tillage distances on maize SYN5018 variety and soil physical properties, under impact some mechanical properties for type tillage machine (moldboard plow),were tested two the angle of plow penetration of soil levels of 75° and 90° and three levels tillage distances of 70,80 and 90 cm. The experiments were conducted in a factorial experiment under randomized complete block design with three replications. The results showed that the angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil 90° as while tillage distances at range 70 cm was significantly superior to the other two levels 80 and 90 cm in all studied conditions. For the angle of plow penetration of soil 75°and tillage distance 70cm,the fuel consumption, slippage percentage, machine efficiency, germination percentage, plant height, 1000 – weight grain, number of grains per ear and the maize crop productivity ,were 9.551, 9.958 $L.ha^{-1}$, 9.303, 8.935%, 71.786, 71.963%, 91.613, 91.810%, 171.07, 173.11cm 256.353, 255.167g, 511.697, 536.060 $grain.ear^{-1}$ and 4.393, 4.768 $t.ha^{-1}$. The best results have come from the overlap among the angle of plow penetration of soil of 75°and tillage distance of 70 cm, in all studied parameter.

***Keywords* :** Maize, soil physical characteristics, mechanical properties, angles, tillage distances, moldboard plow.

Introduction

Maize is now one of the most widely-grown crops around the world in both temperate and tropical regions it is among the 10 most important world crops by value ,In Iraq maize is grown both (as sweet corn) for human consumption and (as machine corn) for other uses such as animal feed and biofuels. only around 15% of maize production is used for food consumption with most production going to animal feed (Alsharifi *et al.*, 2019a). Agricultural tractors are one of the machines important in agricultural productions which have great importance. It is obvious in order to increase efficiency of agricultural products , it is needed to increase the machine working efficiency in all soil physical properties and it is essential to optimize fuel consumption. The basic technique of tillage plowing and tillage operation is consists in returning the soil so that the lower part of soil is brought to the surface, soil tillage where it serves as the primary nutrient base for plants, (Alsharifi and Ameen, 2018). Tractors are used for many different tasks. Because the tractor is a versatile machine. Soil tillage is the quality that enables a soil to provide the proper nutrients, in the proper amounts and in the proper balance, for the growth of specified plants and tillage is the agricultural preparation of soil by mechanical agitation of various types, such as digging and stirring, tillage is often classified into two types, primary and secondary. Primary tillage such as ploughing tends to produce a rough surface finish, whereas secondary tillage tends to produce a smoother surface finish, such as that required to make a good seedbed for many crops. Harrowing and rototilling often combine primary and secondary tillage into one operation (Alsharifi, 2009). Fuel is the source of capacity for the machine as well as there are many parameters in tillage process that affect the fuel consumption of a machine, such as soil texture, soil moisture , machine type and size .Therefore, tractor fuel consumption is not constant and varies from one to another situation . According for the factors mentioned above (Behzad *et al.*, 2014)

The maximum force was observed at 90° angle, which decreased with the decreasing angles. It was also observed that varying angles have considerable effect on the width of cut, while minimum force was observed on the curvature of plow. It was also observed that moisture content has inverse relation with soil forces while depth has direct relation with soil forces (Mari *et al.*, 2014). Soil type and condition, moisture content and tillage depth were affecting on all mechanical conditions for machine (Karimi Inchebron *et al.*, 2012). Tillage is defined as mechanical manipulation of soil to provide a favorable environment for good germination of seeds and crop growth, to control the weeds, maintain infiltration capacity and soil aeration. A well planned tillage practice provides a favorable environment, suitable for better seed germination and effective plant growth. In addition, it also protects and maintains a strong soil structure to reduce soil erosion (Jassim and Alsharifi, 2007).

The machine tests showed that soil conditions were in good working range for tillage operations. A significant increase in draft was observed for all the three tillage implements with an increase in forward speed and tillage depth. The moldboard plow showed greater draft requirement than the disk plow at the same depth and speed in all studied properties (Naderloo *et al.*, 2009). Reported that tillage process using moldboard plow leads to improve soil physical properties such as bulk density, soil porosity, and penetration resistance, as compared with soil physical properties before tillage process. Soil physical properties affected by operating conditions such as tillage depth, tractor speed and soil moisture content . (Bogunovic and Kisi, 2017). The effects of different tillage methods for wheat and maize on the some soil aggregation properties and yields were investigated. The results showed that tillage methods were significant at as regards crop yields, and the highest yields for wheat (Kahlon *et al.*, 2013).

Important indicators for conventional tillage. One of these indicators which could develop other system characterizing indicators is soil properties monitoring which let to farmers to adapt their practices to the new states of the new system (Cociu, 2010). The machine efficiency is one of an important factor to evaluate performance of the tillage implements. Machine performances of agricultural machineries are affected by many factors such as the power unit/machine condition, operating speed, working depth and geometry of the tillage implement (Sale *et al*., 2013)

The main goal of this research is to study the effect of angles of plow penetration of soil, and tillage distances, on some mechanical properties for moldboard plow and maize growth.

Materials and Methods

This study was conducted in 2019, to evaluate for New Holland-TD80 machine with moldboard plow, the experiments were done at two levels of Angle of plow penetration of soil 75° and 90°, and three distance between the point of share and the point of share other 70, 80 and 90 cm. The moldboard plow was selected for the experiments of the plow organized on certain 18cm depth by hydraulic device for tractor and soil moisture 12-14% using the pipette methods .The tillage machine (moldboard plow type) has Working width 120cm, Length 3010mm, Height 1130mm and Weight 320kg. The tractor (New Holland-TD80 type) has engine power 80 PH, engine speed 2500 rpm, engine type perkins (diesel), cylinders number 4 cylinders, firing order 1-3-4-2, P.T.O 540 rpm and Weight 3080 kg**.** Fuel consumption, slippage percentage, machine efficiency, germination percentage, plant height, 1000 – weight grain, number of grains per ear and the maize crop productivity**,** were calculated for each running test.

Mechanical characteristics

(i) Fuel consumption

Fuel consumption is measured by the fuel consumption device in mL for treatment length (60 m) was calculated using Eq. 1 (Alsharifi, 2009).

$$Q_F = \frac{Q_D \times 1000^o}{W_P \times D \times 100^o} \quad ...(1)$$

Where : Q_F fuel consumed amount L\ha, Q_D fuel consumed amount for treatment length (100 m), W_P machine width (m), D treatment length (60 m).

(ii) Slippage percentage

Measured by the practical and theoretical speed (Alsharifi, 2009)

Practical speed : After tillage depth determination in the experiment the plow hacked in the soil with practical speed 3km .hr^{-1}, within treatment length (60 m) for both soil moisture and tillage depth in three replication. the Eq. (2) was used for calculation of practical speed.

$$V_P = \frac{3.6 \times D}{T_P} \quad ...(2)$$

Where : V_P practical speed Km.hr^{-1} , T_P practical time (hr) .

Theoretical speed : Without plowing the soil, only the weapon touches the soil, with speed 3km.hr within treatment length (60 m) for both soil moisture and tillage depth in three replication. the Eq. (3) was used for calculation of theoretical speed.

$$V_T = \frac{3.6 \times D}{T_t} \quad ...(3)$$

Where : V_T theoretical speed Km.hr^{-1}, T_t theoretical time (hr).

Eq. (4) was used for calculation of slippage percentage using two speeds the practical and theoretical.

$$S = \frac{V_t \times V_P}{V_t} \times 100 \quad ...(4)$$

Power losses due to slippage is calculated from the following Eq. (5) (Alsharifi, 2009)

$$P_S = \frac{F(V_t \times V_P)}{270} \quad ...(5)$$

Where : P_S Power losses due to slippage (kw)

(iii) Machine efficiency

Machine efficiency is the ratio of effective machine capacity to theoretical machine capacity, and it can be affected by time lost in the machine and the full width of the machine (Alsharifi *et al*., 2019b)

(a) Theoretical machine capacity

Theoretical machine capacity is the rate of work when the implement uses its full width and time and it was calculated as follow:

$$T_{FC} = \frac{S \times W}{C} \quad ...(6)$$

Where : T_{FC} : theoretical machine capacity ha h$^{-1,}$ S working speed (Km hr^{-1}), W: cutting width of implement (M), and C: Conversion factor (10)

(b) Effective machine capacity

Effective machine capacity is the actual rate of work and it was calculated as follow:

$$E_{FC} = \frac{A}{T} \quad ...(7)$$

Where E_{FC} : effective machine capacity (ha h^{-1})' A: distance (ha), T: time (hour).

Was used for calculation of machine efficiency (Oduma *et al*., 2015)

$$F_E = \frac{E_{FC}}{T_{FC}} \times 100 \quad ...(8)$$

The crop and its components

(i) Germination percentage

Percentage of germination is found for number plants growing in one square meter in three replications.

(ii) Plant height

Maize height are measured by bar or ruler from soil surface till the plant end, in three replications.

(iii) 1000 – weight grain

The samples random were taken for ten plant for calculated 1000- grain weight in one square meter in three replications (Jaddoa and Baqir, 2012).

(iv) Number of grains per ear

The samples random were taken for ten plant for calculated number of grains per ear in one square meter in three replications (Alsharifi, 2009).

(v) The maize crop productivity

The samples random were taken for 25 plants in ten rows and calculate productivity of the crop in three replications .According of the method used by (Mutlak, 2018).

Physical properties

Physical properties of the soils determined ,were taken soil samples for six site randomly selected from the machine and for three tillage depths determined in the experiment were 10, 14 and 18 cm by the hydraulic device for tractor according to the method used by (Boloor *et al.*, 2013) were taken of the soil samples for different depths, when obtain 12-14% moisture soil .And then the first part was executed from experiment. For both distances measured and angles of plow penetration (Behzad *et al.*, 2014) each running test.

(i) Soil moisture :

Samples were taken to measure soil moisture in the surface layer, 10 cm, 14 cm and 18cm. Soil samples were weighted and drying in oven with 105˚C. The moisture content of soil samples, was calculated by using Eq. 12 (Dehroyeh, 2005).

$$W = \frac{W_W}{W_S} \times 100 \quad ...(12)$$

Where : W : Is soil moisture percentage, W_W : Is weight wet soil, W_S : Is weight dry soil.

(ii) Soil bulk density

For measuring bulk density, three soil samples from different parts of the land were collected using the pipette method. The collected samples were immediately put in plastic bags to conserve moisture during transferring to the laboratory and weighed it, then dried at 105 ˚C for 48 hr. Mass of dried soils was weighted, Soil bulk density was determined by Eq. 13 (Langston, 2014).

$$P_b = \frac{M_S}{V_T} \quad ...(13)$$

Where : P_b : Dry bulk density (mg. m^{-3}), M_S: weight of the dried soil sample (mg), V_T : total volume of the soil sample (m^3).

(iii) Total soil porosity

The total porosity of soil samples collected for each treatment was calculated using following equation, an assumed particle density of 2.65 mg.m^{-3}. The Eq (14) was used for calculation of the total porosity of soil (Anna *et al.*, 2010).

$$T_{SP} = \left(1 - \frac{P_b}{P_S}\right) \times 100 \quad ..(14)$$

Where : T_{SP} : total soil porosity (%), P_b : dry bulk density (mg.m^{-3}), P_S : partial density (mg.m^{-3}), and shown in the table below.

Table I : Experiment machine properties

Soil moisture%	Depth tillage cm	Soil bulk density Mg.m^{-3}	Total soil porosity %
10-12%	10	1.28**	51.69**
	14	1.32	50.18
	18	1.44	45.66
12-14%	10	1.34**	49.43**
	14	1.41	46.79
	18	1.49	43.77

The influence of soil moisture and tillage depth on soil bulk density and total soil porosity was shown in Table I. All the interactions are significantly different and the best results (1.28 Mg.$m^{-3}$and 51.59%) have come from the overlap among moldboard plow, 10%-12% soil moisture and 10cm tillage depth. while gives the interactions between among moldboard plow, 12-14 % soil moisture and 10cm tillage depth the best results (1.34 Mg.m^{-3} and 49.43%).

Table II : Soil minutes volumes analysis in the experiment machine

Soil moisture%	Tillage depth Cm	silt	Clay	sand	Soil tissue
	14	490	360	150	
10-12 %	16	480	390	130	
	18	460	370	170	
Av		476.67	373.33	150	Silt Clay loam
12-14%	14	480	380	140	
	16	490	350	160	
	18	450	390	160	
Av		473.37	373.33	153.33	Silt Clay loam

The results were analyzed statistically by using the randomized complete block design RCBD and the difference among treatments for each factor was tested according to the least significant difference L.S.D test (Oehlent, 2010).

Results and Discussion

Fuel consumption

The influence of angles of plow penetration of soil on fuel consumption L.ha^{-1}, was shown in Table **1**. The angle of plow penetration of soil of 75° has the lowest fuel consumption which required of 9.551 L.ha^{-1}, and the angle of plow penetration of soil of 90° has the lowest fuel consumption which required of 11.264 L.ha^{-1}. The fuel consumption increased caused of the high pressure on moldboard plow during tillage process. These findings are consistent with the findings of (Alsharifi and Ameen, 2018). It is indicated that the fuel consumption of the level 70 cm tillage distance was significantly better than 90 cm tillage distance. The results were 9.958, 10.375 and 10.891L.ha^{-1} respectively. Because of high soil resistance of the plow movement and thus increasing fuel consumption when distances of the tillage increased. These results are consistent with the results of (Behzad *et al*., 2014). The best results (9.082 L.ha^{-1}) have come from the overlap among the angle of plow penetration of soil of 75°and tillage distance of 70 cm.

Slippage percentage

The influence of tillage distances on the slippage percentage %. The increasing of the tillage distances led to the decrease of the slippage percentage and the results were 8.935, 9.653 and 10.682% respectively, at different tillage distances. This is due to increased drag force when increase tillage distances led to increase slippage ratio. These results are consistent with the results of (Alsharifi, 2009). From Table 2, it is indicated that the slippage percentage of the angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil 90°, the results were 9.303% and 10.264% respectively. The effect of the penetration angles of soil was found to be correlated with the tillage distances .These results are consistent with the results of (Bogunovic and Kisic, 2017). The best results (8.715 %) was achieved for moldboard plow, at 75° angle of plow penetration of soil and 70 cm tillage distance.

Machine efficiency

The influence of angles of plow penetration of soil on machine efficiency %, was shown in Table **3.** The angle of plow penetration of soil of 75° has the highest machine efficiency which required of 71.786 %, while the angle of plow penetration of soil of 90° has the lowest machine efficiency which required of 69.339 %. The machine efficiency reduction was due to the high pressure on the moldboard plow during the tillage process, there was an inverse relationship between penetration angles and tillage distances. These findings are consistent with the findings of (Mari *et al*., 2014). It is indicated that the machine efficiency of the level 70 cm distance tillage was significantly better than 90 cm tillage distance. The results were 71.963, 70.598 and 69.127% respectively .Because of high soil resistance of the plow movement and thus decreasing machine efficiency when distances of the tillage increased. These results are consistent with the results of (Sale *et al*., 2013). The best result (73.610%) was obtained by moldboard plow at 70 cm tillage distance and angle of plow penetration of soil 75°.

Table 1 : The effect of angles of plow perpetration of soil and tillage distances on fuel consumption. L.ha^{-1} .

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	9.082	9.656	9.915	9.551
90°	10.833	11.095	11.866	11.264
LSD=0.05				0.403
Means of tillage distances	9.958	10.375	10.891	
LSD=0.05		0.613		

Note: L.S.D means Least Significant Difference

Table 2 : The effect of angles of plow perpetration of soil and tillage distances on slippage percentage %.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	8.715	9.092	10.103	9.303
90°	9.155	10.214	11.261	10.210
LSD=0.05				0.321
Means of tillage distances	8.935	9.653	10.682	
LSD=0.05		0.653		

Note: L.S.D means Least Significant Difference

Table 3 : The effect of angles of plow perpetration of soil and tillage distances on machine efficiency %.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	70.816	69.221	68.418	69.485
90°	69.213	68.411	67.526	68.383
LSD=0.05				1.011
Means of tillage distances	70.015	68.816	67.972	
LSD=0.05		1.237		

Note: L.S.D means Least Significant Difference

Germination percentage

The germination percentage was affected by the influence of angle of plow penetration of soil and tillage distances which is indicated that the angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil 90° and were results 91.613 and 89.570 % respectively (Table 4). At tillage distance 70cm the germination percentage was highest of 91.810% and at the tillage distance 90cm indicated the lowest germination percentage 89.227%. Increased soil fragmentation with low tillage distances unlike increasing tillage distances which led to reduced the soil physical properties and reflected negatively on the germination percentage for maize crop. These results are consistent with the results of (Jassim and Alsharifi, 2007). The best result (93.113%)was obtained by moldboard plow at 70 cm tillage distance and angle of plow penetration of soil 75º.

Plant height

The decrease in tillage distances leads to increase plant height being 173.11, 171.12 and 167.29cm respectively for different levels of tillage distances. Decreased physical properties of soil when increasing the tillage distances and this is reflected negatively on plant height. These results are consistent with the results of (Mutlak, 2018). From Table **5**. The angle of plow penetration of soil 75° indicated in the highest plant height (171.07 cm) and at the angle of plow penetration of soil 90° indicated the lowest plant height (169.27 cm). Because the decrease of the angle of plow penetration of soil by the mechanical unit (plow + tractor) led to the fragmentation of the soil blocks and thus led to a decrease in the soil physical properties and reflected positive on the plant height for maize crop .These results are consistent with the results of (Kahlon *et al*., 2013). The best result (174.33%)was obtained by moldboard plow at 70 cm tillage distance and angle of plow penetration of soil 75°.

1000-weight grain

Table 6 shows the influence of tillage distances on 1000- weight grain.The increasing of the tillage distances led to the decrease of the 1000- weight grain and the results were

255.167 , 231.115 and 203.458 g respectively, at different tillage distances .The tillage leads to improve soil ventilation which its a significant impact in the absorption of food and water by the roots hence decreased tillage distances led to increasing 1000-weight grain .These results are consistent with the results that gained by (Sale *et al*., 2013) . From Table 6 it is indicated that the 1000-weight grain for the angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil 90°, the results were 256.353 and 203.350 g respectively. The best results (298.241 g) was achieved for moldboard plow, at 75° angle of plow penetration of soil and 70 cm tillage distance .

Number of grain per ear

The number of grain per ear was affected by the influence of angle of plow penetration of soil and tillage distances which is indicated that the angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil90° and were results 511.697 and 433.498 grain.ear^{-1} respectively (Table 7). At tillage distance 70cm the number of grain per ear was highest of 536.060 grain.ear^{-1}. and at the tillage distance 90cm indicated the lowest number of grain per ear 431.556 grain.ear^{-1}. Increased soil fragmentation with low tillage distances unlike increasing tillage distances which led to reduced the soil physical properties and reflected negatively on the number of grain per ear for maize crop. These results are consistent with the results of (Alsharifi, 2009). The best result (569.710 grain.ear^{-1}) was obtained by moldboard plow at 70 cm tillage distance and angle of plow penetration of soil 75°.

Maize productivity

Table 8 shows the influence of tillage distances on the maize productivity t.ha^{-1} The increasing of the tillage distances led to the decrease of the production of the maize crop and the results were 4.768, 4.034 and 3.551 t.ha^{-1} respectively, at different tillage distances. Soil resistance to penetration increasing is one of the factors influencing the productivity of maize yield through its effect on root extension and plant growth with tillage distance increased. This is consistent with (Jaddoa and Baqir, 2012). From Table **8.** It is indicated that the maize productivity with the angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil 90°,the results were 4.393 and 3.842 t.ha^{-1} respectively. The best results (5.056 t.ha^{-1}) was achieved for moldboard plow, at 75° angle of plow penetration of soil and 70 cm tillage distance.

Table 4 : The effect of angles of plow perpetration of soil and tillage distances on germination percentage %.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	93.113	91.916	89.865	91.613
90°	90.507	89.615	88.589	89.570
LSD=0.05				1.021
Means of tillage distances	91.810	90.766	89.227	
LSD=0.05		1.873		

Note: L.S.D means Least Significant Difference

Table 5 : The effect of angles of plow perpetration of soil and tillage distances on plant height cm.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	174.33	170.49	168.41	171.07
90°	171.90	169.75	166.18	169.27
LSD=0.05				2.706
Means of tillage distances	173.11	170.12	167.29	
LSD=0.05		3.065		

Note: L.S.D means Least Significant Difference

Table 6 : The effect of angles of plow perpetration of soil and tillage distances on 1000 weight grain g.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	298.241	261.315	209.505	256.353
90°	212.093	201.001	197.411	203.350
LSD=0.05				10.432
Means of tillage distances	255.167	231.115	203.458	
LSD=0.05		11.786		

Note: L.S.D means Least Significant Difference

Table 7 : The effect of angles of plow perpetration of soil and tillage distances on number of grain per ear grain.ear^{-1}.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	569.710	499.150	405.231	511.697
90°	502.411	401.204	396.881	432.498
LSD=0.05				16.342
Means of tillage distances	536.060	450.177	431.556	
LSD=0.05		18.987		

Note: L.S.D means Least Significant Difference

Table 8 : The effect of angles of plow perpetration of soil and tillage distances on maize productivity t.ha^{-1}.

The angles of plow perpetration of soil	Tillage distances cm			Means of angles
	70	80	90	
75°	5.056	4.122	4.002	4.393
90°	4.481	3.946	3.099	3.842
LSD=0.05				0.131
Means of tillage distances	4.768	4.034	3.551	
LSD=0.05		0.452		

Note: L.S.D means Least Significant Difference

Conclusions

The angle of plow penetration of soil 75° was significantly better than the angle of plow penetration of soil 90° in all studied condition , the tillage distance 70cm was significantly superior to other two levels 80 and 90cm in all studied properties . The best results were obtained by moldboard plow at angle of plow penetration of soil 75° and 70 cm tillage distance for maize crop.

Recommendation

The present recommends to carry out future studies using other of machinery types and conduct other organizations on machine and the moisture content to know their effect on the physical characteristics of soil and machine.

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