

International Journal of Advanced Multidisciplinary Research (IJAMR)

ISSN: 2393-8870

www.ijarm.com

Coden:IJAMHQ(USA)

Research Article

Machinery Unit Energy Requirement and Fuel Consumption Tractor in Operation Tillage

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Abstract

Keywords

Tractor,
Fuel consumption,
Energy Requirement,
Appearance Tillage,
Plows,
Donam.

The study was carried out at field agriculture in Baghdad–Iraq in 2015. For purpose evaluated the performance the selected implements tillage, suitable tire pressure and speed tractor under silt clay loam to measured Effective field capacity, Actual Time for plowing One Donam (hr), Appearance Tillage (number of clods > 10 cm), Fuel consumption measure in two unit (L/Donam and L/hr) and Machinery Unit Energy Requirement (kw.hr / Donam). Split – split plot design under randomized complete block design with three replications using Least Significant Design 5 % was used. Three factor used in this experiment included Two types of plows included Chisel and Disk plows which represented main plot, Three Tires Inflation Pressure was second factor included 1.1, 1.8 and 2.7 Bar, and Three forward speeds tractor of the tillage was third factor included 2.35 , 4.25 and 6.50 km/hr. Results with Chisel plow was the most effective tillage and best result with it. Significant effects in Three factors above in parameter indicators studying.

Introduction

Iraq agriculture engineering and farmers as many engineering and farmer in the worlds interesting in measure fuel consumption Tractors during difference performance processing agriculture like primary and secondary tillage, seeding, harvesting ...ect in the field. Iraqi Unit agriculture land or survey more used and depend from agriculture Ministry and Farmers is Donam which equal 2500 m² (4 Donam= Hectare). The Tillage Operations, defined as mechanical manipulation of soil, are performed to achieve the desired seedbed to provide optimum environment for seed germination and plant growth (Hamid 2015).Tillage operation depend on many factors as types and design plows, moisture and texture soil, depth and purpose of tillage, speed and tiers pressure tractor, kind the plant of growth...ect. Usually primary tillage by used Machinery Unit (Tractor and plow) as plow chisel and disc plows consumption more fuel than other operation agriculture in the field (Aday 2008 and Hamid 2013). Found (Jasim 2004, Jasim and Juber 2015 and) chisel plow achieved the best indicators performance from Disc plow. Tires pressure effected in performance tractor such as productivity, fuel consumption, speed, slippage, soil compaction, energy requirement and Appearance Tillage and tire consumption...ect. Adjusting tire pressure can result in fuel

savings in the range of 5 to 15 percent (Intelligent Energy Europe, 2012). Speed tractor must selected carefully because every operation and machines agriculture had suitable speed limit, yet we still need conducted the experiment to know which suitable speed give the best indicator performance. Found (Alsharefi 2011and Aljubory et al 2012) significant effects on fuel consumption and Effective Field Capacity with increasing speed tractor. The goal of this experiment is Knowledge which plows Chisel or Disc chive the best results and know the effected difference Tires Pressure and Speed Tractor on Effective Field Capacity (Donam / hr), Appearance tillage, Actual time, Fuel Consumption and Machinery unit energy requirement.

1- Material and Methods

1-1 Field Experiment

Field experiment was conducted in Baghdad-Iraq in March 2015. The field was not agriculture and tilled since three years ago. Field was 31.7 m above sea level and the weather temperature was measured 28 C° and humidity was 36 %, Soil texture was silt clay loam (465, 423 and 112 g.kg-1 respectively). Depth tillage was 18 cm and Soil moisture was 17-19 % when soil tilled.

2-1 Experiment Design

Split-Split plot design under randomized complete block design with Three replication using least significant design (LSD) 5 % was used to compare the mean of treatments. Statistical analysis system was used (Al-Sahookie 1990 and SAS 2010). Three factors were used in this experiment included Two types of plows included Chisel and Disk plows which represented main plot, Three Tires Inflation Pressure was second factor included 1.1 ,1.8 and 2.7 Bar, and Three forward speeds of the tillage was third factor included 2.35 , 4.25 and 6.50 km/hr. Experiment included 18 treatments with three replication for each treatment (2×3×3×3= 54 Treatments).

3-1 Tractor and Plows

Chisel and Disk Plows as represented main plot, mounted behind TUMOSON 95-80 Tractor and adjusted each of them at depth tillage 18 cm . The main specifications of the tractor, tires, Chisel and Disc Plows are listed in Table 1.

Tractor working with full fuel tank and radiator. The tires used in this experiment was standard size for the tractor, as specified by the manufacturer. The tires walls was not damaged and the rear tires pressures was adjusted according to second factor in experiment included 1.1 ,1.8 and 2.7 bar. Three speeds tractor choosing carefully 2.35 , 4.25 and 6.50 km/hr by limited point start treatment length 30 m and must leftover 10 m at least before this distance 30 m to give the speed ground tractor stability in movement and operation tillage and determined time in second by stopwatch to cross the tractor these distance (we calculated the time for 30 m only)(fig.1) , then calculated by the following equation (1):

$$V_t = D/T \times 3.6 \tag{1}$$

When V_t was velocity measure in km / hr , D was distance treatment line tillage limited equal 30 m , T was time (in sec) to cross tractor distance 30 m , 3.6 was factor conversion. Operation tillage conducted with 2000 rpm engine tractor by put and control on lever fuel hand in tractor for all treatments in these experiment.

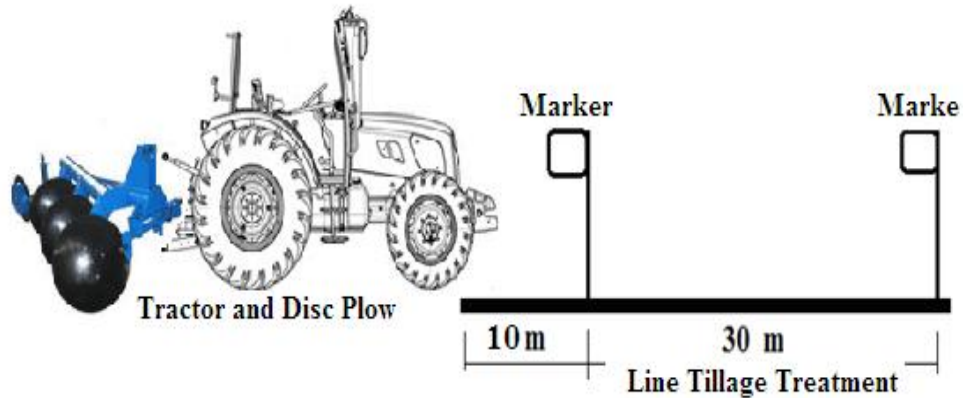


Figure.1. Method of determined and choosing speeds tractor.

Table 1. Main specifications of the tractor, tires, and implements used in field experiment.

<u>Characteristics of agricultural tractor and tires</u>	
Engine model	4DT-39T195
No. of engine cylinders	4
Diameter × Stroke (mm)	104 × 115
Cylinder Volume (Liter)	3.9
Maximum Engine power (hp)	95
Maximum Torque (Nm)	340
Engine Rev. @ 540 r/m PTO rev.	2225
Suspension Seat	2 Spring
Gear Box	Mechanic 12 Forward - 12 Reverse
Clutch Ty	12 Inch / Dry Type Single Disc
Lifting Capacity (kg)	6000
Tractor mass without ballast (kg)	3225
Front tire (width – diameter, in)	7.50 – 18
Rear tire (width – diameter, in)	18.4 – 30
Fuel Tank Capacity (Liter)	115

Characteristics of the Chisel plow	
No. of Tines	7
Max. Working Width (m)	1.40
Plough depth (m)	0.22
Wight (kg)	300
Made	Iraq
Characteristics of the Disc plow	
No. of discs	3
Plough depth (m)	0.30
Width (m)	90
Wight (kg)	380
Made	Iraq

2- Performance parameters

1-2 Effective Field Capacity (Donam / hr)

Any operation tillage conduct found it Time lost such as turning, adjustment and change gear, etc. The effective field capacity was calculated by using the equation (2), (Al-Tahaan et al 1991 and Lyne 1989):

$$EFC = 0.4 \times Va \times Wp \times FT \text{ --- (2)}$$

When *EFC* was Effective Field Capacity in Donam /hr (Donam = 2500 m²), *Va* was actual velocity in km/hr, *Wp* was working actual width plow in m, *ft* coefficient estimate time for primary tillage in Iraq Agriculture depend it almost between (0.65 – 0.75) and we used 0.70 in these experiment, 0.4 was factor conversion.

2-2 Actual Time for plowing One Donam (hr)

We can define Actual Time for plowing One Donam (hr) is the Actual Time require or spent for plowing or tilling One Donam(in Iraq one Donam equals 2500 m²) measuring in

hour, Calculated by divided One Donam on Effective Field Capacity using the equation (3):

$$Tt = \frac{1}{EFC} \text{ --- (3)}$$

When *Tt* was Actual Time for plowing One Donam (hr), 1 = One Donam.

3-2 Appearance Tillage (Number of Clods > 10 cm)

Appearance tillage is Number of clods soil which appearance after using plows such as disc, moldboard and Chisel for primary tillage, these clods be more or bigger from 10 cm. When getting after tillage higher numbers of clods soil > 10 cm that means we getting Roughness Appearance Tillage. We measure Appearance Tillage (number of clods > 10 cm) by determine the numbers clods soil which size more or bigger from 10 cm in one meter square soil tilled, which can't across from Sieve Wirier had distance between wire and another was 10 cm² (Jasim 2004 and Bhushan 1973) (Fig.2)

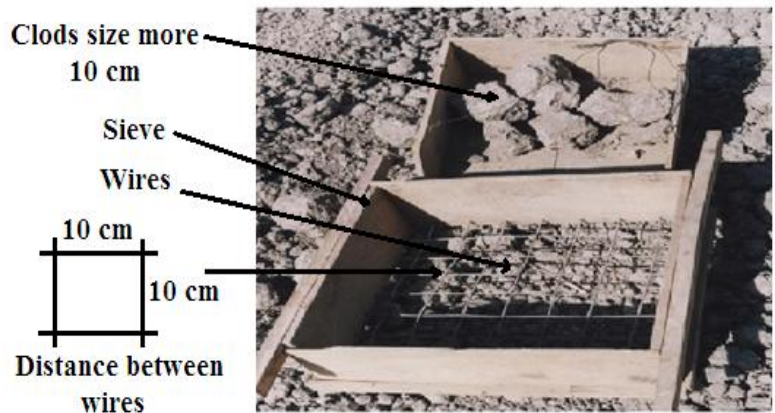


Fig. 2. Sieve Wirier and Method of Calculated the Number of Clods > 10 cm

4-2 Fuel Consumption

In these experiment we calculated fuel consumption in two units Liter /Donam and Liter / hour because the Iraqi farmer`s always used and depended on One of these units. Fuel consumption was measured Volumetrically in this experiment by used a fuel consumption meter (fig.3), which measure consumption quantity for one line tillage treatment (30 m) by unit milliliter (ml), Tied fuel consumption meter

between the tank fuel and engine tractor, in these time we opened valve A to allow fuel full the Graduate burette (cylinder marker), when tractor and plow reach the start point line tillage (See Fig. 1) we close valve A and open valve B to allow fuel go to engine, when we reach the end line tillage treatment we close valve B and see the level fuel in cylinder marker and record the data, then open valve A and B again and replication that process three times for each treatment in these experiment.

4-1-2 Fuel Consumption Liter / Donam

We can calculate the fuel consumption in Unit Liter /Donam by follow the equation (4),(Jasim 2004 and Hunt 2001) :

$$QF = Qd \times 2500 / Wp \times D \times 1000 \text{ ----- (4)}$$

When QF was quantity fuel consumption measure unit L/Donam , Qd was quantity fuel consumption during one treatment measure unit milliliter (ml) , 2500 and 1000 were factors conversion to Litre per Donam.

4-2-2 Fuel Consumption Liter / hour

We can calculate the fuel consumption in Unit Liter / hour by follow the equation (5):

$$QD = Qd \times 3600 / t \times 1000 \text{ ----- (5)}$$

When QD was quantity fuel consumption measure unit L/hr, t was the time in (sec) to across the One treatment. 3600 and 1000 were factors conversion to Litre per hour.

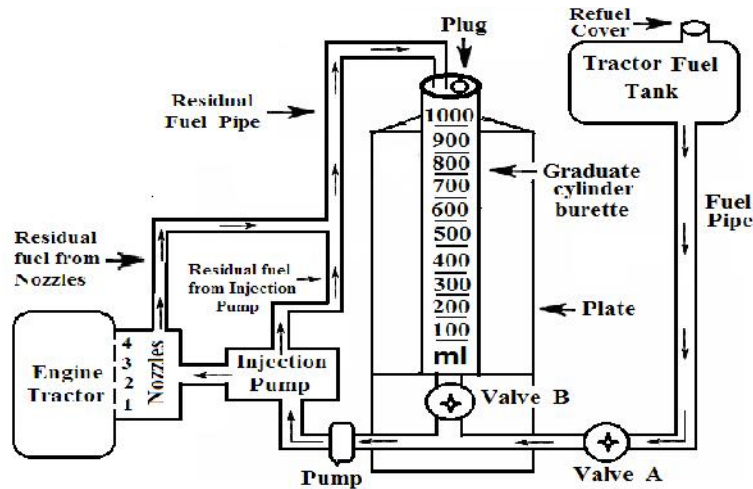


Figure.3. Fuel Consumption Meter

5-2 Machinery Unit Energy Requirement (kw.hr / Donam)

We can define Machinery Unit Energy Requirement is the power spender by engine tractor or Machine to done the operation multiply in the time divided on unit surfing, It effected on types, texture , moisture and density soil, types, design and width plow, speed tractor and depth tillage. Calculated by follow the equations (6 and 7), (Embaby 1985 and AL-Hashimy 2012):

$$E.P = 3.16 \times QD \text{ ----- (6)}$$

$$E.R = E.P / EFC \text{ ----- (7)}$$

When E.P was Engine Power in kw, QD was Fuel Consumption in L/ hr, 3.16 was constant and E.R was Machinery unit energy requirement in kw.hr / Donam.

3- Result and Discussion

1-3 Effective Field Capacity (Donam / hr)

Table 2. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Effective Field Capacity measure in Donam/ hr. Result show significant effects in the type of plows, Chisel plow recorded higher value 1.5746 Donam/hr while disc plow recorded lower value was 0.9945 Donam /hr, that because chisel plow width was 1.40 m while disc

plow was 0.90 m and that agree with result (Jasim 2004). Result show significant effects in tires pressure in Effective Field Capacity, Increasing tires pressure from 1.1 to 1.8 bar result to increasing from 1.2889 to 1.2929 Donam/hr with increasing ratio (0.31%) and that because increasing tire pressure to level limited permissible lead to increasing practical speed tractor then get to increasing Effective Field Capacity and that agree with Al-Kaysi 2004, while increasing tire pressure from 1.8 to 2.7 bar result to decreasing Effective Field Capacity from 1.2929 to 1.2717 Donam/hr with decreasing ratio (1.63%). Result show significant effects in tillage speed in Effective Field Capacity, Increasing tillage speed from 2.35 to 4.25 then to 6.5 km/hr result to increasing Effective Field Capacity from 0.7182 to 1.2611 then to 1.8742 Donam/hr with increasing ratio (75.59 and 48.60 % respectively) and that because speed tractor is the Main Factor in calculate Effective Field Capacity, these result agree with (Hamid 2013 and Taha 2011). Interaction between types plows with Tire Pressure show significant, Interaction between chisel plow and tire pressure 1.8 bar recorded higher Effective Field Capacity was 1.5803 Donam/hr, while interaction disc plow with tire pressure 2.7 bar recorded lower was 0.9784 Donam/hr. Interaction between type plows with tillage speed show significant, Interaction chisel plow with speed 6.50 km/hr recorded higher Effective Field Capacity was 2.2905 Donam/hr, While interaction Disc plow with speed 2.35 km/hr recorded lower was 0.5550 Donam/hr. Interaction between tires pressure with tillage speed show significant, tire pressure 1.8 bar with speed 6.50 km/hr recorded

higher value was 1.8813 Donam /hr, While tire pressure 2.7 bar with speed 2.35 km/hr recorded lower was 0.7136 Donam/hr. Interaction among types plows, tires pressure and tillage speed show significant, Chisel plow with 1.8 bar

and 6.50 km/hr recorded higher Effective Field Capacity was 2.3016 Donam/hr, while disc plow with 2.7 bar and 2.35 km/hr recorded lower was 0.5513 Donam/hr.

Table 2. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Effective Field Capacity Donam /hr.

Effective Field Capacity Donam* /hr.					
Treatments		Interaction Plows, Tire Pressure with Tillage Speeds			Interaction Types plows with Tire Pressure
Types Plows	Tire Pressure (bar)	Tillage Speed km/hr			
		2.35	4.25	6.50	
Chisel	1.1	0.8814	1.5567	2.2969	1.5784
	1.8	0.8870	1.5520	2.3016	1.5803
	2.7	0.8758	1.5466	2.2729	1.5651
Disk	1.1	0.5537	0.9826	1.4623	0.9996
	1.8	0.5601	0.9959	1.4609	1.0056
	2.7	0.5513	0.9330	1.4507	0.9784
Tillage Speeds Mean		0.7182	1.2611	1.8742	Types Plows Mean
Types Plows		Interaction Types plows with Tillage Speeds			
Chisel		0.8814	1.5518	2.2905	
Disk		0.5550	0.9704	1.4580	0.9945
Tire Pressure (bar)		Interaction Tires Pressure with Tillage Speeds			Tires Pressure Mean
1.1		0.7176	1.2697	1.8797	1.2889
1.8		0.7236	1.2739	1.8813	1.2929
2.7		0.7136	1.2399	1.8618	1.2717
L.S.D 0.05					
Types Plows : 0.0003		Tires Pressure : 0.0004		Tillage Speeds : 0.0004	
Interaction Types Plows with Tires Pressure : 0.4971					
Interaction Types Plows with Tillage Speeds : 0.013					
Interaction Tires Pressure with Tillage Speeds : 0.4019					
Interaction Types Plows ,Tires Pressure with Tillage Speeds: 0.001					

***Donam = 2500 m2 and Four Donam = One Hectare.**

2-3 Actual Time for plowing One Donam (hour)

Table 3. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Actual Time for plowing One Donam (hr). Results show significant effects in the types of plows, Chisel plow record lower actual time 0.738 hr while disc plow recorded higher time 1.172, that may because of the difference in the width plows, Figures and method of penetration plow in the soil. Result show significant effects in tires pressure, Increasing tires pressure from 1.1 to 1.8 bar result to decreasing actual time from 0.952 to 0.946 hr with decreasing ratio (0.63 %), while increasing tire pressure from 1.8 to 2.7 bar result to increasing from 0.946 to 0.966 hr with increasing ratio (2.11 %). Result show significant effects in tillage speed in Actual Time for Plowing, Increasing tillage speed from 2.35 to 4.25 then to 6.5 km/hr result to decreasing actual time from 1.467 to 0.837 then to 0.560 hr with decreasing ratio (42.94 and

33.09 % respectively). Interaction between types plows with Tire Pressure show significant, Interaction between chisel plow and tire pressure 1.8 bar recorded lower time was 0.742 hr, while interaction disc plow with tire pressure 2.7 bar recorded higher time was 1.190 hr. Interaction between type plows with tillage speed show significant, Interaction chisel plow with speed 6.50 km/hr recorded lower was 0.436 hr, While interaction Disc plow with speed 2.35 km/hr recorded higher was 1.801 hr. Interaction between tires pressure with tillage speed show significant, tire pressure 1.8 bar with speed 6.50 km/hr recorded lower time was 0.559 hr, While tire pressure 2.7 bar with speed 2.35 km/hr recorded higher was 1.477 hr. Interaction among types plows, tires pressure and tillage speed show significant, Chisel plow with 1.8 bar and 6.50 km/hr recorded lower was 0.434 hr, while disc plow with 2.7 bar and 2.35 km/hr recorded higher was 1.813 hr.

Table 3. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Actual Time for plowing One Donam (hour).

Actual Time for plowing One Donam (hour)					
Treatments		Interaction Plows, Tire Pressure with Tillage Speeds			Interaction Types plows with Tire Pressure
Types Plows	Tire Pressure (bar)	Tillage Speed km/hr			
		2.35	4.25	6.50	
Chisel	1.1	1.134	0.642	0.435	0.737
	1.8	1.127	0.643	0.434	0.734
	2.7	1.141	0.643	0.439	0.742
Disk	1.1	1.805	1.017	0.683	1.168
	1.8	1.784	1.003	0.684	1.157
	2.7	1.813	1.071	0.688	1.190
Tillage Speeds Mean		1.467	0.837	0.560	Types Plows Mean
Types Plows		Interaction Types plows with Tillage Speeds			
Chisel		1.134	0.643	0.436	
Disk		1.801	1.030	0.685	1.172
Tire Pressure (bar)		Interaction Tires Pressure with Tillage Speeds			Tires Pressure Mean
1.1		1.469	0.829	0.559	0.952
1.8		1.455	0.823	0.559	0.946
2.7		1.477	0.858	0.563	0.966
L.S.D 0.05					
Types Plows : 0.0005		Tires Pressure : 0.0006		Tillage Speeds : 0.0006	
Interaction Types Plows with Tires Pressure : 0.4004					
Interaction Types Plows with Tillage Speeds : 0.0135					
Interaction Tires Pressure with Tillage Speeds: 0.3054					
Interaction Types Plows ,Tires Pressure with Tillage Speeds: 0.0016					

3-3 Appearance Tillage (Number of Clods > 10 cm)

Table 4. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Appearance Tillage (Number of clods > 10 cm). Result show significant effects in the type of plows, Chisel plow recorded lower value 7.77 while disc plow recorded higher value was 13.92 clods and that agree with result (Jasim 2004 and Al-Hadithy 2006). Result show significant effects in tires pressure, Increasing tires pressure from 1.1 to 1.8 then to 2.7 bar result to increasing from 10.11 to 10.72 then to 11.72 clods with increasing ratio (6.03 and 9.32 % respectively) and may be because increasing tires pressure reduce cohesion between tire and soil and increasing resistance and that result to reduce turn clods and reduce disintegrating or crumbing soil and that agree with (Altemem 2010 and Alhadithi 2004) . Result show significant effects tillage speed in Appearance Tillage (Number of Clods > 10 cm), Increasing tillage speed from 2.35 to 4.25 then to 6.5 km/hr result to decreasing from 12.05 to 10.88 then to 9.61 clods with decreasing ratio (9.70 and 11.67 % respectively) and that because increasing speed

result to increasing velocity clods movement, increasing speed proportioned inversely with factor disintegrating or crumbing soil, and that agree with (Alhadithi 2004). Interaction between types plows with Tire Pressure show significant, Interaction between chisel plow and tire pressure 1.1 bar recorded lower value was 7.00 clods, while interaction disc plow with tire pressure 2.7 bar recorded higher was 14.77 clods. Interaction between type plows with tillage speed show significant, Interaction chisel plow with speed 6.50 km/hr recorded lower was 6.33, While interaction Disc plow with speed 2.35 km/hr recorded higher was 15.22 clods. Interaction between tires pressure with tillage speed show significant, tire pressure 1.1 bar with speed 6.50 km/hr recorded lower value was 8.83 clods, While tire pressure 2.7 bar with speed 2.35 km/hr recorded higher was 13.00 clods. Interaction among types plows, tires pressure and tillage speed show significant, Chisel plow with 1.1 bar and 6.50 km/hr recorded lower value was 5.66 clods, while disc plow with 2.7 bar and 2.35 km/hr recorded higher value was 16.33 clods.

Table 4. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Appearance Tillage (Number of Clods > 10 cm).

Appearance Tillage (Number of Clods > 10 cm)					
Treatments		Interaction Plows, Tire Pressure with Tillage Speeds			Interaction Types plows with Tire Pressure
Types Plows	Tire Pressure (bar)	Tillage Speed km/hr			
		2.35	4.25	6.50	
Chisel	1.1	8.33	7.00	5.66	7.00
	1.8	8.66	8.00	6.33	7.66
	2.7	9.66	9.33	7.00	8.66
Disk	1.1	14.33	13.33	12.00	13.22
	1.8	15.00	13.66	12.66	13.77
	2.7	16.33	14.00	14.00	14.77
Tillage Speeds Mean		12.05	10.88	9.61	Types Plows Mean
Types Plows		Interaction Types plows with Tillage Speeds			
Chisel		8.88	8.11	6.33	
Disk		15.22	13.66	12.88	13.92
Tire Pressure (bar)		Interaction Tires Pressure with Tillage Speeds			Tires Pressure Mean
1.1		11.33	10.16	8.83	10.11
1.8		11.83	10.83	9.50	10.72
2.7		13.00	11.66	10.50	11.72
L.S.D 0.05 Types Plows: 0.3109 Tires Pressure : 0.3807 Tillage Speeds : 0.3807 Interaction Types Plows with Tires Pressure : 1.1712 Interaction Types Plows with Tillage Speeds : 0.8582 Interaction Tires Pressure with Tillage Speeds: 4.0739 Interaction Types Plows ,Tires Pressure with Tillage Speeds: 0.9326					

4-3 Fuel Consumption

4-1-3 Fuel Consumption Measure in Unit Liter/ Donam

Table 5. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Fuel Consumption Measure in Unit Liter/ Donam. Result show significant effects in the type of plows, Chisel plow recorded lower value 4.020 L/Donam while disc plow recorded higher value was 7.155 L/Donam, that because chisel width more than disc plow, and that agree with (Jasim & Juber 2015). Result show significant effects in tires pressure, Increasing tires pressure from 1.1 to 1.8 then to 2.7 bar result to increasing from 5.314 to 5.550 then to 5.898 L/Donam with increasing ratio (4.44 and 6.27 % respectively) that may be increasing tire pressure result to reduce surfing touch between tire tractor and soil and that result increasing slippage and increasing time tillage for one donam, that agree with (Altmeme 2010 and Alhadithi 2004) . Result show significant effects, Increasing tillage speed from 2.35 to 4.25 then to 6.5 km/hr result to decreasing fuel consumption from 6.832 to 5.736 then to 4.195 L/Donam with decreasing ratio (16.04 and 26.86 % respectively) that because increasing speed tractor

means using engine power perfectly and reduced the time inquire for operation and that result to increasing effective field capacity ant that result decreasing fuel consumption in one Donam, and that agree with (Hamid 2013, Alhadithi 2004, Alsharifi 2011 and Aljubory 2012). Interaction between types plows with Tire Pressure show significant, Interaction between chisel plow and tire pressure 1.1 bar recorded lower value was 3.851 L/Donam, while interaction between disc plow with tire pressure 2.7 bar recorded higher was 7.581 L/Donam. Interaction between type plows with tillage speed show significant, Interaction chisel plow with speed 6.50 km/hr recorded lower value was 2.958 L/Donam, While interaction Disc plow with speed 2.35 km/hr recorded higher was 8.623L/Donam. Interaction between tires pressure with tillage speed show significant, tire pressure 1.1 bar with speed 6.50 km/hr recorded lower value was 3.923 L/Donam, While tire pressure 2.7 bar with speed 2.35 km/hr recorded higher value was 7.170 L/Donam. Interaction among types plows, tires pressure and tillage speed show significant, Chisel plow with 1.1 bar and 6.50 km/hr recorded lower value was 2.796 L/Donam , while disc plow with 2.7 bar and 2.35 km/hr recorded higher value was 9.090 L/Donam.

Table 5. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Fuel Consumption Measure in Unit Liter/ Donam.

Fuel Consumption Measure in Unit Liter/ Donam					
Treatments		Interaction Plows, Tire Pressure with Tillage Speeds			Interaction Types plows with Tire Pressure
Types Plows	Tire Pressure (bar)	Tillage Speed km/hr			
		2.35	4.25	6.50	
Chisel	1.1	4.876	3.880	2.796	3.851
	1.8	4.996	4.010	2.970	3.992
	2.7	5.250	4.290	3.110	4.216
Disk	1.1	8.263	7.020	5.050	6.777
	1.8	8.516	7.410	5.396	7.107
	2.7	9.090	7.806	5.195	7.581
Tillage Speeds Mean		6.832	5.736	4.195	Types Plows Mean
Types Plows		Interaction Types plows with Tillage Speeds			
Chisel		5.041	4.060	2.958	
Disk		8.623	7.412	5.431	
Tire Pressure (bar)		Interaction Tires Pressure with Tillage Speeds			Tires Pressure Mean
1.1		6.570	5.450	3.923	5.314
1.8		6.757	5.710	4.183	5.550
2.7		7.170	6.048	4.478	5.898
L.S.D 0.05					
Types Plows : 0.035		Tires Pressure : 0.0429		Tillage Speeds : 0.0429	
Interaction Types Plows with Tires Pressure : 1.1405					
Interaction Types Plows with Tillage Speeds : 0.2701					
Interaction Tires Pressure with Tillage Speeds: 2.0738					
Interaction Types Plows ,Tires Pressure with Tillage Speeds: 0.1051					

4-2-3 Fuel Consumption Measure in Unit Liter/ hour

Table 6. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Fuel Consumption Measure in Unit Liter/hour. Result show significant effects in the type of plows, Chisel plow recorded lower value 8.364 L/hr while disc plow recorded higher value was 9.501 L/hr. Result show significant effects in tires pressure, Increasing tires pressure from 1.1 to 1.8 then to 2.7 bar result to increasing from 8.503 to 8.953 then to 9.341 L/hr with increasing ratio (5.29 and 4.33 % respectively). Result show significant effects, Increasing tillage speed from 2.35 to 4.25 then to 6.5 km/hr result to increasing fuel consumption from 6.602 to 9.662 then to 10.533 L/hr with increasing ratio (46.34 and 9.01% respectively). Interaction between types plows with Tire Pressure show significant, Interaction

between chisel plow and tire pressure 1.1 bar recorded lower value was 7.998 L/hr, while interaction between disc plow with tire pressure 2.7 bar recorded higher was 9.956 L/hr. Interaction between type plows with tillage speed show significant, Interaction chisel plow with speed 2.35 km/hr recorded lower value was 6.363 L/hr, While interaction Disc plow with speed 6.50 km/hr recorded higher was 11.341L/hr. Interaction between tires pressure with tillage speed show significant, tire pressure 1.1 bar with speed 2.35 km/hr recorded lower value was 6.341L/hr, While tire pressure 2.7 bar with speed 6.50 km/hr recorded higher value was 11.123 L/hr. Interaction among types plows, tires pressure and tillage speed show significant, Chisel plow with 1.1 bar and 2.35 km/hr recorded lower value was 6.140 L/hr, while disc plow with 2.7 bar and 6.50 km/hr recorded higher value was 12.126 L/hr.

Table 6. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Fuel Consumption Measure in Unit Liter/ hour.

Fuel Consumption Measure in Unit Liter/ hour					
Treatments		Interaction Plows, Tire Pressure with Tillage Speeds			Interaction Types plows with Tire Pressure
Types Plows	Tire Pressure (bar)	Tillage Speed km/hr			
		2.35	4.25	6.50	
Chisel	1.1	6.140	8.633	9.223	7.998
	1.8	6.380	8.886	9.833	8.366
	2.7	6.570	9.490	10.120	8.726
Disk	1.1	6.543	9.856	10.623	9.007
	1.8	6.816	10.530	11.273	9.540
	2.7	7.163	10.580	12.126	9.956
Tillage Speeds Mean		6.602	9.662	10.533	Types Plows Mean
Types Plows		Interaction Types plows with Tillage Speeds			
Chisel		6.363	9.003	9.725	
Disk		6.841	10.322	11.341	9.501
Tire Pressure (bar)		Interaction Tires Pressure with Tillage Speeds			Tires Pressure Mean
1.1		6.341	9.245	9.923	8.503
1.8		6.598	9.708	10.553	8.953
2.7		6.245	10.035	11.123	9.341
L.S.D 0.05					
Types Plows : 0.0828		Tires Pressure : 0.1014		Tillage Speeds : 0.1014	
Interaction Types Plows with Tires Pressure : 1.7618					
Interaction Types Plows with Tillage Speeds : 0.4062					
Interaction Tires Pressure with Tillage Speeds: 0.8326					
Interaction Types Plows ,Tires Pressure with Tillage Speeds: 0.2483					

5-3 Machinery Unit Energy Requirement (kw.hr / Donam)

Table 7. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Machinery Unit Energy Requirement (kw.hr / Donam). Result show significant effects in the type of plows, Chisel plow recorded lower value 18.184 kw.hr/ Donam while disc plow recorded higher value was 32.390 kw.hr / Donam. Result show significant effects in tires pressure, Increasing tires pressure from 1.1 to 1.8 then to 2.7 bar result to increasing from 24.031 to 25.091 then to 26.740 kw.hr / Donam with increasing ratio (4.41and 6.57 % respectively). Result show significant effects, Increasing tillage speed from 2.35 to 4.25 then to 6.5 km/hr result to decreasing Machinery Unit Energy Requirement from 30.878 to 25.987 then to 18.997 kw.hr/Donam with decreasing ratio (15.83 and 26.89 % respectively) and that because increasing speed result to decreasing the time require to done the tillage operation and

that lead or result to reduce fuel consumption and that agree with (Alhashimy 2012). Interaction between types plows with Tire Pressure show significant, Interaction between chisel plow and tire pressure 1.1 bar recorded lower value was 17.403 kw.hr/Donam, while interaction between disc plow with tire pressure 2.7 bar recorded higher was 34.430 kw.hr/Donam. Interaction between type plows with tillage speed show significant, Interaction chisel plow with speed 6.50 km/hr recorded lower value was 13.413 kw.hr/Donam, While interaction Disc plow with speed 2.35 km/hr recorded higher was 38.945. Interaction between tires pressure with tillage speed show significant, tire pressure 1.1 bar with speed 6.50 km/hr recorded lower value was 17.818 kw.hr/Donam, While tire pressure 2.7 bar with speed 2.35 km/hr recorded higher value was 32.378 kw.hr/Donam. Interaction among types plows, tires pressure and tillage speed show significant, Chisel plow with 1.1 bar and 6.50 km/hr recorded lower value was 12.683 kw.hr/Donam, while disc plow with 2.7 bar and 2.35 km/hr recorded higher value was 41.053 kw.hr/Donam.

Table 7. Effect Type Plows, Tires Pressure and Tillage Speeds and interaction on Machinery Unit Energy Requirement (kw.hr / Donam).

Machinery Unit Energy Requirement (kw.hr / Donam)					
Treatments		Interaction Plows, Tire Pressure with Tillage Speeds			Interaction Types plows with Tire Pressure
Types Plows	Tire Pressure (bar)	Tillage Speed km/hr			
		2.35	4.25	6.50	
Chisel	1.1	22.006	17.520	12.683	17.403
	1.8	22.723	18.086	13.493	18.101
	2.7	23.703	19.383	14.063	19.050
Disk	1.1	37.333	31.693	22.953	30.660
	1.8	38.450	33.413	24.380	32.081
	2.7	41.053	35.826	26.410	34.430
Tillage Speeds Mean		30.878	25.987	18.997	Types Plows Mean
Types Plows		Interaction Types plows with Tillage Speeds			
Chisel		22.811	18.330	13.413	
Disk		38.945	33.644	24.581	32.390
Tire Pressure (bar)		Interaction Tires Pressure with Tillage Speeds			Tires Pressure Mean
1.1		29.670	24.670	17.818	24.031
1.8		30.587	25.750	18.937	25.091
2.7		32.378	27.605	20.237	26.740
L.S.D 0.05 Types Plows : 0,2163 Tires Pressure : 0.265 Tillage Speeds : 0.265 Interaction Types Plows with Tires Pressure : 5.1475 Interaction Types Plows with Tillage Speeds : 1.2803 Interaction Tires Pressure with Tillage Speeds: 9.4023 Interaction Types Plows ,Tires Pressure with Tillage Speeds: 0.649					

Conclusion

1- The more Effective field capacity (Donam/hr) was recorded in operating Chisel plow, while less Effective field capacity was Disk plow.

2- The minimum (the best) Actual Time for plowing One Donam (hr), Appearance Tillage (Number of Clods > 10 cm), Fuel consumption measure by two unit (L/Donam) and (L/hr) and Machinery Unit Energy Requirement (kw.hr/Donam) wear recorded in operating Chisel plow, while Disc plow recorded more.

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