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Effect of Soil moisture content and tillage depth on tractor performance with using moldboard plow in silty-clay soil

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Abstract

The experiment was conducted in the field of Faculty of agriculture science / sulaimani University in 2012 – 2013 to study the Effect of Soil moisture content and tillage depth on tractor performance with using moldboard plow in silty-clay soil. Split plot design and randomized complete block design (RCBD) was used in this study. Two factors including two tillage depth levels 15 and 25 cm represent the main plot and three soil water content including 10, 15 and 20 % represent sub plot were used in this study . Fuel consumption, Practical speed, Tire slippage, Tillage soil volume, Soil penetration resistance, Porosity and No. Of soil clods that larger than 10 cm where studded. The study shows that: - Significant differences were observed between the two tillage depth treatment means, water content treatment means, and them interaction means for all studied characters in the experiment. also the study shows the best results for all the characters was for the treatment of depth 15 cm compared to the depth of 25 cm, while the opposite happened for the tillage soil volume where the depth 25 cm Superiority on 15 cm depth by giving him the highest value. as for water content factor, the value for fuel consumption, practical speed, tire slippage, and tillage soil volume increased Significantly with increasing soil water content from 10 to 15 then to 20%, while the values for other characters decreased. Also There were differences among the interaction treatment means for all characters value in the experiment that most of them where significant.

Introduction

In general it can be said that the plowing process is one of the most essential operations performed on the soil because they affect the properties and environment of the soil and the production of different crops. So that for natural plant growth, the soil must be prepared well that the plant roots can find enough food and water and air [15]. the application of momentary diagram of fuel consumption can be useful and effective for determining momentary variation of fuel consumption and engine momentary loads. [10]. The basic orientation in agricultural mechanization is on the increase of practical speed according to allowable limits to take advantage of the maximum power of the tractor [21]. The speed of deep plowing of 3-6 km / hr and the speed of plowing a field to cultivate grain of 4-7 km / hr and the speed of the surface plowing of 6-8 km /hr. [8]. The fuel consumption in the agricultural tractor affected by several factors including: the type and structure of the soil, environment, moisture content, the tractor type (two or four wheel drive), the size of the tractor,

and the relationship between the tractor and agricultural equipments. Therefore, tractor fuel consumption in different methods of measurement is not constant and varies from one to another. Although the physical properties of the soil greatly affected by the type of plow, the operational variations play a big role on those properties, and most important of these variations: practical speed of plowing, tillage depth, soil moisture. The level of productivity of agricultural crops significantly affected by changes in the resulting physical properties of the soil [7]. The lack of time for plowing and inadequate moisture content of the soil caused the rough surface of the soil that filled with clods at using primaries tillage of the soil in the most parts of Iran. Therefore, to overcome this problem, disk harrows use several times by farmers that affect soil properties, time and operating costs significantly, so it is very important to know the parameters that can reduce the costs of plowing and traffic in the fields. [2]. Probably the two most important factors influencing the structural and surface conditions produced at time of tillage for a particular soil are moisture content and type of tillage action. This is especially true for medium and fine textured soils. The most important properties of the soil that contribute to the amount of energy spent in tillage are moisture content, bulk density, penetration resistance, soil texture, and soil strength. [18]. The soil moisture content a significant effect on the dismantle and crush the soil when using moldboard plow. During tillage, a lot of energy is needed in the soil when a moisture content is low because the cohesion force between soil particles is very strong. And there are big clods in the field after tillage. While, when the soil moisture content is high in the field, tillage equipment cannot be used. Also the plowing depth is a very important and effective factors. The clod mean weight diameter (MWD) raise with Increasing the plowing depth [20]. [4]. Said that One of the most important indicators to determine the efficiency of tillage equipment is appearance of tillage that creating the appropriate sense of the seed shrine. [17] Indicated that The moisture content of the soil has to be in the optimal limits were tillage produces a minimum number of large voids and a maximum number of small soil particles. They also indicated that when the range of water contents 12.6 to 18.3 percent produced the greatest total macro porosity in soil of (17 % clay, 32 % silt and 51 % sand). Therefore, research was conducted to the purpose of study the effect of tillage depth and moisture content on the performance indicators of the triple mold board plow and some physical properties of the soil.

Materials and methods

at the end of Autumn 2012 in one of sulaimani University with Silty-clay soil texture (Clay 43.6%, 51.13% silt, sand 5.27%) this field experiments were conducted and the proportion of organic matter 2.32% . 2wd New Holland tractor 70 hp used in this experiment. A mounted moldboard plow (3bottoms with a 35 cm working width) was used for tillage. Experimental field was designed as split plots according to randomized complete block design (RCBD) with three replicates . The main plot was for two level tillage depth 15 and 25 cm, while three levels water content Represented sub- plot that done at three different times upon the arrival of soil moisture content to 20,15,and 10%, Special auger was used for measuring the soil moisture content for each depth. The soil samples was putted in an oven at 105°C for 24 hr to measure the changes of weight of soil samples. [11]. Finally, number of experimental units became 18 (2x2x3) per replicate. The length of experiment unit was 30 m while leaving a distance of 10 m at the beginning and end of each unit, the results tested by LSD under 5% level.

- Estimating the amount of fuel consumption (L/ha): The amount of fuel consumption was measured by using graduated cylinder Capacity of (1000) ml per each experiment units then converted to (L/ha) by the following mathematical equation. [12]

$$F.Q = \frac{Q.d * 10000}{Bp*L*1000} \quad \text{..... (1)}$$

Where :

FQ = The amount of fuel consumption . L/ha

FQ = The amount of fuel consumption for each treatment. ml
Bp = the practical work width. cm
L = treatment length (30 m).

- Practical speed (Km/hr): Measured by calculating the time it takes to plough distance of experimental unit length m/s and then convert the data into km/hr by the equation:

$$Vp = \frac{D}{Tp} \times 3.6 \quad \text{.....(2)}$$

Where:
Vp = Practical speed (Km/hr)
D = Tillage distance (m)
Tp = The takes time for ploughing an experiment unit distance(sec)

-Tire slippage percentage (%) :

Slippage = [(theoretical speed - actual speed) / theoretical speed] ×100 ..... (3)

Stop watch was used to measure the theoretical and practical field speed at deferent levels of two tillage factors by record the time taken by the tractor to travel a specific distance (30m) with the specific implement raised up or working in the field respectively. [1].

-Tillage soil volume M^3/hr : As [14] calculated it.

S .V .d = P p *10000 * D/100 ..... (4)
Where :
S .V .d = Tillage soil volume M^3/hr
D = Tillage depth (cm)
P p = Practical productivity of the plow (ha/hr), calculated as the following :

P p = 0.1B p *V p *S tp ..... (5)
Where :
B p - Plow work width (m)
Stp - Field efficiency (%) where it was assumed for this experiment 80%. Said [19] that the value of the efficiency of field operations for tillage range (75-90)%.

Soil penetration resistance (Kpa) : Measured by using dynamic soil penetrometer in three random locations then took the average for each experimental unit.

- Total porosity (%) : Calculated as the following [6]:

$$po = 1 - \frac{Pb}{Ps} * 100$$

Where :
por - Total soil porisity (%)
Pb - Bulk density (gm/cm^3)
Ps - Real density (gm/cm^3)

-Nomber of soil clods that diameters larger than 10 cm/m2: For express to the number of soil clods that diameter bigger than 10 cm/m2 that referred to the tillage appearance used wired sieve area of 0.5 m2 ,where the distance between wire and other was 10 cm. the number of clods × 2 calculate for the purpose of expressing the number of clusters per square meter. [4]

Result and discussion

1- Effect of tillage depth:

Table (1) show that there are significant differences between the two tillage depth levels for all study characters, Where we note that an increase in tillage depth from 15 to 25 cm the values increased significantly for each of the fuel consumption, tire slippage, tillage soil volume, penetration resistance, and number of soil clods that diameter greater than 10 cm/m^2,while the values of practical speed and soil total porosity decreased. This is because the increase in tillage depth leads to increasing the power of resistance to penetrate by plow shears that appears as an increase in tractor wheel slips which leading to decrease in tillage operation practical speed, therefore the tractor most consumes more fuel to overcome this effect. This was confirmed by [16] that the wheel slip is a critical parameter for fuel consumption and field capacity, this means reduction of ploughing depth reduces the slip, hourly and area related fuel consumption. While, the energy consumption per moved soil bulk density increases. [5] find that with increase in tillage depth the volume of worked Soil (m^3) was also increased. Also see that the number of soil clods increased with increasing the plowing depth, The reason for this is that whenever the depth of tillage increased the soil moisture also increase, that cause increasing in the cohesion of soil particles and thus the number of clods increases too, and that who [4] refer to.

Table – 1: effect of tillage depth on study characters

Tillage Depth Factor Cm	Fuel consumption L/ha	Practical speed Km/hr	Slippage Percentage %	Tillage soil volume M3/hr	Penetration Resistance Kpa	Porosity %	No. Of clods/m2
15	17.31	5.73	10.47	722.68	1344.89	47.66	7.89
25	20.87	5.37	16.21	1129.56	1520.11	45.45	9.36
LSD 5 %	**0.4094**	**0.0429**	**0.7346**	**7.561**	**49.457**	**0.3565**	**0.2932**

2- Effect of soil water content %

Table (2) refer to an existence of significant effect of soil moisture on all characters in this study. we see that with increasing of soil water content the fuel consumption, slippage, and total porosity increase. The reason is because the increase of moisture content of the soil decrease cohesion between the soil surface and the wheels causing increase of slippage percentage and fuel consumption with decrease of tractor practical speed. These results are consistent with each of [13] that By increasing the soil moisture content, draught, specific draught and drawbar power increases. and [2] that Soil compaction is an increase in the density of soil and reduction in porosity. while practical speed, tillage soil volume, soil penetration resistance, and number of soil clods/ m^2 decrease with increasing of soil moisture. The reason is that the penetration resistances decrease with increasing water content because the cohesion force among soil particles is very strong decrease with increasing of soil moisture, also after tillage there are big clods in the field. [3]. Tillage soil volume character increase with reducing practical speed Because the forward speed is one of the main factors to determine the value of this character.

Table – 2: Effect of soil water content on study characters

Water content factor %	Fuel consumption L/ha	Practical speed Km/hr	Slippage %	Tillage soil volume M3/hr	Penetration Resistance Kpa	Porosity %	No. Of clods/m2
10	17.52	5.67	11.55	946.05	1592.67	45.21	10.28
15	19.00	5.56	13.39	925.96	1406.50	46.53	8.39
20	20.74	5.43	15.08	906.36	1298.33	47.93	7.20
LSD 5 %	**0.5014**	**0.0526**	**0.8998**	**9.2603**	**60.573**	**0.4367**	**0.3591**

3 - Effect of interaction between tillage depth and soil moisture :

Table (3) shows significantly differences among interaction treatments mean. the best result were 15.89L/ha, 5.86Km/hr,and 8.61% for fuel consumption, practical speed, and slippage percentage respectively when the interaction was accrued between 15cm tillage depth with 10% moisture content. Because the depth of tillage factor with moisture content are important factors effecting on the amount of fuel consumed, and the decrease of value for each depth of tillage and moisture content reduce the tire slip, which in turn increases the tractor practical speed of the process and reduces the amount of fuel consumed to perform agricultural process. while the best result for Tillage soil volume, is 1152.90 m^3/hr when tillage depth of 25cm interacted with 10% moisture content. We note also that 1222.67 Kpas, 49.00%, and 6.46 are best results happened for the penetration resistance, porosity, and number of soil clods that bigger than 10 cm/m2 characters respectively when tillage depth of 15cm interacted with 20% soil moisture.

Table – 3: Effect of interaction between tillage depth and soil moisture

Tillage depth cm & water content %	Fuel consump. L/ha	Practical speed Km/h	Slippage Percentage %	Tillage soil volume M3/hr	Penetration Resistance Kpa	Porosity %	No. Of soil clods /m^2
15&10	15.89	5.86	8.61	739.20	1465.00	46.33	9.57
15&15	17.32	5.75	10.38	724.92	1347.00	47.66	7.64
15&20	18.72	5.58	12.41	703.92	1222.67	49.00	6.46
25&10	19.15	5.49	14.48	1152.90	1720.33	44.10	11.00
25&15	20.69	5.36	16.40	1127.00	1466.00	45.40	9.13
25&20	22.76	5.28	17.75	1108.80	1374.00	46.86	7.94
LSD 5 %	0.709	0.0743	1.2724	13.096	85.663	0.6175	0.5079

As conclusion we see it is necessary to study the effect of enter more levels of tillage depth and soil moisture content due to their significant impact on the physical properties of the soil. Study more mechanical and physical properties by using mold board plow. It appears, also, that the plowing depth had more effect on the unit draft than the forward speed. [5].

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