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Some Techniques Used to Minimize Fuel Consumption and Wheel Slip in Crop Production Growth on Clay Loam Soil

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Abstract: Field expriment was conducted on clay loam soil at El-Dokki, Giza Governorate as a cooperative work between the National Research Centre and the Agricutlural Research Center to study the effects of soil water content at plowing Ɵ1, Ɵ2 and Ɵ3 (8.1, 17.1; 26.4 % w/w), plowing depth D1, D2 and D3 (10, 15; 20 cm) and plowing speed S1 and S2 (1.99; 10.33 km/h), respectively on minimizing both fuel consumption and tractor wheel slip. It was found that:Increasing (D) and (Ɵ)had positive effects on fuel consumption and tractor wheel slip, whearas increasing (S) has positive effect on the 1-set and negative one on the 2nd. The maximum values and the minimum one of fuel consumption and tractor wheel slip were achieved in the following interactions:(D3xS2xƟ3, D1xS2xƟ1)and (D3xS1xƟ3 and D1xS1xƟ2), respectively. The main effect of :(D, S; Ɵ) and their interaction have significant effects on fuel consumption and tractor wheel slip at the 5% level.
Keywords: Soil water content, plowing depth, speed, fuel consumption and wheel slip.

Introduction:

Performance data from various tractors and implements are essential for both their manufacture and management. Proper selection of trctors and implements for a particular farm conditions is a must to minimize energy consumption used in crop production Al-Suhaibani[1]. It becomes more critical as energy costs escalate since the field lools constitute a major portion of the total cost of cropproduction system. Global researches indicated that the draft requirement of chisel plow was about half of that of the moldboard one equal in width and operation depth Kohnke[2]. According to Shafei [3] extensive activities for replacing moldboard plow by chsel one in dry farming have done allover the world.It is worthy to mention that both water and fossil fuel are two limited and precious nutral resources in many countries including Egypt. Agriculture consumes energy in different aspects i.e., soil tilth, irrigation, fertilizer processing, crop harvesting and transportation ex. Onley water pumping can use as 13 % of the energy used in agriculture (Pimental and Giampietro[4], and Smajestria et al., [5]).

The following techniques have been used to decrease fuel consumption and increase it's use efficiency 1-Many researchers showed that increasing of overall energy efficiency and subsequently decreasing fuel consumptioncan be achieved through optimal splitting the gross tractor weight between the front and rear axles and using correct matching of tractor, the company tools and agricultural machinery (Mobarak [6], Nasr [7],Iowa State University [8], Srivastava [9]). This is important to to transfer a much energy power as possible to the drabor . Too little weight or ballast results in excess drive wheel slip. Conversely, carry much ballast or weights on a tractor dramatically lowers wheel slip but results in greater rolling resistance as the tractor sinks too far into the soil, causing wheelsto be constantly climbing out of a deep rut. Since only wheels on powered axles supply traction. It is also important to distribute ballast properly between front and rear axles. Optinal weight split between axles is affected by tractor style and whether the attached implements are pulled or mounted -2- Seedbed preparation should be performed at the right conditions concerning soil moisture content, plowing speed and plowing depth (Korayem and Ismail [10],Tayel et al., [11], Bayoume [12]).

Nasr et al., [13] reported that increasing plowing deph increased both cohesion and adhesion forces of soil. They added that this increased rolling resistance of tractor and decreased its tractive efficiency. Hrrigan and Roosenberg [14] stated that plow draft can vary greatly in the same soil group depending on it's conditions. Lee et al., [15] Said that the power tillers depends on the purpoe of the operations, size of tracors, power tillers and field shope. Ahmed [16] found that the draft force and tillage energy required using chisel plow are linear function with both plowing speed and depth. Adewoyin and Ajav [17] mentioned that theincrease both plowing speed and depth increased tractor fuel consumption. According the same authers plowing depth was the most impactful factor in tractor consumption during fuel plowing process. According to Iowa State University [8] to maximize transfer of power from drive axles to the drawbar the optimum amounts of wheelslip depends on the soil surface and should be in [θ]following ranges: a) 6-13% on firm untilled soil., b)More slip 8-16% on a tilled surface, c) With slightly more yet on a non-cohesive sandy soil and d) 4-8% on concret. Checking wheel slip is a must to be determined to know if tractor is optimally applying fuel and horsepower to the drawbar. Al-Ani and Al-Ani [18] studied the relationship between tractor practical speed and different soil moisture content on plowing soil layer.

The present experiment was conducted to study the influence of seedbed preparation conditions concerning soil moisture content at plowing, plowing speed and plowing depth on fuel consumption and tractor wheel slip.

Materials and Methods

Field expremints was conducted at the experimental station of the Agicultural Research Center, Ministry of Agriculure and Land Reclamation, El-Dokki, Giza, during the year 2016 as a cooperative work between the National Research Centre and Soils, Water and Environment Research Institute. The objectives of the present research was to studying the effect of seedbed preparation conditions i.e. soil moisture content at plowing Θ1, Θ2 and Θ3 (8.1, 17.1; 26.4 % w/w), plowing depth D1, D2 and D3 (10, 15; 20 cm) and plowing speed S1 and S2 (1.99; 10.33 km/h) on minimizing both fuel consumption and tractor wheel slip.

Fuel consumption:

Fuel tank was completely filled at the beginning of plowing each plot under the spcifed working conditions and refilled at its end using 500 ml measuring cylinder.tractor wheel slip% was measured after Srivstava (1990) using the following equation:

$$\text{Wheel slip } \% = [(L1-L2)/L1]\ 100$$

Where: L1 = advance distance per 10 wheel revolution with no pull (m), L2 = advance distance per 10 wheel revolution with pull (m).

The experiment layout was in random plots split twice. Three replicates were used. Data obtained were subjected to statistical analysis after Snedecor and Cochran[19].

Results and Discussions:

The main effect of Θ, D and S:

Table (1) and all figures (1, 2, 3, 4, 5 and 6) indicates the main effects of plowing depth (D), soil moisture (Θ) at plowig and plowing speed (S) on fuel consumption and tractor wheel slip. The increases in fuel consumption and tractor wheel slip were: (91.72; 151.67% and (30.11; 97.22%), respectively at D2=15 cm and D3=20cm, relative to D1 =10 cm.

Table (1): Effect of soil moisture, tractor speed and plowing depth on fuel consumption andwheel slippage in clay loam soil

Soil Moisture content at plowing w/w%	Tractor speed (km/h)	plowing depth (cm)	Fuel consumption (L.fed^{-1})	Wheel slippage (%)
Ɵ1	**speed 1**	**10**	6.8	4.8
8.11	**1.93**	**15**	8.06	8
		20	12.73	10.9
	speed 2	**10**	5.73	4.18
	10.33	**15**	13.66	5.36
		20	17.4	8.35
Ɵ2	**speed 1**	**10**	8.6	3.6
17.06	**1.93**	**15**	18.33	4.74
		20	19.27	11.72
	speed 2	**10**	7.13	6.5
	10.33	**15**	16.2	7.5
		20	22.53	13.3
Ɵ3	**speed 1**	**10**	5.86	11.72
26.37	**1.93**	**15**	10.47	14.52
		20	13.73	15.14
	speed 2	**10**	7.26	5.86
	10.33	**15**	12.56	7.55
		20	18.4	12.88
Mean of tillage depth (cm)		**10**	**6.89**	**6.11**
		15	**13.21**	**7.95**
		20	**17.34**	**12.05**
Mean of tractor speed (Km/h)		**1.93**	**11.53**	**9.46**
		10.33	**13.42**	**7.94**
Mean of tillage at moisture content (w/w %)		**Ɵ1=8.11**	**10.73**	**6.93**
		Ɵ2 =17.06	**15.34**	**7.89**
		Ɵ3 =26.37	**11.38**	**11.28**
LSD$_{0.05}$ of means			**1.12**	**2.01**
LSD$_{0.05}$ of interactions			**0.08**	**0.05**

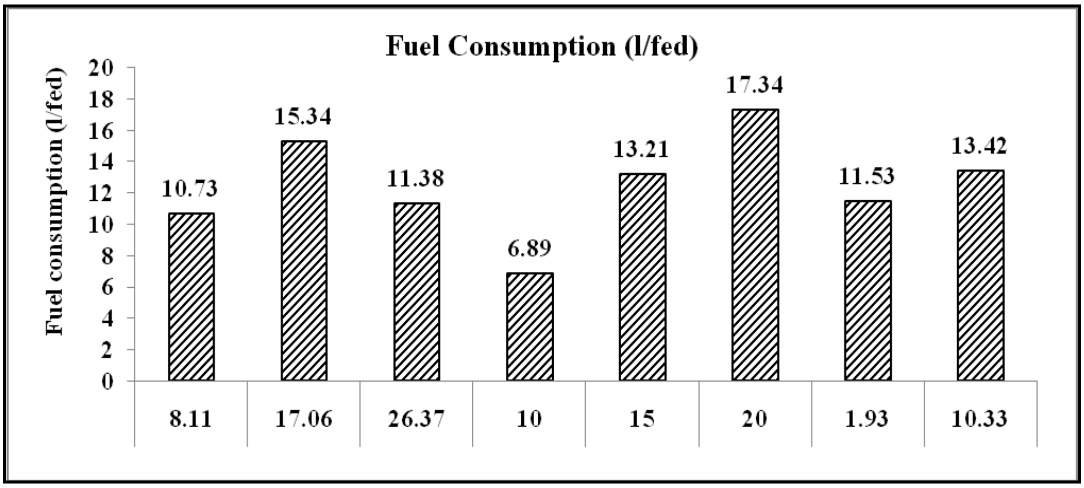


Fig. (1) Effect of soil tillage moisture,soil tillage depth, and tractor tillage speed on fuel consumption.

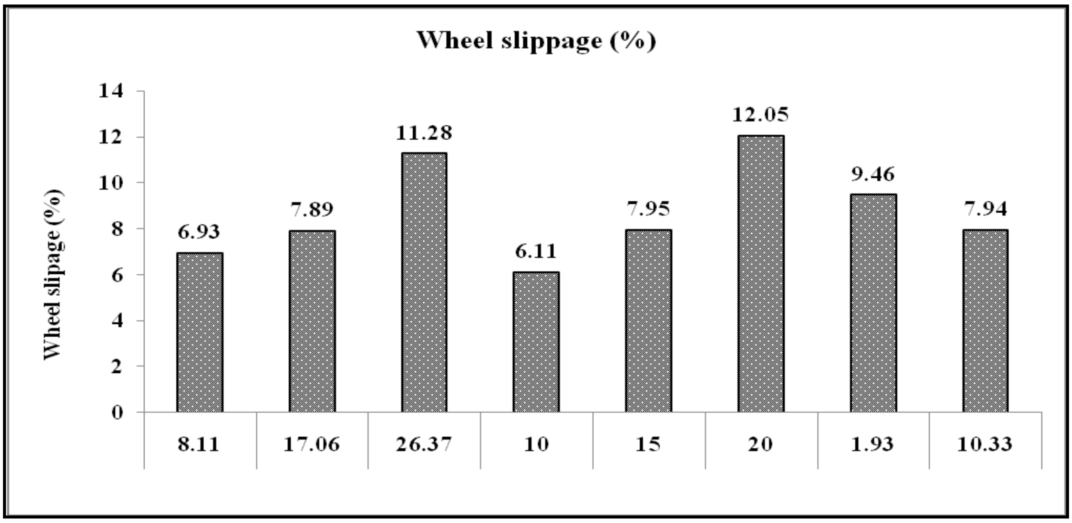
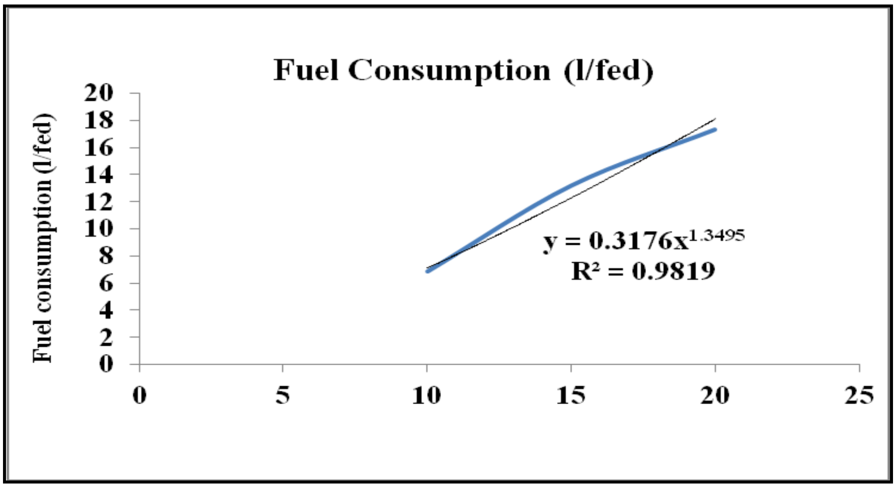
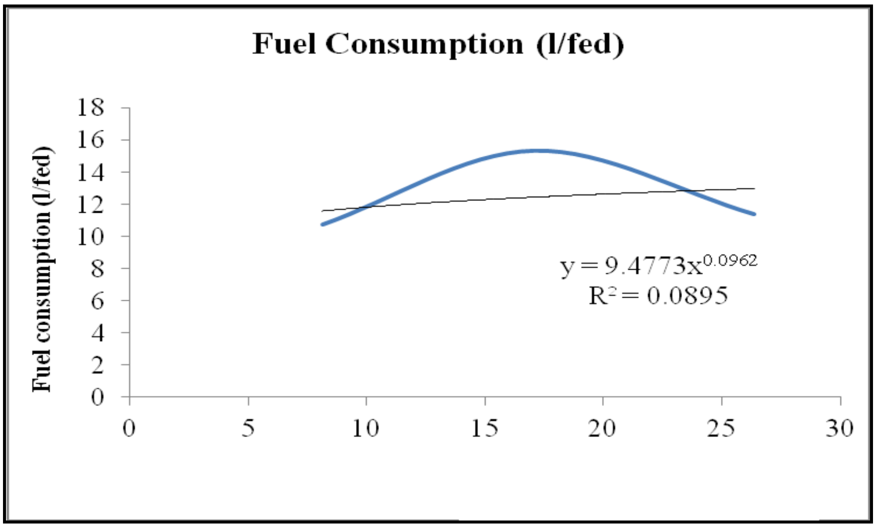


Fig. (2) Effect of soil tillage moisture, soil tillage depth, and tractor tillage speed on wheel slippage .



Soil depth (cm)

Fig. (3) Relationship between soil depth and fuel consumption



Soil moisture content (w/w)

Fig. (4) Relationship between Soil moisture content and fuel consumption

1- Relationship between soil tillage charactristics and wheel slippage percent:

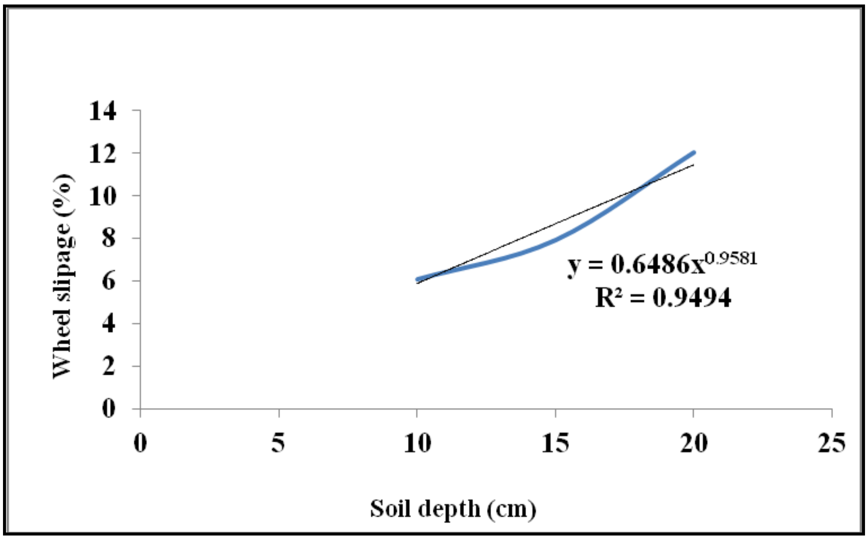


Fig. (5) Relationship between soil depth and wheel slippage percent

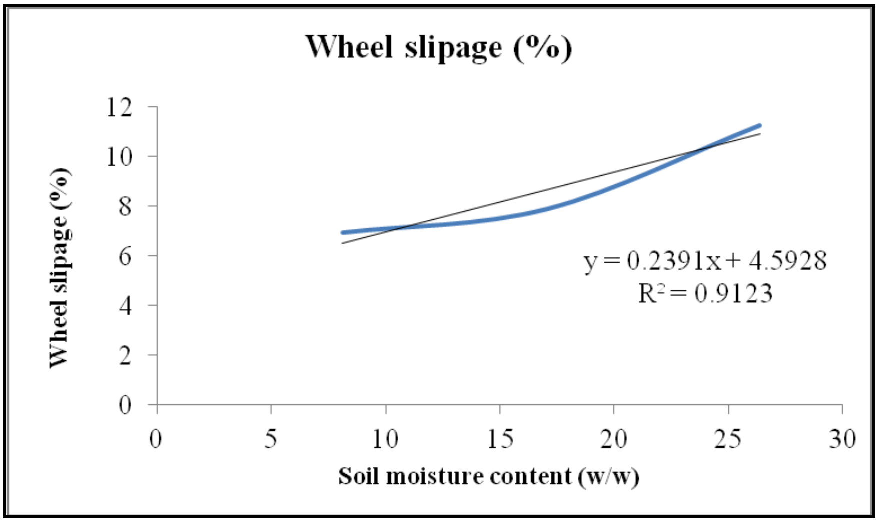


Fig. (6) Relationship between Soil moisture content and wheel slippage percent

The interaction of DxSxϴ:

Regarding the effect of the interaction DxSxϴ on fuel consumption and wheel slip, the obtained data can be seen in Table (1) and Figs. (7 and 8). It is obvious that the interaction: DxSxϴ have pronounced effect on both fuel consumption and wheel slip. The maximum and the minimum values of fuel consumption and wheel slip were achieved in the interactions: (D3xS2xϴ2); (D1xS2xϴ1) and (D3xS1xϴ3 , D1xS1xϴ2), respectively. The main effects of D, S and ϴ and their interactions on both fuel consumption and wheel slip were significant at the 5% level.

Data obtained could be due to one or more of the following reasons: 1- the weight of the above soil layers on the lower ones (overburden pressure) is vertically prossing downward on chizel increased with depth., 2- increasing plowing depth increased cohesion and adhesion forces, 3- increasing plowing depth increased soil pulverization, 4- increasing plowing speed increased soil pulverization , 5- soil organic mtter that acts as a lubricant material relieving friction among sol particles decreases with depth, and 6-weight of the tools used was not properly distributed between the front and rear axles.

Conclusion:

There is an increased need to study the beneficial effects and the deterimental ones of some seedbed preparation conditions concerning soil moisture content at plowing (ϴ), plowing depth (D) and plowing speed (S) on fuel consumption and tractor wheel slip. Results of the study showed that:

1. Increasing D and ϴ in the ranges: 10-20 cm, 8.1-26.4 (w/w %) increased both fuel consumption and tractor wheel slip.
2. Increasing (S) from 1.39 – 10.33 km/h has positive effect on fuel consumption and negative one on tractor wheel slip.
3. The maximum fuel consumption (22.53) and the minimum one (5.73 l/fed) were achieved in the following interactions: : D3xS2x ϴ2 (20 cm x 10.33 km/h x 17.1 w/w %) and : D1xS2xϴ1 (10 cm x 10.33 km/h x 8.1 w/w %, respectively.
4. The maximum tractor wheel slip (15.14%) and the minimum one (3.6 %) were found in the following interactions: D3xS1xϴ3 and D1xS1xϴ2, respectively.
5. Both the main effect of : D, S, and ϴ and their interaction have significant effects on fuel consumption and tractor wheel slip at the 5% level.

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